BABEŞ-BOLYAI UNIVERSITY

FACULTY OF PSYCHOLOGY AND EDUCATIONAL SCIENCES

DOCTORAL SCHOOL „DIDACTICS: TRADITION, DEVELOPMENT, INNOVATION”

# ABSTRACT OF THE DOCTORAL THESIS

# USING GRAPHIC ORGANIZERS TO DEVELOP GEOGRAPHICAL THINKING

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# STATEMENT ON ACADEMIC INTEGRITY

I, the undersigned, Mariana-Doina Cîineanu, a doctoral student at „Babeş-Bolyai University", hereby declare

- The doctoral dissertation titled *„Using Graphic Organizers to Develop Geographical Thinking"* was prepared in accordance with the principles of academic integrity, upholding honesty, responsibility, scientific accuracy, and the ethical framework specific to research. The sources consulted and used in this thesis are properly cited and referenced throughout the text, in accordance with academic standards.
- The similarity assessment was conducted within the „Didactics: Tradition, Development, Innovation" Doctoral School using a specialized tool for detecting similarities and verifying authenticity (Turnitin), and the results obtained fall within the parameters established by current academic standards.
- The thesis is written in accordance with the guidelines of the *APA Publication Manual* (7th edition), adhering to the specific requirements, with the exception of line spacing, which is set to 1.5.
- The published studies are relevant to the research topic and are referenced and cited throughout the thesis.

## LIST OF TABLES AND FIGURES

### Tables



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## LIST OF ABBREVIATIONS AND ACRONYMS

| | | |
|---|---|---|
| ANCOVA | — | Covariance analysis |
| APA | — | American Psychological Association |
| AS | — | Standard Deviation |
| *Z* | — | The value of the Z-statistic (standardized) |
| *d* | — | Effect Size (Cohen's *d*) |
| et al. | — | and others |
| GC | — | Control Group |
| GDPR | — | General Data Protection Regulation |
| $GE^1$ | — | Experimental Group 1 |
| $GE^2$ | — | Experimental Group 2 |
| *W* | — | The W statistic value of the Wilcoxon rank-sum test |
| I | — | Hypothesis |
| OG | — | Graphic Organizers |
| IA | — | Artificial Intelligence |
| *M* | — | Average |
| *M*_aj | — | Adjusted Average |
| *M* | — | Medium rank |
| *S* | — | Higher Rank |
| $\eta p^2$ | — | Partial Square Eta |
| *N* | — | Number |
| p. | — | Page |
| pp. | — | Pages |
| *r* | — | Correlation Coefficient (Guttman Split-Half) |
| *SE* | — | Standard Error |
| *t* | — | Independent-Samples t-test |
| *vs*. | — | Versus |
| $\alpha$ | — | Cronbach's Alpha (Internal Consistency/Reliability Coefficient) |

| | | |
|---|---|---|
| *Δ* | — | The Difference Between Two Measurements |
| *Df* | — | *Degrees of Freedom* |
| *F* | — | The *F*-test value |
| *P* | — | Probability Value (Significance Level) |
| *p-aj* | — | The adjusted p-value (for multiple comparisons) |

# CHAPTER I. THEORETICAL FRAMEWORK

## 1.1 Research Premises and Context

The development of students' geographical thinking through graphic organizers [GO] should be intensified in the current educational context, which is influenced by advances in the economy, technology, and information, as well as by the need to understand the complex problems facing humanity today, and by the paradigm shift in the approach to geographical knowledge, which is also evident in current official curriculum documents regarding the study of geography in high school (Ministry of National Education, 2025).

The study in this doctoral dissertation of the development of students' geographical thinking through GO in high school education is based on the observation that high school students tend to use the internet, multimedia sources, and Artificial Intelligence tools [AI] in an inappropriate manner, by ignoring certain aspects in the evaluation of visual materials (photographs and maps) and geographic information, in the critical evaluation of arguments, and in solving complex problems, which has negative effects on the formulation of answers, actions, the anticipation of consequences, and the making of correct decisions. Given that students' scientific literacy and digital literacy in the context of studying geography are achieved through the involvement of teachers, students, and parents, in this thesis we will analyze the perceptions of geography teachers and students regarding the use of GO in the development of geographical thinking and we will test the effects of graphic organizers on students' analytical spatial thinking, comparative thinking, systemic thinking, and explanatory thinking in the subject of „Geography".

## 1.2 Geographical Thinking and Graphic Organizers

### The Concept of Geographical Thinking

Bendl et al. (2024) identified three approaches to conceptualizing geographical thinking in geography education: explicitly linking geographical thinking to key geographical concepts; defining it from a procedural perspective, through higher-order thinking skills; combining the two approaches; and other approaches.

Based on the literature, Bendl et al. (2025) proposed a two-dimensional model of geographical thinking, with a structure in which they conceptualized geographical thinking as consisting of two inherently interconnected dimensions: one content-based, specific to the field of „geography," and the other procedural, more general („thinking") (Figure 1.1). Bendl et al.

(2024b) suggest that Geographical thinking also includes an affective dimension, but affective aspects are more difficult to operationalize.

*The content dimension* includes six key concepts for the field of geography: place, space, interconnectedness, environment, scale, and time (Bendl et al., 2025).

*The procedural dimension* includes seven types of thinking: spatial, relational, systems, critical, creative, prospective, and metacognitive. It is a simplified model for conceptualizing geographical thinking called a five-step inquiry process („asking geographical questions", „acquiring geographical information", „organizing geographical information", „analyzing geographical information" and „answering geographical questions") (Bendl et al., 2025, p. 5).

**Figure 1. 1**

*A Framework for Analyzing School Curricula Through the Lens of Geographical Thinking*

(Bendl et al., 2025, p. 5)


According to geographers, by following the stages of the investigation (Figure 1.1) and using meta-concepts, students should think geographically. To the seven types of thinking presented (Figure 1.1), we have added analytical thinking. The arrow in this model could represent the development of these types of thinking in a specific order, but in reality, they develop in an interconnected manner. As thought processes, however, it can be said that analytical thinking precedes the other types of thinking, and creative and prospective thinking precede critical thinking. To facilitate geographical thinking, there should be a balance between the content and procedural dimensions (Lambert, 2017; Bendl et al., 2024b).

## Graphic Organizers

Based on the literature, we consider that GO are: (1) visual cognitive tools used in the structuring of empirical and scientific knowledge, and are therefore also learning tools; (2) external visual and symbolic representations, created with the aid of language, through the process of representing information or knowledge and the relationships between them, in a simplified and abstracted form; (3) linguistic, abstract representations, composed of visual symbols, based on rules.

In creating visual representations, the following are used: visual symbols (Qi & Jiang, 2021); lines, circles, and boxes to form images, visually organize a hierarchy of information, compare and contrast information, represent cause and effect, and align information in a recurring or linear sequence (Ellis & Howard, 2007); lines, arrows, and spatial arrangement to describe the text's content, structure, and relationships between key concepts in a visual and spatial display (Kim et al., 2004).

Table 1.1 presents the classification of GO based on the nature of the represented relationships, construction, and formal structure. The first category includes logical-formal organizers, i.e., logical diagrams. The second category of GO includes quantitative-mathematical organizers, i.e., diagrams based on mathematical rules. The third category of GO includes conceptual organizers and semantic organizers that have a radial or semi-radial structure. The fourth category of GO includes relational and systems organizers. The fifth category of GO includes organizers for causal relationships. The sixth category of GO includes organizers for comparison. The seventh category of GO includes organizers for classification and ranking. The eighth category of GO includes sequential organizers. The ninth category of GO includes organizers for critical thinking and argumentation. The tenth category of GO includes organizers for reflection and metacognition.

**The table 1.1**

*Classification of OG based on the nature of the relationships represented, formal structure, and construction*

| Types of GO | Examples of GO |
|---|---|
| I. Logical-formal organizers (*diagrams*) | Venn diagram, Euler diagram, Peirce diagrams, Marquand square, Macfarlane spectrum |
| II.Quantitative/ Mathematical Organizers (*chart, graph*) | Column chart/graph; vertical bar chart/graph, bar chart/graph; horizontal bar chart/graph, histogram, frequency polygon, cumulative frequency polygon/graph; ogive, pie chart; pie graph, radar chart; radar graph, line chart, time series graph, doughnut chart; doughnut graph, combo graph |

| | |
|---|---|
| III. Conceptual/semantic organizers (*map*, *web*) | Concept map, semantic network, web, web graphic organizer, mind map, character map, spider map; spider map diagram; spider map technique, spider web; network concept, main idea web, big question map |
| IV. Facilitators for systemic and relational thinking | Systems map, interdependency chart, web, web diagram, topic map, network |
| V. Organizers for causal relationships | Cause-and-effect diagram, fishbone diagram, Ishikawa diagram, causal chain, causal diagram or causal map |
| VI. Organizers for comparison | T-Chart, double bubble maps, semantic feature analysis, syntactic/semantic features analysis, Comparison chart, matrix, similarity-difference chart |
| VII. Organizers for classification and ranking | Classification chart, tree diagram, hierarchy chart, hierarchical problem space tree diagram, the problem tree strategy |
| VIII. Sequential organizers | Flowchart, cycle diagram or cyclical graphic organizers, life cycle diagrams, timeline; timeline shape, sequence chart, process chart, storyboard, step-by-step chart |
| IX. Organizers for Critical Thinking and Argumentation | The matrix SWOT, claim-evidence chart, pros and cons chart, debate organizer, argument map, decision-making chart, conclusion chart |
| X. Organizers for reflection and metacognition | Chart Know – Want to know – Learned (KWL Chart), reflective diagram, self-Assessment charts/self-assessment documents, learning logs, reflective journal, metacognitive journal |

From the perspective of learning and the development of geographical thinking, the value of visual aids lies in the role they play as tools during the processing or construction of new information when certain learning strategies are applied. GO perform cognitive functions: structuring information, focusing attention, supporting comprehension and active learning, reducing cognitive load, facilitating memorization and retrieval of knowledge from long-term memory, and supporting metacognitive processes.

### 1.3 Theories Supporting the Use of Graphical Organizers in Learning

With regard to GO, we should consider three scenarios: processing information presented in GO from various sources created by others; processing information from various sources and creating GO either collaboratively with others or independently. In these scenarios, students primarily perceive verbal and visual information from physical sources and process it mentally.

The development of geographical thinking through the use of GO can be explained by various theories: cognitive theories that explain information processing (dual coding theory, working memory theory, cognitive load theory, the cognitive theory of multimedia learning, the schema theory and the theory of processing levels) and constructivist theories that explain information processing (social constructivism, cognitive scaffolding theory).

### 1.4 Domain Status

In general, the studies reviewed highlight the fact that the use and effectiveness of GO in pre-university education, specifically in the teaching of social studies and science, are influenced both by teachers' awareness of the role of GO in teaching and by the type of GO, with certain GO being considered important for learning. The results of the studies show that teachers who teach social studies and science use GO, however, the most effective GO are those created through collaboration between teachers and students, GO used for students with learning difficulties, concrete representations for student teachers, and abstract visual models for experienced teachers, as well as GO developed in stages with guidance from the teacher.

Research incorporating GO indicates improvements in students' understanding of scientific content, as well as the promotion of higher-order thinking and metacognition. Study results show that GO are effective in supporting students' cognitive processes by identifying learning problems and gaps in students' understanding and correcting misconceptions, by increasing students' concentration, transforming complex information into simpler information, and visually organizing knowledge. However, GO are not effective at indicating a student's level of knowledge about a subject or a section of text. In this context, the literature suggests that there are also some time-management-related disadvantages to using mind maps in the classroom, as they can be difficult to use in a short period of time.

### 1.5 Significance of the Research

The relevance of this research stems from the need to provide a theoretical and practical foundation for the use of GO in the development of geographical thinking in pre-university education.

Study 1 investigates the perceptions of geography teachers, thereby contributing to the existing literature at the middle and high school levels.

Studies 2–5 analyze, through an experimental design with pre- and post-tests, the effectiveness of certain GO on spatial analytical thinking, comparative thinking, systemic thinking, relational thinking, and explanatory thinking compared to other methods of organizing learning, such as individual observation of maps and photographs and reading texts, and the individual extraction of essential demographic data from tables and texts and their comparison.

The first study in the thesis is theoretically relevant because it contributes to the international literature in the field of educational sciences and helps fill a gap identified in the

Romanian-language literature regarding research on this topic. From a thematic perspective, Study 1 is relevant because it focuses on the subject of geography and on the middle and high school levels, thus offering a specific perspective on an aspect that has been less explored at the national and international levels, where research is oriented toward other subjects and other levels of education.

Studies 2–5 fill a gap in national and international research in the field of geography education at the middle and high school levels. The literature indicates that there are few experimental or quasi-experimental studies investigating the effect of using GO on students' geographical thinking.

Studies 2–5 have practical relevance for teachers, students, and researchers because they provide clear evidence of the impact of GO on students' immediate post-test performance and of the effects of forgetting on the stability of their knowledge, spatial analysis skills, and ability to compare, in the absence of spaced repetition exercises. Studies 2–5 are theoretically relevant because they provide a better understanding of the teaching strategies through which GO can be easily used and integrated into teaching, learning, and assessment activities in high school geography, with the aim of facilitating the efficient processing and storage of information in long-term memory.

Studies 2–5 are methodologically relevant because they employ a two-group experimental design in which the researcher strictly controls all research activities and variables.

Studies 2 and 5 are relevant due to the dual perspective of the research objectives: on the one hand, they compare students' results obtained using GO with those obtained without guidance through these GO, and on the other hand, they compare students' results obtained using GO to solve tasks involving spatial analysis of geographic location based on maps and photographs and spatial analysis of terrain based on maps and photographs, or they analyze students' ability to extract essential demographic data from tables and texts and to compare them based on the analysis and selection of demographic data from data tables, on the other hand.

By comparing students' results from these two perspectives, the studies provide a deep understanding of how students select and organize relevant information using GO.

# CHAPTER II. RESEARCH OBJECTIVES AND GENERAL METHODOLOGY

## 2.1 Research Objectives

### 2.1.1 General Objectives

In this thesis, we aim to investigate the effects of using certain teaching materials on the geographical thinking of high school students in Romania, from theoretical, methodological, and practical perspectives.

### 2.1.2. Specific Objectives

The general objectives of the research are addressed in the five studies of the thesis: Study 1 analyzes and interprets geography teachers' perceptions of GO, while Studies 2, 3, 4, and 5 measure, first, the effect of completing GO on students' analytical spatial thinking, comparative thinking, the level of development of their ability to explain geographical processes, and systemic thinking; and, second, the students' perceptions regarding the GO, learning strategies, and the enjoyment they derive from completing the GO are analyzed.

## 2.2 General Methodology

The thesis comprises five studies: one quantitative study conducted via a questionnaire-based survey and four quasi-experimental studies. All five studies strictly adhere to the requirements of scientific research methodology specific to the field of educational sciences, as well as to standards regarding legality, ethics, and data protection. All necessary conditions for the proper conduct of the studies and for achieving all research objectives have been met.

# CHAPTER III

# ORIGINAL RESEARCH PAPERS

## 3.1. Study 1: Experience, Use, Typology, and Utility of GO in the Teaching Practice of Geography Teachers

### 3.1.1. Introduction

From the perspective of the development of geographical thinking, an analysis of previous studies shows that, overall, teachers are aware of the role that visual aids play in students' acquisition of knowledge, in facilitating their understanding of content, in addressing complex concepts, in the visual organization of knowledge and in organizing students' thoughts, in guiding students' reasoning and thinking, in developing their skills and thinking, in facilitating the development of higher-order thinking, metacognition, and the improvement of critical thinking.

The purpose of this study is to explore geography teachers' experiences in the development of the GO, the strategies based on the GO that they use, the frequency of using some GO, the importance of using GO in teaching and what differences exist among teachers based on their generation, teaching rank, and the level of education at which they work.

*The research questions* are as follows:

1. In what contexts have geography teachers gained experience in developing GO?

2. How frequently do geography teachers use GO-based strategies?

3. How frequently do geography teachers use various types of GO?

4. What is the perception of geography teachers regarding the importance of using GO in teaching?

5. What differences exist among geography teachers based on age regarding GO?

6. What differences exist among geography teachers based on teaching rank regarding GO?

7. What differences exist among geography teachers based on educational level regarding GO?

### 3.1.2 Method

#### *Participants*

To participate in this study, participants were selected based on two criteria: being a geography teacher; and teaching geography in the pre-university education system. A total of 115 geography teachers participated in this study, representing a diverse range of characteristics regarding gender, age, education, teaching experience, teaching certification, the location of the school, the educational level at which they teach, and the county.

#### *Data Collection*

Data collection took place between February 16, 2026, and March 9, 2026, using a questionnaire. Geography teachers participated voluntarily in this survey, having been invited to take part in the research through an unconventional method known as the „snowball sampling" technique. The study ensures data protection in accordance with the provisions of the GDPR (2016) and complies with the requirements of educational research methodology, research ethics, and applicable legislation.

#### *Instrument*

The questionnaire was designed by the researcher based on her own teaching experience

and information about GO found in the literature. The instrument was reviewed by two experts in geography and an expert in geography education and was statistically validated.

The questionnaire contains four sections with items related to teaching guides: Section 1, „Previous experience in developing teaching guides" with 19 items; Section 2, „Current use of teaching guides", with 12 items; Section 3, „Types of teaching guides used", with 8 items; Section 4, „The usefulness of developing the curriculum" with 15 items. Each item in these sections is associated with a Likert scale, and geography teachers are asked to assign a score of 1–5 based on their own beliefs, activities, and teaching experience. At the end of the questionnaire, data is collected about the geography teachers: gender, age, education, teaching experience, teaching rank, the region where the institution is located, the level of education at which the teachers teach, and the county.

***Data Analysis***

The internal consistency of the questionnaire was assessed using Cronbach's alpha and the split-half method, employing Spearman–Brown and Guttman coefficients. The analysis of the questionnaire's reliability was supplemented by examining item-total correlations and the Cronbach's alpha if item deleted statistic.

### 3.1.3 Results and Discussion

***Preliminary Results – at the Level of the Instrument Used.*** The very high values of Cronbach's Alpha ($\alpha = 0.999$), as well as the Spearman-Brown ($r = 0.988$) and Guttman Split-Half ($r = 0.987$) coefficients demonstrate excellent internal consistency and reliability for the entire instrument, confirming that the items are homogeneous and appropriately formulated for the targeted theoretical construct - the experience, use, typology, and utility of GO in the teaching practice of geography teachers.

***Main Results and Discussions Among the Entire Group of Geography Teachers***

The mean scores (ranging from 2.81 to 3.90) indicate a moderate to high level of teachers' experience in developing teaching guides, with self-directed learning using digital resources available online being the most important ($M = 3.90$), followed by independent study using books ($M = 3.79$) and digital applications ($M = 3.65$), with most teachers gaining experience through the development of GO at the middle school level ($M = 3.77$) and at the high school level ($M = 3.54$).

Geography teachers use GO in their teaching practice from online sources ($M$ = 3.66) and from print sources ($M$ = 3.63), as tools for presenting and explaining content during class, created by themselves ($M$ = 4.07), and displayed on screen during class ($M$ = 3.99). Geography teachers most highly value linear-type GO ($M$ = 3.97), structured-list-of-ideas-type GO ($M$ = 3.93), and cluster-type GO ($M$ = 3.88). In the teaching-learning process, geography teachers use GO primarily to represent classifications and hierarchies ($M$ = 4.51), to synthesize information or data ($M$ = 4.49), and to review acquired knowledge ($M$ = 4.48).

***Main Results by Age of Geography Teachers and Discussion***

The experience of developing GO in middle and high schools reveals average frequencies and clear differences between generations of teachers, with the frequency of GO use increasing with age and professional experience. The highest values are reported by teachers from the Baby Boomer generation, who use most types of GO, particularly tree-type ($M$ = 5.00), cluster, and linear organizers ($M$ = 4.80). Generation Z teachers use linear GO ($M$ = 4.00) and structured lists of ideas (M = 3.86), while Millennial and Generation X teachers use structured lists of ideas ($M$ = 3.96 vs. 3.90) and tree-type GO ($M$ = 3.81 vs. 3.77). Generation Z teachers use GO to synthesize information, memorize more easily, represent classifications and hierarchies ($M$ = 4.43), the stages of a process, phenomenon, or event, and the components and relationships within or between geographic systems, as well as to review acquired knowledge ($M$ = 4.29). Teachers from the Millennial and Generation X cohorts (M ≈ 4.0–4.6) use GO for the visual organization of information, the representation of knowledge structures, and the synthesis of data. Teachers from the Baby Boomer generation give very high scores for nearly all items ($M$ ≈ 4.6–5.0).

***Main Results by Teaching Experience of Geography Teachers and Discussion***

Teachers in the four categories believe they gained experience in developing GO through independent study using books and online sources ($M$ = 4.33); teachers without a teaching degree gained experience through study during college and by observing how others used GO ($M$ = 3.67); teachers with permanent tenure, through study in middle school ($M$ = 4.10) and high school ($M$ = 3.80), either as students or as teachers in the early years of their careers. Teachers with Teaching Degree II consider that they have diverse experience in developing GO, while teachers with Teaching Degree I indicate a well-established experience acquired both through teaching practice and through professional development or online educational resources.

Teachers without a teaching degree use GO in their own teaching activities ($M$ =3.67) and observe GO made autonomously by students, at home or in class ($M$ =3.67), especially structured lists of ideas ($M$ =4.00) and linear organizers ($M$ =3.67). Teachers with a permanent degree frequently display GO of various types on the screen or perform them, demonstratively, on the board or together with students ($M \approx 3.70–3.80$). They involve students less in the autonomous realization of GO or in cooperative activities ($M \approx 2.20–2.60$).

Teachers without a teaching degree and teachers with a permanent degree seem to be aware of the role of GO as an efficient teaching tool for facilitating students' cognitive processes. Teachers with a teaching degree II use GO moderately compared to other teacher categories ($M \approx 2.22–3.67$), in particular, structured lists of ideas, linear organizers ($M$ = 3.67) and tree organizers ($M$ = 3.56). Teachers with a teaching degree I did not develop GO during their university studies or together with other people. Teachers with didactic degree I use GO made by themselves ($M$ =4.19), display GO during explanations ($M$ =4.12), especially, cluster type ($M$ =4.02), structured lists of ideas ($M$ =3.98). Teachers with didactic degree I use GO the most, in representing classifications and hierarchies and in organizing and synthesizing information.

***Main Results According to the Level of Education at which Geography Teachers Teach and Discussions***

Teachers teaching at the middle school level have more experience in developing GO ($M$ = 4.02), actively integrate GO for most learning activities and use cluster organizers ($M$ = 4.02) and structured lists of ideas ($M$ = 4.02). Teachers teaching at the high school level have much less experience ($M$ = 2.50) and use their own GO ($M$ = 4.00), display them in the lesson ($M$ = 3.89) involving students in developing GO, especially in autonomous individual activities, carried out at home or in class, and use linear ($M$ = 4.13), cluster ($M$ = 3.95) and tree GO ($M$ = 3.89). Teachers teaching at the middle school and high school level have more diverse teaching experience in developing GO ($M$ = 4.14 at the middle school level and $M$ = 4.20 at the high school level).

In general, GO are appreciated, especially for information synthesis ($M$ = 4.50), representation of classifications and hierarchies ($M$ = 4.45), recapitulation ($M$ = 4.39) and organization of complex contents (geographic systems) ($M$ = 4.34).

### 3.1.4 Conclusions

The experience gained by geography teachers is reflected in the current use of GO in teaching. The current use of GO is more frequent and diversified among teachers with more experience and higher teaching degrees, while young teachers and those in the initial stages of their careers use GO in a more limited or less varied manner in a phase of consolidating teaching strategies.

The diversity of the types of GO used increases with professional experience, with more experienced teachers using a wider range of graphic structures, while younger teachers tend to use simpler forms of information organization more frequently. There are consistent relationships between geography teachers' experience in developing GO, the perception of the usefulness of GO in the teaching-learning process, and teaching.

#### *Research Limitations*

The research limitations are related to the number of geography teachers surveyed, the high proportion of female respondents and the urban environment, the uneven distribution of respondents across counties, the lack of data analysis based on geography teachers' characteristics, the subjective nature of the responses and the wording of the items, but the excellent internal consistency of the instrument ($\alpha = 0.999$; $r = 0.987$) confirms the stability and coherence of the measurement of the targeted construct.

#### *Research Directions*

In future research, this original questionnaire could be applied to other educational disciplines, at the level of primary school teachers in Romania, teachers from other countries, through the balanced involvement of several geography teachers, the teaching strategies through which students are actively involved in the development of GO could be explored and the role of digital applications in their creation and use in the teaching-learning process could be analyzed.

## 3.2 Effects of Tree-Type OG on Students' Spatial Analytical Thinking

### 3.2.1 Introduction

In the development of geographical thinking, spatial thinking is very important, which involves the knowledge and use of spatial concepts, the understanding and use of spatial representations in solving problems, reasoning in conceptualization, the ability to observe, visualize and interpret data about space, to encode and store them in memory. Spatial thinking is based on analytical thinking, which represents the person's ability to deconstruct the parts of a

problem, based on information that clarifies things and to formulate logical conclusions and to plan before making a decision. In organizing optimal educational contexts for studying geography, analysis is described as a competence, the competence to analyze being associated with spatial thinking. Studies have found that students have difficulties when answering questions that correspond to analytical thinking objectives, are poorly prepared to deal with complex information structures, and their levels of argumentation and analytical thinking skills are low.

***Purpose, Variables, Assumptions***

The primary purpose of this research is to investigate the effects of the efficiency of using tree-type OG on students' analytical spatial thinking in the subject „Geography" and compare it with the effects of observing maps and photographs and reading texts.

The research hypotheses are the following:

**$I^1$**– Students who complete pre-structured tree-type GO based on maps and photographs will obtain significantly higher scores on the post-test compared to the pre-test, which indicates the development of spatial analysis competence.

**$I^2$**– Students who observe maps and photographs and read a text will obtain significantly higher scores on the post-test compared to the pre-test, which indicates the development of spatial analysis competence.

**$I^3$**– Students who complete pre-structured tree-type GO based on maps and photographs will obtain significantly higher scores on the re-test compared to the pre-test and post-test, which indicates the development of spatial analysis competence.

**$I^4$**– Students who observe maps and photographs and read a text will obtain significantly higher scores on the re-test compared to the pre-test and post-test, which indicates the development of spatial analysis competence.

**$I^5$** – Students who complete pre-structured tree-type GO based on maps and photographs will obtain significantly higher scores on the post-test compared to the pre-test than students who observe maps and photographs.

**$I^6$**– Students who complete pre-structured tree-type GO based on maps and photographs will obtain significantly higher scores on the re-test compared to the pre-test and post-test, than students who observe maps and photographs.

**$I^7$**– Completing pre-structured tree-type GO, based on maps, about geographical position

determines higher performances than completing tree-type GO based on photographs about relief.

The second aim of the research is to investigate students' perceptions regarding the application of of rules and the use of landmarks in the processing of verbal and visual information, about the efficiency of strategies for analyzing and memorizing information, the usefulness of tree-type GO and the level of satisfaction and enjoyment of students for the activity of analyzing texts, photographs, texts and developing GO. The research questions are:

**IC[1]** – What rules do students follow when analyzing and presenting the geographical position of a locality? (items 1-3)

**IC[2]**– What landmarks do students use when analyzing and presenting the coastal relief? (items 4-6)

**IC[3]**– What is the students' perception of the efficiency of strategies for analyzing and memorizing information extracted from visual and verbal materials? (items 10-13)

**IC[4]**– What are the perceptions of students in GE[1] regarding the usefulness of tree-type OGs? (item 14)

**IC[5]**– What is the level of satisfaction and enjoyment of students for the activity of analyzing texts, photographs, texts and developing GO? (item 15)

### 3.2.2 Method

***Participants***

This research was attended by 107 ninth-grade students from the "Nicolae Bălcescu" National College in the city of Brăila, Brăila County, in the 2025-2026 school year, in September-October.

***Procedure***

The quasi-experimental research has a pre-test – intervention – post-test – re-test design and two groups. A week after the re-test, a questionnaire was administered to both groups. The research complied with the requirements and ethics of research, as well as the protection of the participants' personal data according to GDPR.

***Instruments***

The research data collection was carried out through 3 tests, of our own design: a pre-test, a post-test, a re-test and a questionnaire. *The pre-test, post-test* and *re-test* included 4 subjective items, with open answers. *The questionnaire* included 15 items: seven dual and multiple choice

items with 2-4 constructed answers (items 1-7); five Likert scale items (8-15). Item 14 was applied only to $GE^1$.

***Data Analysis***

**Preliminary Analyses.** The data obtained from the pre-test, post-test and re-test were statistically analyzed using Excel and SPSS programs, the *Kolmogorov-Smirnov* test and the *t*-test.

**Main Analyses – Hypothesis Testing.** For each group, the dependent samples *t*-test, *t* (53), p, Cohen's *d, d*, dependent samples t-test on thematic subcomponents, mean, standard deviation and independent samples *t*-test were applied for each item category separately.

**3.2.3 Results**

***Preliminary Results***

At the pre-test, $GE^1$ ($M = 3.77$) has a slightly higher mean than $GE^2$ ($M = 3.32$). At the post-test, $GE^1$ ($M = 5.25$) has a higher mean than $GE^2$ ($M = 3.57$). At the re-test, $GE^1$ ($M = 2.82$) has a higher mean than $GE^2$ ($M = 2.07$). The results of the independent samples *t*-test show that at the pre-test there is no statistically significant difference between the mean scores of the two groups ($p = 0.241 > 0.05$). The effect size (Cohen's $d = 0.23$) indicates a very small difference and supports the claim that the initial level of the two groups is comparable.

***Main Results – Hypothesis Testing***

The results show that students who completed the tree-type GO based on maps and photographs obtained significantly higher scores on the post-test compared to the pre-test, which indicates the development of spatial analysis competence. The results show that students who observed maps and photographs and read a text did not obtain significantly higher scores on the post-test compared to the pre-test and also did not obtain significantly higher scores on the re-test compared to the pre-test and post-test, which does not indicate the development of spatial analysis competence.

Students who completed the tree-type GO based on maps and photographs obtained significantly higher scores on the post-test and re-test compared to the pre-test than students who observed maps and photographs. At pre-test, post-test and re-test, students in $GE^2$ achieved significantly better results on map-based items compared to relief-based items, which confirms the general trend of achieving better performance on spatial identification tasks ($p < .001$) (d = 0.98 at post-test; $d = 1.04$ at re-test). At pre-test, the difference between performance on map and

photo items was significantly greater in $GE^1$than in $GE^2$ ($p = 0.037$, $d = 0.41$). At post-test and re-test, the difference between performance on map and photo items is statistically insignificant ($p = 0.745$, $d = 0.06$; $p = 0.282$, $d = 0.21$).

***Main Results at the Research Question Level***

The results show that students in $GE^1$ score higher than students in $GE^2$ when solving the items: they start presenting the neighbors to the north (probably as a result of completing pre-structured OGs), analyze the coastal relief from the photographs and from its presentation in the text, estimate the altitude, the slope of the relief in relation to sea level, identify: the cliff, the beach, the bays and the piers based on the images in their minds, the type of relief due to previous observations of this type of relief in photographs or in reality.

For students in $GE^1$, the most effective strategies for memorizing the relief characteristics of a territory are reading a text and observing the map ($M = 3.92$), listening to the teacher's explanation and observing what it shows in the photo ($M = 3.86$), and students in $GE^2$ consider that they memorize more effectively by listening to the teacher's explanation and observing what it shows in the photos ($M = 3.77$) and listening to the teacher's explanation and observing what it shows on the map ($M = 3.75$). Students in $GE^1$considered that the tree-type GO were moderately useful ($M_{min} = 3.08$; $M_{max} = 3.45$) in understanding the geographical approach to the subject ($M = 3.45$) and for synthesizing data ($M = 3.41$). Students in both groups rated all activities at a medium level of satisfaction and enjoyment ($M_{min} = 2.81$; $M_{max} = 4.16$). Students in $GE^1$ enjoyed completing tree-type GO the most ($M = 4.16$), extracting data from texts ($M = 4.06$). Students in $GE^2$ enjoyed extracting data from maps the most ($M = 3.47$) and analyzing maps ($M = 3.43$).

**3.2.4 Discussions and Conclusions**

***Discussions about Progress Within Each Group (Evolution Over Time)***

At the pre-test, the analysis of the means of the two groups shows that the students solved the items at the incompetent level of spatial analysis competence ($GE^1$: $M = 3.77$; $GE^2$: $M = 3.32$). The standard deviation ($GE^1$: $AS = 1.83$; $GE^2$: $AS = 2.05$) shows that, in both groups, some students solved the tasks at the lower level of spatial analysis competence. At the post-test, the analysis of the means of the students in the two groups shows that the level of spatial analysis competence of the students in $GE^1$ increased to the lower level of spatial analysis competence ($GE^1$: $M = 5.25$), but $GE^2$: solved the tasks at the incompetent level ($GE^2$: $M = 3.57$). The standard deviation ($GE^1$: $AS = 2.10$; $GE^2$: $AS = 2.01$) shows that some students in $GE^1$ solved

them according to the average level of spatial analysis competence. The texts written by students in GE included more assertions about geographical position and relief than the texts written by students in $GE^2$.

From the analysis of the *content dimension* of geographical thinking used in these activities, it is found that students use background concepts that refer to the substance of geography and meta-concepts or key concepts implicitly. From the analysis of the *procedural dimension* of geographical thinking, it is found that students in $GE^1$are located in the context of a research or investigation process because they go through the five key stages listed by Bendl et al. (2025). Students in $GE^2$ go through the same stages, except for organizing geographical information in GO. In these activities, students are asked to think geographically, which implies mastering geographical concepts and cognitive operations used in exploring topics, thus correlating the content dimension with the procedural one.

Students in both groups did not obtain significantly higher scores on the re-test compared to the pre-test and post-test. $GE^1$ maintained its level of spatial analysis competence better, so GO had a more consistent effect. The results obtained by students in $GE^1$ and $GE^2$on all tests show that visual-spatial information is easier to analyze and recognize on the map or interpret than that about relief in photographs.

***Discussions Regarding Research Questions***

Regarding the determination of the geographical position of localities based on maps, students in $GE^1$ prove to know the rules better than those in $GE^2$, so this result can be attributed both to prior knowledge and to the use of GO. The students' responses regarding the analysis of relief in photographs and the identification of cliffs, beaches, bays and piers show that many students have problems identifying their own cognitive processes, so they require their involvement in activities aimed at developing metacognitive thinking. Regarding the analysis of relief in a photograph, students consider it useful to previously observe it in photographs, then in reality and less in drawings in school textbooks. Regarding the identification of the shore in photographs, students use the concepts and their association with images as a result of learning in school contexts.

Regarding the effectiveness of strategies for analyzing information from visual and verbal materials, students are aware that they need direct support from a teacher to decode what is represented on maps or in photographs or indirect scaffolding, provided through a written text.

Observing or developing GO does not provide students with all the support they need to understand what is represented on maps or in photographs. Regarding the effectiveness of strategies for memorizing information, the results suggest that students do not yet perceive observing or developing GO as strategies that facilitate understanding and memorization, probably because they need more learning experiences in which to use GO.

***General Conclusions***

The results show that students who completed pre-structured tree-type GO, observed maps, photographs, and read a text have a higher level of spatial competence than those who observed maps, photographs, and read a text. Pre-structured GO represented a useful cognitive scaffold for selecting essential information from maps, photographs, and texts, in learning spatial analysis procedures, and in information retention. Pre-structured tree-type GO had a clear positive effect on immediate learning, but for students to develop their spatial analysis competence and think analytically, they should perform more exercises in locating on the map, and more exercises in analyzing relief in photographs.

***Research Limitations***

The results show that students who completed pre-structured tree-type GO, observed maps, photographs and read a text have a higher level of spatial competence than those who observed maps, photographs and read a text. Pre-structured GO represented a useful cognitive scaffold for selecting essential information from maps, photographs and texts, in learning spatial analysis procedures and in information retention. Pre-structured tree-type GO had a clear positive effect on immediate learning, but for students to develop their spatial analysis competence and think analytically they should perform more exercises in locating on the map, and more exercises in analyzing relief in photographs.

***Research Limitations***

The research presents some limitations regarding the stability of the level of spatial analysis competence over time, the relevance of the chosen topic for students, the lack of a text in which students could find information that could be extracted from maps and photographs, in the context in which they prefer reading as a learning strategy, the opportunity for students to fully, autonomously, develop the GO and the study was conducted on a sample from a single school.

***Research Directions***

Aims to verify the potential of pre-structured tree-type GO and their effect on spatial analytical thinking, to test the efficiency of this learning strategy, in several learning activities, within a longer formative intervention and to expand interpretations at the national level by involving more middle and high school students, from urban and rural areas, from different localities.

## 3.3 Study 3: The Effects of Using Venn Diagrams on Students' Comparative Thinking

### 3.3.1 Introduction

Comparison is a primary operation of thought, which represents a means or premise for other operations of thought, as well as an elementary logical structure of thought, through which the essential similarities and differences between objects and phenomena are established at a mental level, based on some criteria (Zlate, 1999). Comparison has a specificity that depends on the structure and particularities of the material intended for comparison, on the similarities, differences and the appearance of the properties of objects or phenomena (Zlate, 1999). Researchers propose various strategies to involve students in the use of comparison.

The Venn diagram is considered a simple and easy-to-use, flexible, analytical and creative visual tool that helps students identify the components and explore the relationships between the interested parties. The Venn diagram is a very useful logical-formal organizer for the development of geographical thinking because it helps students to logically structure information (similarities and differences) and shows the relationships between two objects or concepts. Having an inferential function, the Venn diagram helps students formulate conclusions based on identified relationships and organized information. The literature analysis shows little interest from teachers and researchers in using the Venn diagram in the geographical education system (Cîineanu et al., 2020), in developing comparative geographical thinking through this GO, and the existence of a small number of works addressing this topic.

***Purpose, Variables, Assumptions***

The primary purpose of this research is to investigate the effects of using the Venn diagram on students' comparative thinking in the subject „Geography” and compare it with the effects of observing maps, photographs and reading texts. The independent variable in this study is the learning method. The independent variable has two levels: completing the Venn diagram;

observing maps, photographs and reading texts. The dependent variable is the volume of students' inferences, operationalized by the number of correct assertions about geographical position and relief, made based on maps, photographs and texts, measured at pre-test, post-test and re-test. The control variables are represented by the pre-test (initial level of inferences), the actual activity time and the students' previous experience in using the Venn diagram.

The research hypotheses are as follows:

**$I^1$** – Students who use the Venn diagram to compare information extracted from maps, photographs, and texts will obtain significantly higher scores on the post-test than on the pre-test, which indicates the development of the ability to compare geographical features.

**$I^2$** – Students who observe maps, photographs, and read texts will obtain significantly higher scores on the post-test than on the pre-test, which indicates the development of the ability to compare geographical features.

**$I^3$** – Students who use the Venn diagram to compare information extracted from maps, photographs, and texts will obtain significantly higher scores on the post-test than on the pre-test than on the students who observe maps, photographs, and read texts.

**$I^4$** – Students who use the Venn diagram to compare information extracted from maps, photographs, and texts will obtain significantly higher scores on the re-test than on the pre-test and post-test than on the students who observe maps and photographs.

**$I^5$**– Students will achieve higher scores when comparing the geographical position of two localities based on maps than when comparing the relief based on photographs, when reading texts and completing the Venn diagram.

The second aim of the research is to investigate students' perceptions regarding the observance of rules and the use of landmarks when comparing and presenting the geographical position and relief of two localities, the efficiency of strategies for comparing the geographical position and relief of two localities, the usefulness of the Venn diagram, and the level of satisfaction and enjoyment of students for the Venn diagram completion activity. To achieve the second aim of the research, six research questions were formulated:

**$IC^1$** – What rules (criteria) do students observe when comparing and presenting the geographical position and relief of two localities? (items 1-2)

**$IC^2$**– What landmarks (criteria) do students have when comparing and presenting the geographical position and relief of two localities? (items 3-4)

**IC$^{3}$**– What is the students' perception of the efficiency of strategies for comparing two localities based on information extracted from visual and verbal materials? (items 5-6)

**IC$^{4}$**– What are the perceptions of students in GE1 regarding the usefulness of the Venn diagram? (item 7)

**IC$^{5}$**– What is the level of satisfaction and enjoyment of the students for the activity of completing the Venn diagram? (item 8)

**IC$^{6}$**– What are the specific aspects and common aspects of the geographical position and relief of the resorts of Mamaia and Eforie Sud, completed by the students from GE1 ($N$ = 54) in the Venn diagram?

### 3.3.2 Method

#### *Participants*

The study involved 107 students from four ninth-grade classes, with an average age of 15 years, of both genders, from the „Nicolae Bălcescu” National College in the city of Brăila, Brăila County, in the 2025-2026 school year, in September-October, divided into two experimental groups (GE$^{1}$, $N$ = 54; GE$^{2}$, $N$ = 53), based on the results of the initial test and compliance with ethical provisions (GDPR, 2016).

#### *Procedure*

The quasi-experimental research has a pre-test - intervention - post-test - re-test design, questionnaire with two groups. In the four classes, four stages were completed with the students in different weeks, lasting 80 minutes.

In the pre-test, students analyzed two maps and then two photographs, and wrote a short text about the similarities and differences of the geographical positions and relief of the resorts of Mamaia and Eforie Sud. During the formative intervention, students in GE$^{1}$ received a worksheet and, based on the texts, maps and photographs used in the pre-test, completed two Venn diagrams with the similarities and differences of the geographical positions and relief of the resorts of Mamaia and Eforie Sud. Students in GE$^{2}$ analyzed the same maps, photographs, read the same texts about the geographical position and relief of the resorts of Mamaia and Eforie Sud and remembered their characteristics.

At the post-test, students from both groups presented in writing the similarities and differences between the geographical position and the relief of the two resorts, but without access to visual materials. At the re-test, students received tasks similar to those from the pre-

test, but related to other resorts.

***Instruments***

The collection of research data was carried out through three tests, of their own design: a pre-test, a post-test and a re-test, the maximum score being 10 points, and a questionnaire.

***Data Analysis***

**Preliminary Analyses**. The data obtained at pre-test, post-test and re-test were statistically analyzed using Excel and SPSS programs. The *Kolmogorov-Smirnov* test tested the normality of the distribution of the results collected from each group. The *t*-test for independent samples on the pre-test scores verified whether the groups were comparable before the intervention.

**Main Analyses – Hypothesis Testing**. To verify the evolution of the results over time and whether $GE^1$ progressed significantly between the test moments, the Wilcoxon signed-rank test and the *t*-test for dependent samples, *t* (53), *p*, Cohen's *d*, were applied for pairwise comparisons. The Friedman test was applied for the analysis of the global progress.

To verify whether, in the same group ($GE^1$or $GE^2$), students had significantly higher scores on geographical position items than on relief items, separately in each group, the *t*-test for dependent samples was applied on thematic subcomponents, the mean, standard deviation, *t*, *p* and Cohen's *d* were calculated. To compare the progress between groups between pre-test and post-test, between post-test and re-test, between re-test and pre-test and to verify whether the differences between $GE^1$and $GE^2$ are maintained for each category of items separately, the *t*-test for independent samples was applied.

**3.3.3 Results**

***Preliminary Results***

At the pre-test there is no statistically significant difference between the mean scores of the two groups ($p = 0.81 > 0.05$), therefore, the groups are equivalent in terms of initial level of inferences. At the pre-test, the mean scores are close between the groups ($GE^1$: $M = 2.33$; $GE^2$: $M = 2.26$), suggesting that the initial level of performance was comparable. At the post-test, $GE^1$ ($M = 2.45$) has a higher mean than $GE^2$ ($M = 2.06$). At the re-test, $GE^1$ (M = 2.47) has a higher mean than $GE^2$ (M = 1.86).

***Main Results – Hypothesis Testing***

The statistical analysis does not confirm **$I^1$** and **$I^2$** showing that both students who completed the Venn diagram based on maps and photographs and students who observed maps, photographs and read the text did not obtain significantly higher scores on the post-test compared to the pre-test, so their ability to compare did not improve. The results do not confirm **$I^3$** showing that students who completed the Venn diagram based on maps, photographs and texts did not obtain significantly higher scores on the post-test compared to the pre-test, so their ability to compare did not improve, than students who observed the maps, photographs and read the texts. Regarding the progress between the re-test and the post-test (**$I^4$**), the results show that the level of performance remained relatively constant in both groups, with no significant differences between them. The results confirm **$I^5$** by showing that students obtained higher scores when comparing the geographical position of two localities based on maps than when comparing the relief based on photographs, when completing the Venn diagram and reading texts.

Students in $GE^1$ state that they can most easily compare the geographical position of two localities by reading a text and observing a map or more maps ($M$ = 3.76) and by reading a text ($M$ = 3.71). Students in $GE^2$ state that they can most easily compare the geographical position of two localities by reading a text and observing a map or more maps ($M$ = 3.70) and by observing a map or more maps ($M$ = 3.45). The most effective strategies for comparing the relief of two localities are reading a text and observing a photo or more photos ($GE^1$: $M$ = 3.86; $GE^2$: $M$ = 3.55) and reading a text and observing a map or more maps ($GE^1$: $M$ = 3.76; $GE^2$: M = 3.60). Students in $GE^1$found Venn diagrams to be moderately useful ($M_{min}$ = 3.08; $M_{max}$ = 3.57) in all information processing activities: identifying specific aspects of each compared element ($M$ = 3.57), comparing information to other subjects ($M$ = 3.57), identifying common aspects of the compared elements ($M$ = 3.49). Students in $GE^1$ enjoyed completing the Venn diagram on average ($M$ = 3.98), less than completing the tree-type GO ($M$ = 4.16).

Regarding geographical position, most students identified a small or moderate number of features. Regarding relief, the results show that students were able to identify more frequently 1–2 features for each analyzed category and rarely identified a larger number of aspects.

**3.3.4 Discussions and Conclusions**

The pre-test results show that students had difficulties in identifying the specific aspects and the common aspects of the geographical position and the relief of the two resorts,

suggesting, on the one hand, that students did not identify all the information necessary to make the comparisons and, on the other hand, that they did not apply a systematic comparison procedure based on criteria.

Students in GE[1] compared the geographical position of the two localities based on criteria and filled in the diagram first the criterion, then the characteristic, they received the standard that they had to respect in the comparison for restructuring the information previously included in the pre-structured tree-type GO. Regarding the comparison of the relief of the two resorts, students did not receive criteria, but could identify or deduce them from pre-structured tree-type GO. The analysis of the Venn diagrams completed by students in GE[1] shows that students did not include in the diagrams the criteria on which they made the comparisons, but used a logical comparison procedure; that most students identified one or two aspects for similarities and differences between the two resorts, suggesting an average level of capacity and ability for comparative analysis and difficulties in developing more complex or detailed comparisons.

The results show that students identified more easily the aspects specific to the geographical position and relief of each resort than the common aspects, in the case of relief a relatively large proportion of students did not identify any common characteristics. Students in GE[1] enjoyed completing the Venn diagram less ($M$ = 3.98) than completing the tree-type GO ($M$ = 4.16), perceiving the task as more difficult and needing support from the teacher.

The results show that students are novices in extracting information about the geographical position of the resorts from the available maps and identifying the relief features in the photographs, that they do not perceive the learning task as relevant to them and do not make an effort to memorize the information.

Overall, the results suggest that the use of the Venn diagram allowed students to structure the information and identify some similarities and differences between the geographical positions and relief of the two resorts, but the relatively low level of the number of aspects identified indicates the need for additional teaching activities that support the development of comparative thinking and the ability to analyze geographical information.

***Pedagogical Implications***

Students need specific training to make the transfer between different forms of geographical representation. In order for students to be able to use Venn diagrams effectively in making comparisons, several conditions need to be met: novice students should observe

completed diagrams, learn explicitly the procedure to apply, and complete diagrams together with the expert teacher.

***Research Limitations***

The selection of a small number of participants and their origin from the same high school, the small number of content elements studied and of GO developed by students, the short duration of the formative intervention, the lack of a completion model, the content studied and the materials used in solving the problem situation, can be interpreted as limits, although they contributed to the uniformity of conditions and the control of knowledge.

***Research Directions***

In future research, these GO could be used in more learning activities, within a formative intervention with a longer duration, the effect of presenting Venn diagrams by the teacher could be compared with the effect of Venn diagrams made autonomously by students, more students from middle school and high school, from urban and rural areas, from different localities could be involved, in order to extend the interpretations at the national level.

## 3.4. Study 4: The Effects of Using Pre-Structured Tree-Type GO on Students' Systems Thinking, Relational Thinking, and Explanatory Thinking

### 3.4.1 Introduction

Students' understanding and explanation of geographical phenomena is approached as a problem-solving activity. Systems thinking is the result of a problem-solving process, it means identifying and understanding the different components of a system and the relationships between them. Geographic relational thinking means explaining and predicting the relationships that cause change. Favier & van der Schee (2014b) suggest expressing knowledge about geographical relationships in standard formats (e.g., applying rules, making generalizations). One such standard format to facilitate understanding of the occurrence of geographical processes could be pre-structured GO.

Studies conducted worldwide show the difficulties of students in understanding natural processes (Fuller et. al., 2000; Ulfa et al., 2024) and support the importance of developing systems thinking (Hmelo-Silver et al., 2007; Hmelo-Silver & Pfeffer, 2004), as well as knowledge of human-environment systems and their causal interrelationships in geography lessons (Heuzeroth & Budke, 2020). Pre-structured GO could be an effective learning strategy in understanding geographical processes and in developing systems thinking, as a higher-order

thinking skill (Frank, 2000).

***Purpose, Variables, Hypotheses***. The primary purpose of this research is to investigate the effects of using pre-structured tree-type GO on students' systemic thinking and explanatory thinking in the „Geography" discipline and compare it with the effects of observing maps and photographs and reading texts.

The research hypotheses are the following:

**$I^1$**– Students who complete pre-structured tree-type GO based on maps, photographs, and appropriate texts will score significantly higher on the post-test compared to the pre-test, indicating the development of competence in explaining geographical processes and systemic thinking.

**$I^2$** – Students who complete pre-structured tree-type GO based on maps, photographs, and appropriate texts will score significantly higher on the re-test compared to the pre-test and post-test.

**$I^3$**– Students who observe maps and photographs and read appropriate texts will score significantly higher on the post-test compared to the pre-test, indicating the development of competence in explaining geographical processes and systemic thinking.

**$I^4$**– Students who observe maps and photographs and read appropriate texts will score significantly higher on the re-test compared to the pre-test and post-test.

**$I^5$** – Students who complete pre-structured tree-type GO based on maps, photographs, and appropriate texts will score significantly higher on the post-test compared to the pre-test than students who observe the maps, photographs, and read the same texts.

**$I^6$**– Students who complete pre-structured tree-type GO based on maps, photographs, and appropriate texts will score significantly higher on the re-test compared to the pre-test and post-test than students who observe the maps, photographs, and read the same texts.

The independent variable in this study is the learning method. The independent variable has two levels: completing the tree-type GO; observing maps and photographs and reading some texts. The dependent variable is the level of development of the competence to explain geographical processes and systemic thinking, operationalized by the number of correct assertions or inferences about the production of geographical processes, made based on maps, photographs and texts, measured at pre-test, post-test and re-test. The control variables are represented by the pre-test, the actual activity time and the students' previous experience in using

the GO.

The second aim of the research is to investigate the students' perceptions regarding the external representations and internal representations, the cognitive strategies and metacognitive strategies used by students to explain the production of geographical processes and the aspects to which they pay attention. In order to achieve the second aim of the research, three research questions were formulated:

**IC[1]** – What cognitive strategies and metacognitive strategies do students use to explain the occurrence of geographical processes? (question 1)

**IC[2]**– What aspects do students pay attention to when explaining the occurrence of a geographical process? (question 2)

**IC[3]**– What external representations and internal representations do they use to explain the occurrence of geographical processes? (question 3)

### 3.4.2 Method

***Participants***

The research was conducted in the „Nicolae Bălcescu" National College in the city of Brăila, Brăila County, in the 2025-2026 school year, in September-October. The study involved 107 students from four ninth-grade classes, with an average age of 15 years, of both genders, divided into two groups: $GE^1$ ($N$ =54) and $GE^2$ ($N$ =53).

All provisions regarding research ethics and data confidentiality were respected, according to GDPR (2016).

***Procedure***

The research design was pre-test - formative intervention - post-test - re-test, with two experimental groups ($GE^1$- GO tree group vs. $GE^2$ - tree and reading). The students went through three stages in two different weeks: the pre-experimental stage (pre-test); the formative intervention stage; the post-experimental stage (post-test) and the re-test. A week after the re-test, a questionnaire was administered to both groups.

***Instruments***

The research data collection was carried out through 3 tests, of our own design: a pre-test, a post-test and a re-test. In these tests, the maximum score assigned was 10 points. The evaluation of the texts is carried out by comparing them with a solution model. The questionnaire includes two dual-choice items with 2 constructed answers and one multiple-

choice item.

***Data Analysis***

**Preliminary Analyses.** The data obtained at the pre-test, post-test and re-test were statistically analyzed using Excel and SPSS programs. In order to decide the appropriate type of analysis for testing the hypotheses and to test the equivalence of the experimental groups before the formative intervention, comparative statistical analyses were performed. The *Kolmogorov-Smirnov* test was applied to test the normality of the distribution of the results collected from each group and the Mann-Whitney U test to compare the initial performance of the two groups.

**Main Analyses – Hypothesis Testing**. In order to verify the evolution of the results over time and whether $GE^1$and $GE^2$ progressed significantly between the test moments, the Wilcoxon signed-rank test was applied. To verify the initial equivalence and the differences at the measurement times, the Mann-Whitney U test was applied. To analyze the progress, the progress score was calculated for each student, and the difference between the distributions of the progress scores of the groups was analyzed using the Mann-Whitney U test. The effect size was estimated by the r coefficient.

### 3.4.3 Results

***Preliminary results***

The analysis of the pre-test results shows that $GE^1$ (GO tree) obtained significantly higher scores at the pre-test compared to $GE^2$ (observation and reading), having a slightly higher level of initial performance. At the three interventions and at the two test times, the p values $p < 0.05$ in the *Kolmogorov-Smirnov* test indicate that the distributions of the scores do not respect normality, requiring non-parametric tests for subsequent comparative data analysis.

**The table 3.29**

*Kolmogorov-Smirnov test results*

| **Dependent variable / testing moment** | **$GE^1$ (GO tree)** ($N$ = 54) | | | | **$GE^2$ (observation and reading)** ($N$ = 53) | | | |
|---|---|---|---|---|---|---|---|---|
| | ***M*** | ***AS*** | ***Z (K-S)*** | ***p*** | ***M*** | ***AS*** | ***Z (K-S)*** | ***p*** |
| Pre-test | 0,71 | 0,71 | 0,196 | 0,028 | 0,51 | 0,75 | 0,281 | 0,0003 |
| Post-test | 1,36 | 1,66 | 0,253 | 0,0015 | 0,68 | 0,94 | 0,294 | 0,0001 |
| Re-test | 1,19 | 1,90 | 0,279 | 0,0003 | 0,54 | 0,86 | 0,310 | 0,00005 |

***Main Results – Hypothesis Testing***

The results show that **$I^1$**, is confirmed, students in $GE^1$ obtained significantly higher scores on the post-test compared to the pre-test, recording an increase in the level of competence

in explaining geographical phenomena and processes. Hypotheses **$I^2$**, **$I^3$**, **$I^4$**, **$I^5$**and **$I^6$** are not confirmed, students in both groups did not record an increase in the level of competence in explaining geographical phenomena and processes. To explain geographical processes, 74.5% of students in $GE^1$ and 60.4% of students in $GE^2$ declared that they used knowledge from their own knowledge base about them, most students in $GE^1$ (54.9%) chose the more comprehensive answer, and 62.3% of students in $GE^2$ chose the less comprehensive answer and most students ($GE^1$: 66.7%; $GE^2$: 35.8%) declared that they needed maps, photographs, explanatory text, information from memory.

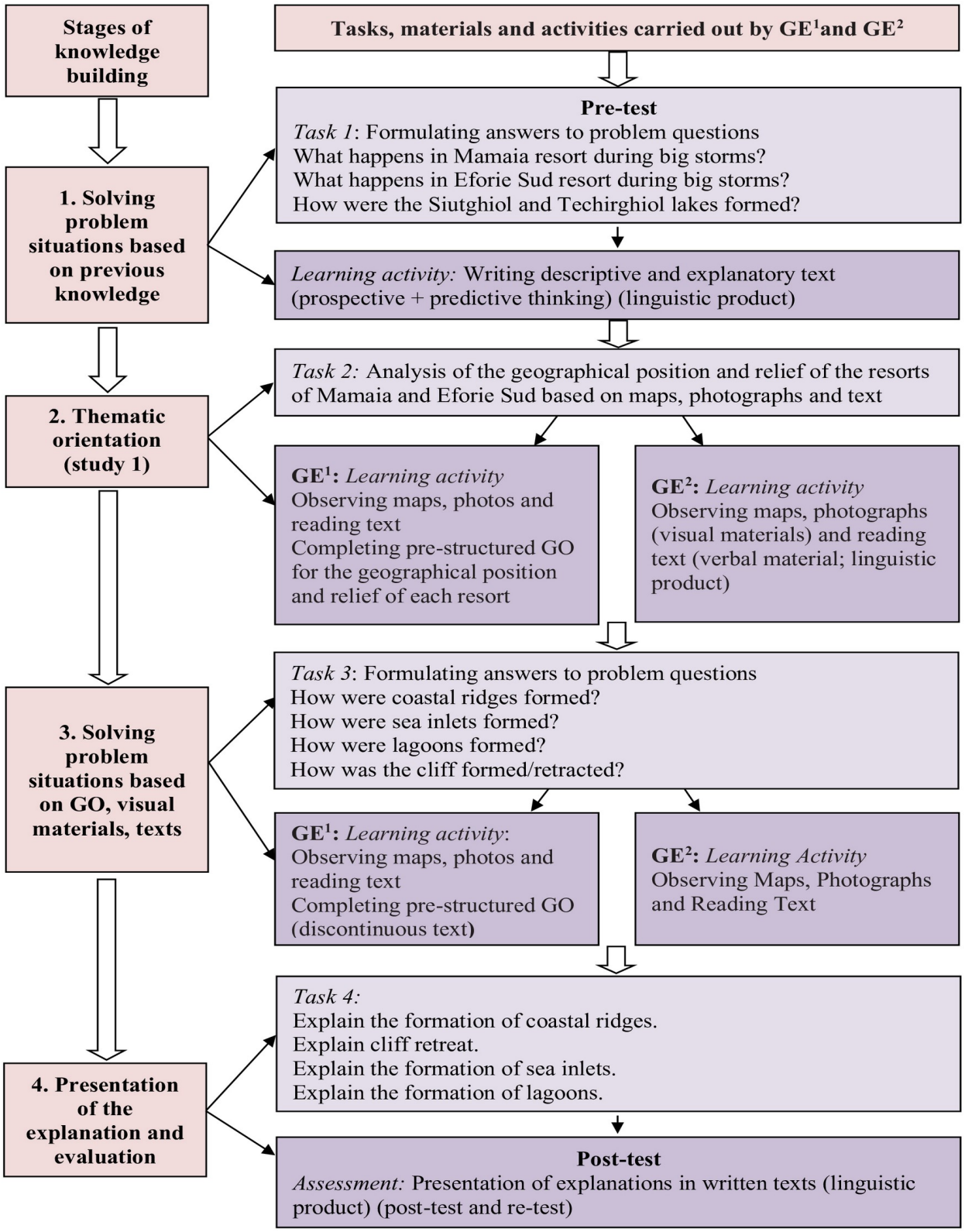
### 3.4.4 Discussion and Conclusions

Figure 3.4 presents the tasks, materials and activities carried out by the students in the two groups and in which they built their new knowledge. The pre-test results ($GE^1$: $M = 0.71$; $GE^2$: $M = 0.51$) show that the students had very great difficulties in terms of prospective thinking, predictive thinking, systemic thinking and relational thinking based on their prior knowledge.

The students in $GE^1$: were placed in a learning situation based on observation, individual reading and completion of pre-structured tree-type GO. The students in $GE^2$ were placed in a learning situation based on observation and individual reading.

**Figure 3.4**

*The tasks, materials and activities carried out by students in GE[1] and GE[2]*



The results of the pre-test ($GE^1$: $M = 0.71$; $GE^2$: $M = 0.51$) and post-test ($GE^1$: M =1.36; $GE^2$: M = 0.68) show that students from both groups have difficulties in explaining geographical processes. Unlike the situation in $GE^2$, in $GE^1$the completion of the GO determined a significant improvement in the competence to explain geographical phenomena and processes, the effect coefficient ($r = 0.57$). The results of the re-test ($GE^1$:$M = 1.19$; $GE^2$: $M = 0.54$) show a relative stability of the students' knowledge acquired in the learning activity.

The level of students' competence to explain geographical processes, which reflects systemic thinking, relational thinking and explanatory thinking, was influenced by the lack of prior declarative knowledge, their representation in the form of images, procedural knowledge and skills.

The statistical results only support the confirmation of the hypothesis that students in $GE^1$ obtained significantly higher scores on the post-test compared to the pre-test, which indicates an immediate increase in the level of competence in explaining geographical phenomena and processes, confirming the difficulty of explaining geographical processes by students and the need to be guided by teachers in this endeavor.

The responses of the students in the two groups to the questions in the questionnaire about the learning activity and metacognitive processes show that the students have the metacognitive strategies to evaluate their own thinking, approach the production of geographical processes and in the future ($GE^2$, 62.3%; $GE^1$, 54.9%), use information from memory in explaining geographical processes based on maps, photographs, explanatory texts ($GE^1$, 66.7%) and use only visual materials and texts ($GE^2$, 41.5%).

***Pedagogical Implications***

The study shows that pre-structured tree-type GO represent effective tools in guiding students in the process of identifying essential information in texts regarding the explanation of natural processes. From a didactic perspective, the activity of completing the GO should be continued by involving students in discussions with the teacher based on these processes, in explanations based on schematic drawings, in consolidation and memorization exercises carried out at their home and in evaluation situations, in the use of linear GO and cyclic GO.

***Research Limitations***

Although the results support the effectiveness of the interventions and the cognitive progress of the students, they must be interpreted taking into account the possible influence of

the content studied and the materials used in solving the problem situation, the lack of prior knowledge, the way the processes are presented in the texts studied, the lack of linguistic and symbolic markers on maps and photographs that allow establishing connections between a concept and its visual representation, the use of a single type of GO, the small number of participants and their origin from the same high school, the short duration of the formative intervention.

***Research Directions***

Based on the results and identified limitations, the research could be expanded by introducing GO into more learning activities, within a longer formative intervention, the effect of presenting GO of this type by the teacher could be compared with the effect of GO of this type carried out autonomously by students, linear GO and cyclic GO could be used in addition, more students from middle school and high school, from urban and rural areas, from different localities could be involved.

## 3.5 Study 5: The Effects of Using Pre-Structured Tree-Type GO on the Analytical Thinking and Comparative Thinking of 10th Grade Students

### 3.5.1 Introduction

In geography, it is important for students to learn to analyze, extract, compare and interpret data from tables, diagrams, texts, therefore in this study they are involved in a learning activity in which they process demographic data presented in tables and texts. In order to present essential information regarding demographic data in the text, students should learn, with the help of teachers, some procedures for analyzing and comparing data.

***Purpose, Variables, Hypotheses***

The primary purpose of this research is to investigate the effects of using pre-structured tree-type GO on students' analytical thinking and comparative thinking in the subject „Geography” and compare it with the effects of analyzing data from tables and reading relevant texts.

The independent variable in this study is the learning method. The independent variable has two levels: completing pre-structured tree-type GO; analyzing data from tables and reading relevant texts. The dependent variable is the number of correct statements about the population structure, based on the data in the tables, measured at pre-test and post-test. The control variables are represented by the pre-test, the actual activity time and the students' previous experience in

using the tree-type GO.

The research hypotheses are as follows:

**$I^1$**– The use of tree-type GO for organizing information extracted from demographic data tables, associated with reading relevant texts, leads to significantly higher scores at the post-test compared to the pre-test, indicating the development of skills for analyzing and comparing geographic data.

**$I^2$**– Analyzing demographic data from tables, associated with reading relevant texts, leads to significantly higher scores at the post-test compared to the pre-test, indicating the development of skills for analyzing and comparing geographic data.

**$I^3$**– The use of tree-type GO for organizing information extracted from demographic data tables, associated with reading relevant texts, leads to significantly higher scores at the post-test, compared to simply analyzing data from tables and reading texts, indicating a higher level of development of skills for analyzing and comparing geographic data.

The second aim of the research is to investigate students' perceptions of the effectiveness of learning strategies in understanding, comparing and memorizing demographic data, the usefulness of tree-type GO and the pleasure felt in the activity of processing demographic data from tables, texts and completing tree-type GO. In order to achieve the second aim of the research, three research questions were formulated:

**$IC^1$** – What is the students' perception of the effectiveness of learning strategies in understanding, comparing and memorizing demographic data?

**$IC^2$**– What are the perceptions of students in $GE^1$, regarding the usefulness of tree-type GO?

**$IC^3$**– What is the level of satisfaction and pleasure of students for the activity of processing demographic data from tables, texts and completing tree-type GO?

### 3.5.2 Method

#### *Participants*

The research was conducted in the „Nicolae Bălcescu" National College in the city of Brăila, Brăila County, in the 2025-2026 school year, in the months of September-October. 104 students from the 10th grade, with an average age of 16 years, of both genders, participated in the study. The students were divided into two groups: $GE^1$ ($N$ = 52) and $GE^2$ ($N$ = 52).

### *Procedure*

The quasi-experimental research has a pre-test - intervention - post-test design and two groups. The two groups went through three stages with the students in different weeks: the pre-experimental stage in which the pre-test was applied; the formative intervention stage, in which the students studied the „Demographic structure of the population in the counties of Maramureș and Constanța" based on seven tables and some texts; the post-experimental stage in which the post-test was applied. One week after the post-test was applied, a questionnaire was applied to both groups. The students completed the tests in physical format and the questionnaire in online format.

### *Instruments*

The collection of research data was carried out through two self-designed tests (a pre-test and a post-test) and a questionnaire. The pre-test and post-test have seven subjective, open-ended items, which require the development of seven short texts on essential aspects regarding the demographic structure of the population in two counties based on data from seven tables, the maximum score being 20 points: 10 points for analytical thinking and 10 points for comparative thinking. The questionnaire contains five items.

### *Data Analysis*

**Preliminary Analyses.**The data obtained at the pre-test and post-test were statistically analyzed using Excel and SPSS programs. In order to decide the appropriate type of analysis for testing the hypotheses and to test the equivalence of the experimental groups before the formative intervention, comparative statistical analyses were performed. *The Kolmogorov-Smirnov* test was applied to test the normality of the distribution of the results collected from each group, the t-test for independent samples on the scores from the pre-test for analytical thinking to verify that the groups are comparable before the intervention, *the Mann–Whitney U* test at the pre-test to verify that the groups are equivalent before the intervention.

**Main Analyses – Hypothesis Testing**. To verify the evolution of the results over time and whether the groups progressed significantly between the test moments, for analytical thinking, the *t*-test for dependent samples was applied, *t, p,* Cohen's *d* were calculated. To verify the evolution of the results over time and whether the groups progressed significantly between the test moments, for paired comparisons, the Wilcoxon (signed-rank) test was applied, positive, negative and equal ranks, *Z, p, r* were calculated. To examine the differences between the groups

at the post-test, for comparative thinking, a unifactorial analysis of covariance (ANCOVA) was used.

The dependent variable was the total score at the post-test, the independent factor was the group of affiliation ($GE^1$vs. $GE^2$), and the total score at the pre-test was entered as a covariate variable. Before interpreting the model, the assumption of homogeneity of the regression slopes was checked by including the interaction term between the covariate and the factor (Pre-test × Group). The effects were evaluated by means of *F* values, the significance level (*p*) and the effect size estimated by partial eta square ($\eta p^2$).

### 3.5.3 Results

#### *Preliminary Results*

The results of the Kolmogorov–Smirnov test at pre-test and post-test, for analytical thinking, show *p*-values greater than 0.05 for both groups and a normal distribution of scores, small skewness values in all cases. The results of the Kolmogorov–Smirnov test, for comparative thinking, show that the normality condition is met for all analyses in the post-test and for $GE^1$ at pre-test, but not for $GE^2$ at pre-test. At pre-test, the mean scores are close between groups for analytical thinking ($GE^1$: $M = 3.23$; $GE^2$: $M = 3.06$), but they are not close for comparative thinking ($GE^1$: $M = 2.69$; $GE^2$: $M = 1.88$). At post-test, $GE^1$: ($M = 4.15$) has a slightly lower mean for analytical thinking than $GE^2$ ($M = 4.21$). At post-test, $GE^1$ (M = 3.78) has a slightly higher mean in comparative thinking than $GE^2$ ($M = 3.50$). The results of the independent samples *t*-test at pre-test do not indicate statistically significant differences between groups in terms of analytical thinking, $t\ (102) = 0.95$, $p = 0.344$. The results of the Mann–Whitney U test applied at pre-test, in comparative thinking, show a statistically significant difference between the two groups ($U = 1689$, $Z = 2.21$, $p = 0.023 < 0.05$), indicating that the groups are not equivalent at baseline, which must be taken into account when interpreting the effects of the intervention.

#### *Main Results – Hypothesis Testing*

The results indicate an increase in students' performance in analytical thinking, the t-test for paired samples highlighting a statistically significant increase in scores from pre-test ($M = 3.23$) to post-test ($M = 4.15$), $t\ (51) = -6.1$, $p < 0.001$, ($AS = 0.98$), ($d = 0.94$).

**The table 3.39**

*Paired samples t-test for analytical thinking*

| Group | *n* | *M_pre* | *M_post* | *Average difference* | *SD distinction* | *t* | *df* | *p* | Cohen's *d* (*dz*) |
|---|---|---|---|---|---|---|---|---|---|
| GE1 | 52 | 3.23 | 4.15 | 0.92 | 0.98 | -6.81 | 51 | < 0.001 | 0.94 |
| GE2 | 52 | 3.06 | 4.21 | 1.15 | 0.90 | -9.19 | 51 | < 0.001 | 1.27 |

The results indicate an increase in student performance between pre-test (*M* = 2.69, *AS* = 1.88) and post-test (*M* = 3.78, *AS* = 1.66) scores, *Z* = -3.45, p = 0.001, in comparative thinking. The results confirm hypotheses **I**[1] and **I**[2]: students improve their skills in analyzing and comparing geographic data by using tree-type GO to organize information extracted from demographic data tables, associated with reading relevant texts, and by analyzing demographic data from tables, associated with reading relevant texts.

The results of the t-test for independent samples did not indicate significant differences between groups, *t* (102) = - 1.25, *p* = 0.214. The mean difference was 0.92 (*AS* = 0.98) for $GE^1$ and 1.15 (*AS* = 0.90) for $GE^2$. The effect size was small (*d* = - 0.25).

**The table 3.40**

*Comparison of progress (gain scores) between groups in analytical thinking*

| Group | *n* | *M_ gain* | *SD* | *t* | *df* | *p* | Cohen's *d* |
|---|---|---|---|---|---|---|---|
| $GE^1$ | 52 | 0.92 | 0.98 | -1.25 | 102 | 0.214 | -0.25 |
| $GE^2$ | 52 | 1.15 | 0.90 | | | | |

The results of the analysis of covariance (ANCOVA) revealed a significant effect of the pre-test covariate on the post-test scores, F (1. 101) = 20.71, p < 0.001, $\eta p^2 = 0.170$, indicating that the initial level of the students is an important predictor of subsequent performance. Regarding the effect of the group factor, after controlling for the initial scores, the results did not indicate statistically significant differences between the two groups, *F* (1. 101) = 0.02, *p* = 0.882, $\eta p^2 = 0.0002$. The analysis of the adjusted means shows very close values for the two groups, respectively *M*_adjusted = 3.62 (*SE* = 0.21) for $GE^1$ and *M*_adjusted = 3.67 (*SE* = 0.22) for $GE^2$. These results suggest that, after controlling for initial differences between groups, students' performance on the post-test does not differ significantly between the two groups.

***Results Regarding the Research Questions***

Students from both groups declare that they understand most easily and can compare and memorize data about the population structure of a territory from a data table. Very few students (under 12.2%) declare that the tree-type GO was useful to them. Students appreciated that the

tree-type GO was useful to them ($M_{min}$ = 4. 16; $M_{max}$= 4.51) in: identifying essential data from tables ($M$ = 4.51), classification criteria ($M$ = 4.49) and visual organization ($M$ = 4.49) and data synthesis ($M$ = 4.45), understanding the geographical way of approaching the subject ($M$ = 4.41) memorizing information ($M$ = 4.37).

Students in both groups rated the tasks most clearly ($GE^1$: $M$ = 4.16; $GE^2$: $M$ = 4.16). Students in $GE^1$rated the most that the diagrams guided them on the correct way to approach geography ($M$ = 4.57) and on important aspects ($M$ = 4.55). Students in $GE^2$ assigned lower scores than students in $GE^1$.

### 3.5.4. Discussions and Conclusions

**Discussions on Immediate Progress Within Each Group (Post-test – Pre-test)** (Hypothesis $I^1$ and Hypothesis $I^2$).

From the analysis of the texts elaborated by the students from both groups at the pre-test, it is found the general tendency to present, in more extensive informative texts, all the demographic data extracted from the tables, with a reduced concern for selecting the relevant data, for ranking and for highlighting the similarities and differences. When evaluating the texts, points were awarded for the assertions specific to analytical thinking and for the assertions specific to comparative thinking.

At the pre-test, in both groups, the low means show a low level of analytical thinking ability ($GE^1$: $M$ = 3.23; $GE^2$: $M$ = 3.06) and comparative thinking ability ($GE^1$: $M$ = 2.69; $GE^2$: $M$ = 1.88). The results suggest that students have difficulties in selecting essential aspects regarding the demographic structure of the population, in particular, in highlighting hierarchies, similarities and contrasts. At the post-test, the means are higher in both groups, compared to the pre-test, both in terms of analytical thinking ability ($GE^1$: $M$ = 4.15; $GE^2$: $M$ = 4.21) and comparative thinking ability ($GE^1$: $M$ = 3.78; $GE^2$: $M$ = 3.50). The results indicate that both groups made significant progress in terms of the development of analytical thinking, ($GE^1$: $d$ = 0.94; $GE^2$: $d$ = 1.27) and comparative thinking ($GE^1$: $r$ = 0.48; $GE^2$: $r$ = 0.57).

**Comparison of Progress Between Groups** (Hypothesis $I^3$). Regarding analytical thinking, at the pre-test, the results showed that the groups were equivalent ($GE^1$: $M$ = 3.23; $GE^2$ : $M$ = 3.06), but were not equivalent in comparative thinking ($GE^1$: $M$ =2.69; $GE^2$: $M$ = 1.88), a fact explained by the existence of differences between classes or contextual influences specific to the educational environment. The results suggest that both didactic approaches are

effective in stimulating analytical thinking, but there is not sufficient evidence to state that one of them produces stronger effects than the other.

Regarding comparative thinking, at the pre-test, the analyses revealed statistically significant differences between the groups. The results indicate that both groups progressed significantly in terms of the development of analytical thinking and comparative thinking, but students in $GE^2$ had a greater progress between pre-test and post-test. This progress can be explained by the fact that students in $GE^1$, in the formative intervention, focused their attention for the longest time on selecting data from the tables and completing the GO, while students in $GE^2$ analyzed the data and tables more carefully and read, in parallel, the text in which these data were presented, thus they processed the information more deeply.

***General Conclusions***

The analysis of the texts developed at the post-test reveals that students need precise indications and descriptions of the procedures for analyzing and comparing demographic data in tables, they need to apply this learning strategy several times by developing GO, using diverse, geography-specific content, in order to strengthen their ability to analyze data and the ability to compare data from various sources and to be able to apply them in new contexts.

***Research Limitations***

The results may be influenced by the small number of participants and their origin from the same high school, the absence of randomization of participants and the lack of initial equivalence between groups, the short duration of the formative intervention, the small number of content elements studied and GO developed.

***Research Directions***

To more consistently verify the potential of pre-structured tree-type GO and their effect on analytical and comparative thinking, further studies are needed in which GO should be used in more learning activities, within longer formative interventions, the effect of presenting GO of this type by the teacher could be compared with the effect of GO of this type completed autonomously by students, more content elements could be addressed and multiple assessment tools could be used, more students from middle school and high school, from urban and rural areas, from different localities could be involved.

# CHAPTER IV
# RESEARCH CONCLUSIONS AND IMPLICATIONS

## 4.1 Theoretical Implications

The theoretical implications of the research consist in the conceptual clarification of geographical thinking and graphic organizers as essential educational outcomes of geography learning that can be associated with an instructional strategy or model, depending on the context and the degree of guidance, as well as in highlighting the role of scaffolding in supporting higher-order cognitive processes involved in relevant learning activities.

## 4.2 Methodological Implications

From a methodological perspective, the close connection between the content elements addressed in the four cvsi-experimental studies is highlighted, thus providing a broader context for the use of GO of various types, in relation to the specificity of the selected contents and which allow the construction of geographical knowledge, the organization of geographical information and the development of certain types of geographical thinking, in an integrated, holistic, constructivist manner.

## 4.3 Practical Implications

The practical implications of the research consist in providing concrete guidelines for the design and organization of geography learning by integrating GO as a support tool for supporting higher-order cognitive processes, emphasizing that the efficiency of this strategy as a type of teaching and learning is determined mainly by the teacher's pedagogical decisions and the active, motivated and informed involvement of students.

## 4.4 Research Limitations

The samples of participants involved in the research are not representative at the national level (limited geographical distribution, predominance of urban environment or a certain gender, relatively small number of participants), which reduces the possibility of generalizing the conclusions. In study 1, the use of the questionnaire based on self-reporting may lead to under- or overestimation of real behaviors, and the wording of the items reflects one's own vision on the development of geographical thinking with the help of graphic organizers. In quasi-experimental studies, the number and origin of students and teachers from the same high school, the content studied and the materials used, the lower relevance of the topics for students, the higher degree of abstraction of the information represented on the map than in photographs, the lack of

opportunity for students to develop the GO, the lack of a model for completing this instrument, may influence the results. Student characteristics, conditions and assessment tools may affect the comparability of the results. The absence of a long-term retention measurement does not allow for the formulation of conclusions regarding the stability of maintaining the level of development of spatial analysis skills, to compare the geographical positions and relief of some localities, to explain the geographical processes observed immediately after the learning activity.

**4.5 Research Directions**

To confirm the current conclusions and generalize the results, future research can expand and understand more deeply the cognitive processes that can be stimulated and improved through GO, in geography, in pre-university education, can apply the self-designed questionnaire to collect data on the use of GO by geography teachers from other countries, at the level of primary education teachers or in other educational disciplines, the role of digital applications in their creation and use in the teaching-learning process could be analyzed, GO created by students, individually, in pairs or in groups, at home or at school could be analyzed and compared with standard formats.

**4.6 General conclusions**

Regarding geographical thinking, there is a relatively small number of studies on geographical thinking worldwide. Regarding GO, worldwide there are many studies from various scientific fields that present GO with diverse conceptions and forms, but few studies investigate the use of GO in the representation of geographical information and in learning geography, the typology of these GO being much more restricted.

Unlike other studies, which show the general effects of several GO, the quasi-experimental studies in this thesis focus on precisely measuring the effects of pre-structured GO through which each student is supported to successfully complete the given tasks. Taking into account the difficulty of understanding and developing GO, the limited time resources allocated in the timetable for geography, the difficulty of measuring the level of development of thinking skills, the studies in the thesis investigate GO that can be used more easily and quickly in the classroom by students and teachers, with the recommendation of using other types of GO in the classroom, depending on the specifics of the geography content.

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