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USING THE VENN DIAGRAM FOR DEVELOPING UNIVERSITY STUDENTS' ANALYTICAL GEOGRAPHICAL THINKING

Mariana-Doina Cîineanu (a), Maria Eliza Dulamă (b), Oana-Ramona Ilovan (c)*,
George Mihai Rus (d), Béla Kobulniczky (e), Cristina-Georgiana Voicu (f), Olga Chiș (g)
*Corresponding author

(a) Faculty of Psychology and Sciences of Education, Babeș-Bolyai University, 7 Sindicatelor St., Cluj-Napoca; "Nicolae Bălcescu" National College, 182 Al. I. Cuza Blvd., Brăila, Romania, officeroseromania@gmail.com
(b) Faculty of Psychology and Sciences of Education, Babeș-Bolyai University, 7 Sindicatelor St., Cluj-Napoca, Romania, dulama@upcmail.ro
(c) Faculty of Geography, Babeș-Bolyai University, 5-7 Clinicilor St., Cluj-Napoca, Romania, ilovanoana@yahoo.com
(d) Faculty of Geography, Babeș-Bolyai University, 5-7 Clinicilor St., Cluj-Napoca, Romania, rusgeorgemihai@yahoo.com
(e) Faculty of Geography, Babeș-Bolyai University, 5-7 Clinicilor St., Cluj-Napoca, Romania, kobulniczky.bela11i@yahoo.com
(f) "Titu Maiorescu" Secondary School, 10 Decebal Alley, Iași; Romanian Geographical Society, Iași branch, Romania, voicucristina2004@yahoo.fr
(g) Faculty of Psychology and Sciences of Education, Babeș-Bolyai University, 7 Sindicatelor St., Cluj-Napoca, Romania, olga_marcus@yahoo.com

Abstract

Developing university students' analytical geographical thinking is one of the major objectives of university geographical education irrespective of the fact that it is achieved during Didactics of Geography lectures and seminars or fundamental courses in Geography. This objective can be achieved by various means, the Venn Diagram being among them. It is used to identify the aspects characteristic to concepts or the common features of geographical systems. Our research raised the following questions: which are the main geographic concepts and systems as the object of a certain comparison, and second, what are the main criteria on which a comparison is completed? To answer these questions, we used Venn Diagrams as research material made by students and published in articles, chapters, books, or as part of their portfolios for learning Geography and the Didactics of Geography, as well as during written exams or as exercises included in lesson planning. Our conclusions are the following: the critical and analytical geographical thinking have a peripheral position within the educational process, many sampled diagrams highlight the comparison of different objects without specifying the particular criteria, and students make use of critical and analytical thinking but with certain limitations when the geographic language is used.

Keywords: Competence, Didactics of Geography, comparison criteria, higher education, graphical organizer, cognition

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1. Introduction

One of the major objectives of university geographical education is developing university students' analytical geographical thinking. This is true either for Didactics of Geography lectures and seminars or for fundamental courses in geography. There is well acknowledged that in territorial planning research three stages have to be completed in order to investigate all spatial features through the lens of systemic analysis: the human and economic analysis and the global investigation of all features occurred from the previous approach (Zotic, 2005, pp. 31-32).

The geographic analysis represents a mental or a real action through which the whole territorial system is decomposed into its elements, each being examined to identify its properties and to establish the relationship between them. In this regard, each element is approached to find out the main relations established between all the components of a territorial system. Studying each part of a system is important to exclusively separate all the parts, and the investigation upon them to be undoubtedly complete. Accordingly, this approach is meant to unveil both the internal structure of the investigated spatial elements as well as their specificities (Dulamă, 2010a, p. 163). The second step of the critical thinking is the comparison, thus enabling the mental or physical approach to geographical objects, systems, and processes in order to identify the main similarities and differences among them. Against such a background, the comparison is completed based on particular criteria and, in line with each criterion, there are multiple opportunities to discover whether the compared objects are similar or different (Dulamă, 2010a, p. 163).

In geographical research, there are various means for student' critical and analytical thinking development, through Venn Diagram usage. It was created by the English logician John Venn (1834-1923) to represent visually the complex logical propositions and algebraic statements (Edwards, 2004). Canela Morales and Ruiz Sosa (2020) pointed out in a thematic study the symbolic nature of formal rationale of this diagram and its diagrammatic nature, as well as how knowledge could be ensured using diagrams and symbols. The authors investigated the various ways of diagrams use in the teaching and learning processes.

Venn and Euler Diagrams are well-defined mathematical diagram types used during Mathematics examinations in secondary education in the UK. In order to make the grading more efficient, an automatic system for assessing student's answers was created based on Venn and Euler Diagrams. The grade is assigned after comparing the student's answer with a model answer (Wijesinghe et al., 2017).

Focused on the use of Venn Diagram in Geography, the whole body of the international literature in the field introduces only indirectly the contribution of this didactic resource during Geography teaching and learning. Some aspects highlight the wide range of the various forms of graphical organizers (see Gottfried, 2015), while other studies are concerned with the natural sciences (Lynam et al., 2007). In Romania, Venn Diagram started to be extensively used in geography education after 2000, as a result of the awareness of its importance during training programs in which geography teachers were involved. Although this diagram is presented in some logic studies, several teachers have learned in recent decades that the Venn Diagram is a cognitive organizer of two partially overlapping circles that represent the similarities and differences between two aspects, ideas, or concepts (Steele et al., 1998a; 1998b). The similarities are mentioned in the area where the circles overlap, and the differences in the free, outer areas (Dulamă, 2002,

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p. 166). When using the Venn Diagram, spatial information is classified into two categories: real objects and their spatial properties and abstract objects (Gottfried, 2015).

2. Problem Statement

Although in Romania the Venn Diagram is largely introduced by a whole body of the literature focused on the Didactics of Geography, its benefits for the critical thinking development remain peripheral. Furthermore, this cognitive organizer is underused in the Romanian educational system both in pre-university education and in academic training. A review of the observed educational practices, pointing out a certain teaching style (Fetti & Albulescu, 2020), and of the specialized literature shows that there are different approaches on Venn Diagrams, thus generating relevant qualitative differences in line with its efficiency in the students' critical thinking, who are interested in learning Geography. Both the literature and various practices show that some teachers have no relevant information on the role of the diagram within knowledge modelling in a certain domain (Gottfried, 2015).

3. Research Questions

Using the Romanian literature review concerned with the Venn Diagram, we intend to find some answers to the following questions: which are the main geographic concepts and systems as objects of a certain comparison, and second, what are the main criteria on which a comparison is completed? In addition, the study aims to reveal the main compared aspects, attributes and objects, the contexts and situations in which students use comparisons according to certain criteria. Finally, based on these findings, we are interested in unveiling some information on how students use Venn Diagrams in their particular learning actions, as well as on students' difficulties in certain situations of comparing geographic objects, ideas, elements, and geographic processes.

4. Purpose of the Study

This research focuses on the following major objectives: on the one hand, it aims to investigate different Venn Diagrams included in the Romanian specialized literature to understand their main theoretical and methodological perspectives and, on the other hand, to analyze Venn Diagrams made by the students to find out the ways they use to include Venn Diagrams in their own learning processes, as well as to identify the students' major difficulties within these specific training situations.

5. Research Methods

***Procedure*.** Within the electronic portfolio made for the subject entitled "Geography, environment/sciences and their didactics in kindergarten and the primary grades", during the Spring semester of the 2020, the students had to compare two distinct major landforms on various continents (e.g. mountains, hills, plateaus and fields), by completing two particular aspects of a landform, two specificities of the other landform and two common aspects for both investigated landforms within the Venn Diagram. As a background in solving this task, the students were informed about the theoretical support in terms of

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a handbook, a thematic presentation, four profiles of the investigated landforms and a table including the key aspects of the relief (Table 1). The portfolio tasks had to be solved individually until the exam. The work was designed in groups, to avoid any stress caused by the Romanian pandemic crisis.

Table 1. The main characteristics of the landforms

Landform	Altitude	Valley depth	Tilt/Slopes	Mineralogy and rocks
Mountain	- over 800 m	- deep valleys between 400-500 m	- strong tilt surfaces prevail (slopes)	- made of strong rocks (metamorphic, magmatic, pleated sedimentary)
Hill	- 300-800 m	- deep valleys over 100 m	- strong tilt surfaces prevail (slopes) to the plate areas (interfluves)	- made of soft rocks (un-pleated sedimentary: sand, gravel, clay)
Plateau	- over 300 m	- deep valleys over 100 m	- large interfluves prevail	- made of soft rocks (un-pleated sedimentary: sand, gravel, clay), as well as string rocks (metamorphic, magmatic, pleated sedimentary)
Field	- under 300 m	- deep valleys under 100 m	- the plate areas prevail (interfluves)	- made of soft rocks un-pleated sedimentary, sand)

***Participants*.** 37 students in their 3rd year of study, attending the Program of the Primary Education Pedagogy from the Faculty of Psychology and Education Sciences, Babeş-Bolyai University from Cluj-Napoca, Romania, were involved in the research. These students train for a teaching career in the primary educational field of the Romanian pre-university education system. Of these, about 50% graduated the Pedagogic College and work in the primary education system. The second author of this study assigned this task to the students, assessed all students' portfolios, being perceived by the students as a professor, not as a researcher.

The research material comprised 20 Venn Diagrams included in various works on Didactics of Geography (Dulamă, 2002; 2008; 2009; 2010a; 2010b; 2010c; Ilovan et al., 2010; Ilovan & Mihalca, 2010; Ţolaş, 2010) and in two scientific papers (Costa & Antonie, 2006; Dulamă & Ilovan, 2004), identified by the first author. The research material also covered eight diagrams made by some groups of four students, all diagrams being included in the students' portfolios in order to be evaluated. The collected data are represented in tables specific to Education Sciences (Magdaş, 2018).

Collecting data and data analysis. Diagrams were extracted both from the specialized literature and from the students' portfolios. Their content was then critically investigated in terms of their topics and contents.

6. Findings

6.1. Literature review on Romanian Venn Diagrams specialized work

Based on the critical analysis of the content included in the previously mentioned 20 diagrams, several aspects have been identified as follows:

a. Concepts and geographic systems are subjected to comparison. Literature recommends that Venn Diagrams are used for diverse comparisons: concepts (river/stream, glacier/ice shelf, island/peninsula, delta/estuary), hydrographic elements (The Rhine/The Danube, The Black Sea/The

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Caspian Sea, Aral Lake/Baikal Lake), mountains (The Alps/The Carpathians, The Western Carpathians/The Southern Carpathians), countries (Romania/Hungary, Italy/Norway, Romania/France, Italy/Greece, Brazil/Argentina), people (Romanians/Dutch, Hungarians/Romanians, Greeks/Italians, etc.), animal species (cat/lion), and types of plants (Dulamă, 2008, p. 346). In other works, diagrams are used to compare continents, countries, cities, lakes, civilizations, and types of forests (Dulamă & Mihalca, 2010).

b. Key features using Venn Diagrams. A sample of each identified category has been extracted (Table 2) to analyze through the lens of the critical geographic thinking. Differences occur after comparing all these diagrams. Some of them have been made by various authors to provide diverse examples for teachers and students (Dulamă, 2002, 2008, 2009), while others were achieved by the students in different contexts for their work assessment (Dulamă & Ilovan, 2004) or in various research contexts (Costa & Antonie, 2006). A diagram includes information about the people and works as a subjective tool/resource (Dulamă & Ilovan, 2004), while the other ones unveil some geographic information with higher objectivity (Costa & Antonie, 2006; Dulamă, 2002; 2009). They do not include criteria on which the comparison has been made with these issues being implied. Multiple aspects were presented in a mirroring manner; particularly a certain aspect has been analyzed in both compared geographical systems and concepts. Considering diagrams about geographical systems, there have been included geographical names of some realia (The Danube, Bucharest, The Carpathian Mountains, and The Black Sea), as well as some general or spatial features as the relief proportionality and variety, or types of countries, etc.

Table 2. The content of Venn Diagrams and their outcomes

Content				Characteristics by Venn Diagrams	Source
Category	**Specific aspects**	**Similarities**	**Specific aspects**		
Countries	Romania Bucharest – the capital city The Carpathian Mountains The Black Sea The Danube Relief variety Relief proportionality	Leul The national flag Ştefan The Great Romanian language Temperate climate Pro Tv Romanians Republics Prut Eminescu Orthodoxy	Moldova Chişinău – capital No exit to the sea Airport Prevailing plateaus Agrarian country	- exemplification / illustration - without mentioning the criteria - highlighting geographical names - focus on some general characteristics	Dulamă, 2002, p. 166
People	Romanians *Positive features*: hospitable, kind, communicative, optimistic, agricultural workers, sensitive, tolerant, intelligent, spontaneous, optimistic, generous, religious,	Educated, creative, flowers and animal lovers, flexible, witty, inventive, artists, adaptable, intelligent, sociable, tolerant, sincere, sport lovers, patriots	Dutch people *Positive features*: honest, sincere, traders, efficient, civilized, free minded, practical, tenacious, educated, kind, tolerant, ambitious, urban, pragmatic, friendly, nonconformists, punctual,	- resulted from the research - no focus on the general characteristics - analyses based on specific perceptions - a higher degree of subjectivity	Dulamă & Ilovan, 2004, p. 230

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	ingenious, friendly, smart *Negative features*: traditionalist, conservative, speculative, Latin spirit, Balkan mentality, careless, corrupt, boastful, nationalist, proud, greedy, boastful, unpunctual, etc.		rigorous, open-minded, serious, clean, disciplined, meticulous, active, etc. *Negative features*: seriousness, individualism, party lovers, dissolute		
Concepts	**SEA** - salted water - with a marine basin - connected to the Planetary Ocean	-accumulation of water - reduced surfaces compared to the oceans - lower depth towards the oceans	**LAKE** - salty or non-salty water - lake basin (nook) - no connection to the Planetary Ocean	-exemplification/illustration - no focus on the criteria that are involved here - focus on the characteristics of the concepts	Dulamă, 2008, p. 346
Rivers	**The Danube** - crosses eight countries: Germany, Austria, Slovakia, Hungary, Serbia, Romania, Bulgaria, Ukraine - 2,860 km length - crosses four capitals Vienna, Budapest, Bratislava, Belgrade - Basin surface: 805,300 km^2 - tributary to The Black Sea - The Delta	- The Rhine-Main-Danube Canal	**The Rhine** - crosses four countries Switzerland, Germany, Holland, Lichtenstein - 1,320 km length - basin surface: 224,000 km^2 - tributary to the North Sea - estuary	- exemplification - no focus on the criteria that are involved here - focus on the characteristics of the concepts and the geographic names	Dulamă, 2009, p. 313
Rivers	**The Danube** - 2,860 km length - its spring in The Black Forest Mountains - tributary to the Black Sea - W-E direction - the longest gorge in Europe crossing ten countries and four capitals - the second river in Europe in length	- The Delta - The Rhine-Main-Danube Canal - rivers with large basins and many tributary rivers - used for electricity and water suply - fishing, transport, tourism	**The Rhine** - 1,320 km length - springs in The Alps - tributary to the Northern Sea - S-N direction - crosses four countries - the 8^{th} river in Europe in length	- resulted from the students' research - no focus on the criteria that are involved - low focus on the geographical names - focus on the precise numerical data	Costa and Antonie, 2006, p. 361

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c. Comparative aspects of Venn Diagrams. To set the main categories of aspects revealed by the use Venn Diagrams included in Table 2, as well as of other diagrams discussed in this research, the data included in Table 3 was systematized. The table is an example of a working tool that could be further developed according to various and countless topics. The main aspects resulted from the table investigation are as follows. When two geographical objects are compared, as for instance two rivers, the analysis can be done at the level of concepts or of some real rivers (the Rhine and the Danube). Considering the concepts, the analysis is made using some abstract objects with real features that define these concepts (Dulamă, 2010a, p. 163). In the case of real rivers, multiple properties in terms of their characteristics, features, particularities, etc. are focused on by Venn Diagrams, all these being perceived as relevant features defining that real or abstract object. Furthermore, they relate to some features that differentiate one object from another (Academia Română, 2009). When it is about the real rivers, their properties are included despite the concepts or features that are not included in this category.

Table 3 shows some information related to Venn Diagrams during the process of comparing the real objects and the real systems of objects. Based on the investigated diagrams, several types of elements have been designed and each category details several elements discovered during the comparison processes using Venn Diagrams.

Table 3. Examples of geographic elements and systems investigated through Venn Diagrams

Categories of elements	Geographic elements (objects)	Comparable elements of geographic objects	Comparison criteria
Hydrographic units	Rivers, streams	Spring	Location
		River course	Length, depth, direction, crossed countries and cities, ports, etc.
		Shedding	The shedding place, the shedding form, etc.
		Hydrographic basin	Surface
	Lakes	Lake basin	Surface, depth, etc.
		Water	Salinity, color, temperature, sources, etc.
Relief units on the continents	Mountains Hills Plateaus Fields	Geology	Genesis, lithology, structure, etc.
		Morpho-graphic characteristics	Slope and interfluves
		Morpho-metric characteristics	Surface, altitude, slope, declivity, fragmentation density, depth of fragmentation
Territorial systems	Countries	Geographic position	On the Earth, on the continent
		Natural characteristics: relief, climate, rivers, vegetation, soils, resources	Relief altitude and typological variety of relief Climate types and climate characteristics, etc.
		Population	Number, density, religions, natality, mortality, natural growth, etc.
		Human settlements	Number, density, types
		Economy	Economic fields and their characteristics
	Human settlements	Position	On continent, country, region, etc.
		Evolution	Dynamics, characteristics
		Population	Number, density, religions, natality, mortality, natural growth, etc.
		The hearth/urban characteristics	The hearth form and structure

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6.2. Students' analysis of Venn Diagrams

Considering students' work and involvement in the context of the distance learning through the Microsoft Teams platform, the students had less support from the tutor. The main activities were represented by their individual study using various support teaching resources during their instruction, alongside other resources as syllabus, PowerPoint presentations, resources uploaded in Microsoft Teams as well as in private discussion groups via Facebook. The students discussed and kept in touch with their professor by online forums. Through all these means and methods, specific to the online environment, we did our best to provide a suitable instruction for students.

The proposed tasks aimed to allow the proper understanding and an objective learning assessment with all these important in the consolidation of a real perception towards diagram contents. Since each students' team chose for comparison the landforms, mountains and plateaus were compared with the hills and fields (plains). The students had to follow the criteria included in Table 4. The information provided by the table was added only in three diagrams (30%), showing that only some students understood the task. A diagram unveils the usage of term 'height', and the concept of 'reduced height' instead of 'altitude', as a specific concept in physical geography, is used in another diagram. In the second diagram, the terms 'lower altitude' and 'higher altitude' are used. Within these diagrams, we identified different types of wording that are not in line with the particular criteria since they do not refer to the features of the landforms, on the contrary, they refer to their current or possible use during the process of geography learning.

The ways in which students compared the landforms showed that they lacked relevant knowledge for teaching geography and they frequently used common or colloquial language rather than a geographical one. However, the students demonstrated the use of their critical thinking, making comparisons based on the suggested criteria.

Table 4. The content students' diagrams

The landform	Specific aspects	Common aspects	Specific aspects	The landform
Field/Plain	- altitudes below 300 m - deep valleys below 100 m	– plain surfaces and interfluves prevail - geology: soft rocks, sedimentary, sands	- altitudes above 300 m - deep valleys above 100 m	Plateau
Mountain	- made by pleated processes, eruptions - steep slopes and ridges	- landforms - present in Romania	- the altitudes are generated by the raising mountains - lower temperatures compared to the mountains	Hill
Plate	- altitudes above 300 m - large and plain surfaces	– formed by soft rocks as sand and clay - deep valleys over 100 m	- altitude between 300 and 800 m - sloping surfaces	Hill
Field	- low altitudes - plain interfluves	- it can be cultivated - it can be used as pastures	- altitudes between 200 and 800 m - forests prevail	Hill
Hill	- sloping surfaces prevail	- deep valleys over 100 m - altitudes over 300 m - formed by soft rocks as sedimentary, sands and clay	– large and plain surfaces prevail - hard rocks prevail	Plateau
Mountain	- higher altitudes - above 800 m	- they are forms of relief - both have plants and animals	- lower than mountains - well populated	Hill

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Plate	- large interfluves and plain surfaces - made of hard rocks and pleat sedimentary	- deep valleys, over 100 m - altitudes over 300m - made of soft rocks as sedimentary, sand and clay	- sloping areas and slope prevail compared to the interfluves and the plain areas	Hill
Mountain	- altitudes above 800 m - strong sloping areas prevail	- made of rocks - crossed by rivers - present in Romania	- lower altitudes under 300 m - plain surfaces prevail - higher temperatures	Field

7. Conclusion

The study focused on Venn Diagrams used in the field of Geography, for various comparisons, and revealed some relevant concluding remarks. The specialized literature revealed that the main actors in the students' education are less interested in Venn Diagrams, with this teaching resource remaining marginal in teaching and learning Geography. Accordingly, the critical and analytical geographical thinking also have a peripheral position within the educational process, as this topic remains marginal in the specialized literature. The diagrams included in various works illustrate a major diversity of geographic objects (geographic systems) that are differently compared, using various approaches. Many sampled diagrams highlight the comparison of different objects without specifying particular criteria.

The students' analysis of diagrams indicated relevant difficulties when the diagrams were used. This is argued by the fact that only 30 percent of them are correctly using the resources recommended by the professor. The textual expressions included in diagrams clearly indicate that the students make use of critical and analytical thinking but with certain limitations when the geographic language is used. These issues could be solved through some major time resources in order to properly learn the geographic contents, either during university study programs or through individual study. Making use of some specific exercises aiming at diagrams construction closely supervised by the professor could represent one action in the learning of geography using Venn Diagrams.

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