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THE USE OF MENTAL MAPS IN THE ASSESSMENT OF GEOGRAPHIC KNOWLEDGE: FORM AND CONTENT OF MAP SKETCHES DRAWN BY LAST YEAR PRIMARY EDUCATION STUDENTS IN THE BALEARIC ISLANDS (SPAIN)

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Abstract

This work pursues the study of mental maps as a tool to assess the geographic knowledge of the Balearic Islands among school students from 17 primary education schools. The study reveals an interrelationship between the formal aspects of the cartographic sketches and the level of geographic knowledge expressed (content) through the mentioned places. This finding adds value to the power of cartographic sketching as a tool for the study of geographic knowledge, disproving those who question it.

Key words

geographic literacy • mental maps • Balearic Islands • location • profile

Introduction

The current importance of Geography has been recently acknowledged (de Blij, 2012). Globalization, added to the relentless progress of geographic information technologies (GIT), has unleashed a growing interest in our science in related fields such as geo-archaeology, geo-linguistics, etc. (Murphy, 2018).

Paradoxically, many wonder about the lack of geographic knowledge of citizens in general, or about students' scarce interest in geography. As an example, De Miguel (2018) reports the decrease in the number of geography teaching hours in primary education amid the indifference of future teachers and the scant consideration given to this subject matter in student surveys.

The debate, however, goes further and also stresses the role of geography in the official curriculum. The confrontation between everyday geography and academic geography (Catling & Martin, 2011), the choice of knowledge content when preparing the school curriculum (Roberts, 2014), and the discussion around powerful knowledge in geography teaching (let us recall Geocapabilities, the project by Lambert et al., 2015) bring to light the doubts that are also cast by how our field is approached in the areas of primary and secondary education.

Said concerns have led to the creation of a research group interested in students' knowledge of geography at different stages of compulsory and university education. Pursuing this avenue of reflection, students' personal geographies across different educational cycles have been used to analyze the state of geographic knowledge of university and primary education students from the didactics of geography perspective. For more than five years, in the field of Spanish geography research, there have been several initiatives focused on an evidence-based topic that examines the relationship between geography and education, exploring the geographic knowledge of future teachers and school students (Binimelis Sebastián & Ordinas, 2016). This has been used as a basis for several studies whose first results analyzed the areas or enclaves mentioned in mental maps by the participating students (Binimelis Sebastián & Ordinas, 2018, 2022). The relationship between the distance to the school center and the frequency of appearance of the quoted placenames was another of the addressed topics, alongside differences in school students' cognitive patterns regarding the islands (Binimelis Sebastián et al., 2021). Moreover, how students from different universities view Spain has also been studied (Gómez-Gonçalves et al., 2021; García-González et al., 2023). In short, the acquisition of geographic knowledge and skills among students and schoolchildren is setting the pace of the research team's agenda. For this purpose, mental mapping and multiple-choice tests have been used as diagnostic tools, both being methods that are categorized under the label of cognitive geography (Portugali, 2018).

This study delves into an aspect of this same area that has scarcely been broached in the literature. The presence and correct location of the elements (islands) on the whole (Balearic archipelago), the study of the coastline of the insular spaces reflected in the filed cartographic sketches are the first formal aspects approached. Additionally, the relationship between content (number of mentioned placenames) and form (profile of the isles and their presence and location) of the mental maps is also analyzed in what is the most original and significant contribution of the article. The research hypothesis defends that there is an interrelationship between form and content in the sketch maps drawn by schoolchildren.

Cognitive geography, education and geographic knowledge.

Since the 1960s of the past century, we have witnessed the birth and irregular development of what was termed as the geography of perception, the common denominator among the authors who have cultivated it is the claim of the subjective dimension in human's relationship with the territory, an individual with limited rationality who not only responds to economic stimuli. Mental maps on an individual's spatial perceptions (landmarks, paths and areas of a city, perception of atmospheric weather, residential preferences) have been one of the most commonly used tools by those who have pursued this line of reflection in geographic science. In general, geographers gather a significant sample of individual mental maps to seek, after their analysis, the commonplaces of the group subjected to the cartographic survey (Gould & White, 1974).

Geography of perception emerged as a hybrid line between two trends. On the one hand, it was contemporary with and close to the structuralist-Marxist-humanist revolution,

since, by dealing with human behavior in space, it has been close to humanistic geography because of its emphasis on people's subjectivity and sense of place. On the other hand, from a methodological point of view, it shared quantitative techniques, although the coincidence of its development with humanistic geography led to the development of a line where qualitative methods were used (Boira et al., 1994). In the United States, it reached its zenith in the early 1980s, when different indicators reveal the numeric importance of environmental perception (number of geographers in the Association of American Geographers, number of PhDs defended, master's theses and dissertations on environmental perception) (Saarinen, 1984). Meanwhile, cognitive geography drew from its close ties with environmental psychology in Francophone areas, finally having scarce relevance in France, materializing in a collection of scattered individualities across the French university map. In the meantime, in the United Kingdom, there was a small number of researchers with initial expectations that proved unrealistic (Gold, 1984). Nevertheless, geography of perception found its own path beyond the influence of the structuralist-Marxist-humanist revolution and also away from the topics of interest of quantitative geography (Portugali, 2018).

Interest to date in cognitive development regarding spatial and geographic issues, as is, for example, the retention of geographic knowledge (especially placenames and their location, skills to navigate and orient oneself on the territory, and skills to understand cartographic language) has drawn the attention of psychologists, neurologists, experts in the area of artificial intelligence and, obviously, geographers (Montello et al., 2018).

The elaboration of tests and techniques to measure the acquisition and retention of geographic knowledge is known as geographic literacy (Turner & Leydon, 2012). In its most complex conception, it demands that respondents have critical understanding tools and skills to appreciate the association of geography with natural resources and the difficulties that countries face (Memisoglu, 2017). Its implementation involves a variety of methods and techniques among which are sketch maps, also called mental maps, place location knowledge and, finally, multiple criteria tests that include the identification of places alongside physical geography and human geography tasks (Misheck et al., 2013).

The use of mental maps as a source to diagnose geographic knowledge has a long history. It is a long-established line of work, especially from the 1970s to the 1990s in the United States (Saarinen, 1973; Saarinen & Maccabe., 1995; Chiodo, 1997; Nishimoto, 2012), and also in the United Kingdom. Patrick Wiegand (1995, 1998), as a single author or in collaboration with Bernardette Stiell (Wiegand & Stiell, 1996, 1997a, 1997b), uses mental maps of the world and the British Isles in his research, believing, as we do, that they are high-value material to study the development of knowledge and the spatial understanding of school students and teachers-to-be, their analysis and classification playing a key role in the improvement of teaching activity (Wiegand, 1998). Later, Harwood and Rawlings (2001) take over Wiegand's baton and, using a largely qualitative methodology, conduct an educational intervention including a pre-test and a post-test based on the use of a mental map of the world to assess the correct location of countries and continents, outline and size or surface area. The British have always shown concern with their young people's knowledge of their territory, stressing the fact that ignorance of their own geography has a bearing on their poor national awareness, which is more marked among primary education schoolchildren (Catling, 2009). More recently, the Meaningful maps project was developed, based on the use of mental maps drawn by 7-to-11-year-old schoolchildren in the United Kingdom to assess their progress in cartographic skills and geographic knowledge, as well as their sense of place, reflecting on affective aspects that explain the sketches drawn and on underlying cultural reasons (Vujakovic et al., 2018).

On the other hand, knowledge of Europe and the world has generated valuable literature in other academic contexts. In this light, attention should be drawn to the article by Rédep et al. (2011), exploiting the partial results of the project Eurobroadmap -Visions of Europe and the World-, where Hungarian university students analyze their perception of Europe and the world. Mention should also be made of the study by Sudas and Gotken (2012), based on the survey replies of Turkish students, and of the most recent work by Bagoly et al. (2023), where the maps of Europe drawn by 43 secondary students of Berlin are studied. The local context perceived by students, using Lynch's method, continues to be used as a research tool, as evidenced in recent studies focused on cities such as Szczecin (Poland) (Osóch & Czaplinsa, 2019), and Albacete (Spain) (García, 2018).

Ultimately, although never considered in Spanish geography, deliberation on the acquisition of geographic knowledge is a well-trodden path in other academic contexts (Scoffham, 2019). We are unaware of any solid initiatives aimed at using mental maps as a tool to diagnose the geographic knowledge of schoolchildren and students in Spain, except for the odd occasion (Boira et al., 1994).

The development of this line of research in Spain coincides in time with the implementation of the new Organic Law 3/2020, which amends the former Organic Law on Education (LOMLOE). The weight given to the geographic knowledge of Spain and its Autonomous Communities in its curricular design justifies this article on mental maps of the Balearic Islands.

Methodology

In former studies, progress in the search for a quantitative methodology fitting to assess students' mental maps was made (Binimelis Sebastián et al., 2021; Binimelis Sebastián & Ordinas, 2022b). Research here is focused on future teachers and primary education schoolchildren's geographic knowledge of the Balearic Islands. Mental maps have been the tool that, based on references specific to cognitive geography, has been used to assess and analyze geographic knowledge. The purpose of this article is to continue such task, studying the intrinsic qualities of the drawing itself, such as the presence and location of the islands (parts) on the archipelago (whole), as well as their corresponding outlines. On the other hand, these formal variables of schoolchildren's map sketches are associated with another variable: the number of placenames listed by students on their sketches. The purpose, in essence, is to find out the relationship between form and content in the mental proposals of insular schoolchildren, working from the hypothesis that both dimensions are related and are, therefore, indicators of students' geographic knowledge of the islands. With this in mind, the aim is not only to advance in a methodology that uses education in geography to delve into the assessment of students and schoolchildren's geographic knowledge but also to provide new arguments, from the cognitive geography perspective, to support that mental maps are an indicator of an individual's awareness of the represented place and not merely an exercise to display drawing skills.

For this purpose, we have used a total of 556 sketches drawn by sixth-year primary education students from 17 school centers in Mallorca. The maps were collected during academic years 2016-17, 2017-18 and 2018-19. The average number of schoolchildren registered in the last year of primary education in the Balearic Islands over such period was 11,721. Hence, the sample size allows work with a 98.44% confidence interval and a 5% margin of error (Clemente, 1992). A total of 220 schoolchildren belong to 7 aided schools and the remaining 336 to 10 public education centers, all of them scattered across the insular geography, although convenience sampling was used. In a previous study, we addressed the content of mind maps drawn by primary education schoolchildren based on the toponyms or places they mentioned (Binimelis Sebastián et al., 2021). This study approaches the analysis of formal

aspects of mental maps and delves into their relationship with their contents.

In this case, the objective is the study of the presence and location of the main islands (Mallorca, Menorca, Eivissa, Formentera and Cabrera) on the Balearic archipelago and the characteristics of their coastline, to subsequently address the relationship between formal characteristics and map content in more detail. The use of drawing skills to measure geographic knowledge has been criticized in the past. However, Bell (2004, 99) tested the relationship between the two components that are included in the assessment of mental maps: on the one hand, geographic knowledge proved through the countries and places mentioned and, on the other, the skill to adequately draw their outline. And he proved that both spheres of geographic knowledge acquisition are related and that the design of a map from memory cannot be mistaken for drawing skills acquisition. The exercise conducted also explores this aspect.

The following criteria were used to study the presence, location and outline of the islands.

Firstly, the presence and correct location of the larger islands on the insular group was recorded. There are exercises where only Mallorca is sketched and others where Cabrera is not drawn. On the other hand, Formentera or even Cabrera can be drawn north of Eivissa. Hence, we have registered all the anomalies of the analyzed maps.

Secondly, the so-called weights matrix of relative locations was used (Wiegand & Stiell, 1997a), where each map was allocated a value according to the relative position of each of the five regions that made up the British Isles regarding the rest (England, Scotland, Wales, Northern Ireland and the Irish Republic). In our study, the relative position of each of the five main islands is assessed (Mallorca, Menorca, Eivissa, Formentera and Cabrera). A map with an optimal relative location of all its elements is rated 10, while 0 would be the value given when the relative position is incorrect for each of the group of combinations of two islands of the archipelago. It is, unquestionably, a tool that offers a synthetic method of assessment of the relative position of the elements drawn on the group they belong to. It is a simple matrix that is built to mark whether each of the pieces of the set (islands in this case) appears in the correct relative position regarding its pair (Tab. 1).

Table 1. Weights matrix of relative locations using Map 0700553202[1] as an example (see Fig. 4)

	Mallorca	Menorca	Eivissa	Formentera	Cabrera
Mallorca	-	1	1	1	1
Menorca		-	1	1	1
Eivissa			-	1	1
Formentera				-	1
Cabrera					-

Thirdly, the outline of the islands on each map is assessed. For this purpose, 10 elements in total that provide the coastline of the Balearic archipelago's islands with singularity and describe its concavities (capes, peninsulas, etc.), convexities (ports, bays) and other unique forms of the outline were identified. Wiegand and Stiell (1997a, 1997b) used a total of 32 elements or landmarks to define the outline of the British Isles among schoolchildren and 36 among teachers-to-be. In this study, the selection is limited to the following 10: presence of the bays of Palma; Alcúdia; Pollença; Cap de Formentor as the northernmost point and Cap de ses Salines as the southernmost on the largest island; the position of Ciutadella slightly more to the north than Maó; the presence of Sant Antoni de Portmany Bay; Barbaria Cape as the southernmost point of Formentera; the concave outline of Migjorn beach and the presence of the point of La Mola lighthouse. The assessed items reduce the outline of the

[1] This is a code of anonymization that is made according to the official school code of the Register of the Balearic Islands' schools (Balearic Islands Regional Government).

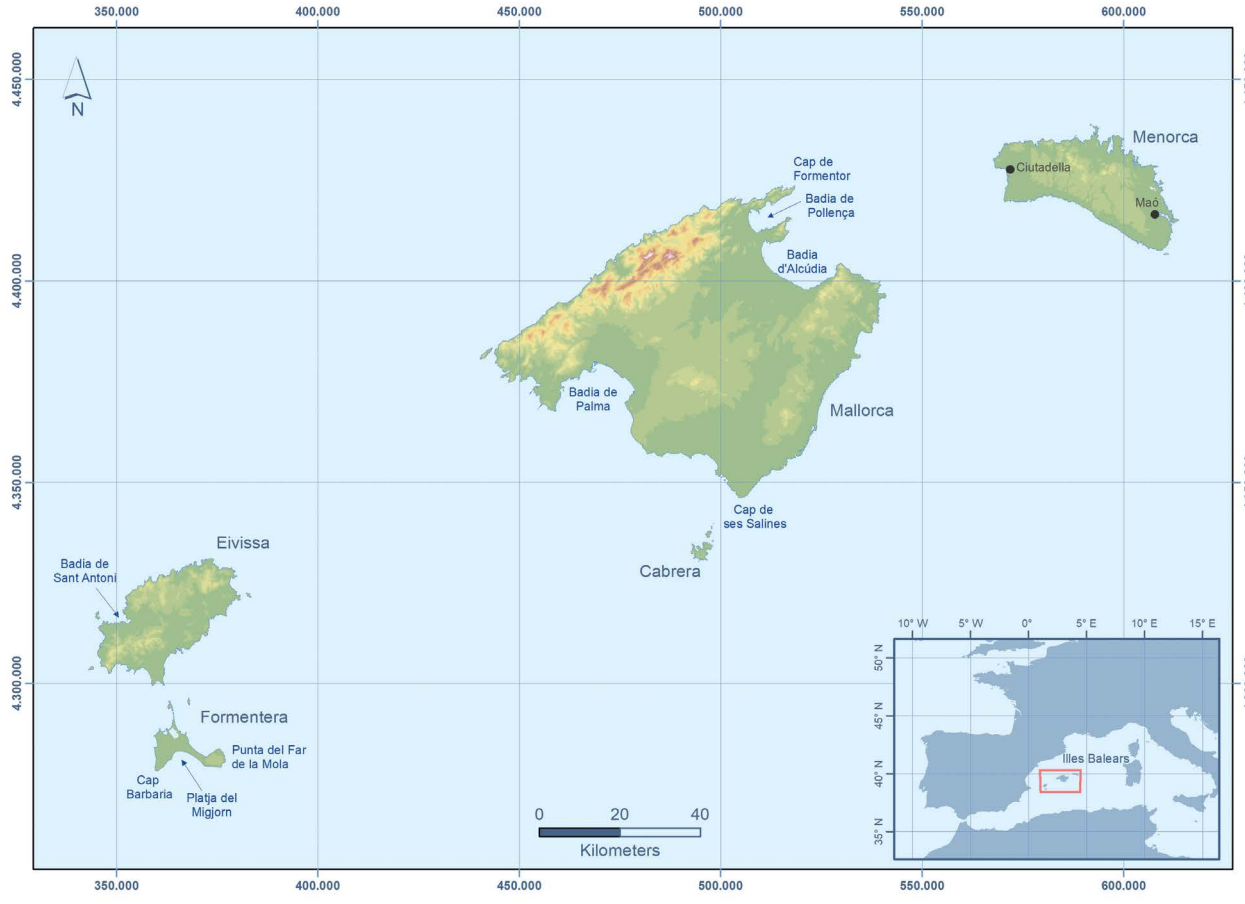

Figure 1. Map of the coastline enclaves of the Balearic archipelago assessed on the mental maps

Balearic Islands to a minimalist version of the archipelago. Features as singular as Punta de n'Amer, the ports of Eivissa, Sóller, PortoColom, Ciutadella, Maó or the Badia de Fornells have not been taken into account. Nor has the double curve drawn by the southern coastline of the larger island when it goes from the dip of Palma to the dip of Campos, following the outline of the Vindobonian platform. After previewing the group of maps, the decision to assess the outline of the islands based on 10 items was made[2].

These features or enclaves that add uniqueness to the outline of the larger islands of the archipelago on each map have built the information used to assemble a database with values 1 and 0 according to their presence or absence in the cartographic sketches designed by the students. Their absence and, therefore, shaping of a more unreal sketch, was given a value of 0, whereas their presence and, in essence, sketching of a drawing that is closer to reality, was assessed as 1.

The binary data matrix obtained was used as the source for conducting a cluster analysis where the mental maps of the participating students were arranged. On the other hand, principal component analysis was used to reduce the number of variables from 10 to two (the first two factors). Both analyses finally led to representing the mental maps, according to the cluster they belonged to, on a scatter plot where the two factors of the PCA (principal components analyses) worked as variables.

The binary data information matrix was used for hierarchical clustering using SPSS software (IBM SPSS Statistics 25), using Ward's method and squared Euclidean distance as the parameter to measure the distance between the values of the different individuals. On the other hand, principal components factor analysis is a technique that allows the reduction of dimensionality, which means that its purpose is to synthesize a large volume of data (García de León, 1988). This procedure has led to the graphic representation of the clusters (3) obtained from the cluster analysis by reducing the number of variables (10) to only two that explain 60% of the variance.

Finally, the results obtained from the categorization of the mental images (cluster the sketches belong to) according to the accuracy of their outline, as well as the result achieved by each of them on the weights matrix of relative locations, were interrelated with the content of said maps (number of placenames mentioned). Hence, the measures used (Kruskal Wallis, Mann-Whitney; Spearman's correlation, Kolmogorov-Smirnoff test...) have facilitated the statistical significance between form (location, presence and outline) and content (places mentioned) of the cartographic sketches drawn by the schoolchildren of 17 primary education schools.

Results obtained

Presence and location of the islands

Only 44.8% of the total sketches of the Balearic Isles drawn by the schoolchildren are complete, meaning that the percentage of inclusion of all the main islands of the archipelago is reduced to a percentage below one-half. As regards the rest, the most noticeable absence is Cabrera, which disappears from the reader's observation in 257 cases, being present in only 53.8% of the total. The outlines of Menorca (78.6%) and Eivissa (77.2%) appear in percentages that are similar to and near three-quarters of the total. In turn, Formentera is only included in 70% of the cases, while the largest island is omnipresent. In essence, it is surprising that a considerable number of the schoolchildren who complete the primary education cycle fail to include one or another of the larger islands of the community they live in (Fig. 2).

From another perspective, the outcomes regarding the correct location of the islands were very negative. Only 31.5% of the participants managed to draw sketches where the five main islands were correctly located (175 maps). In this case, the two Pityuses

[2] The decision is not oblivious to subjective bias, but responds to the reality of the examined maps. In the hypothetico-deductive method, there is mutual feedback between induction and deduction.

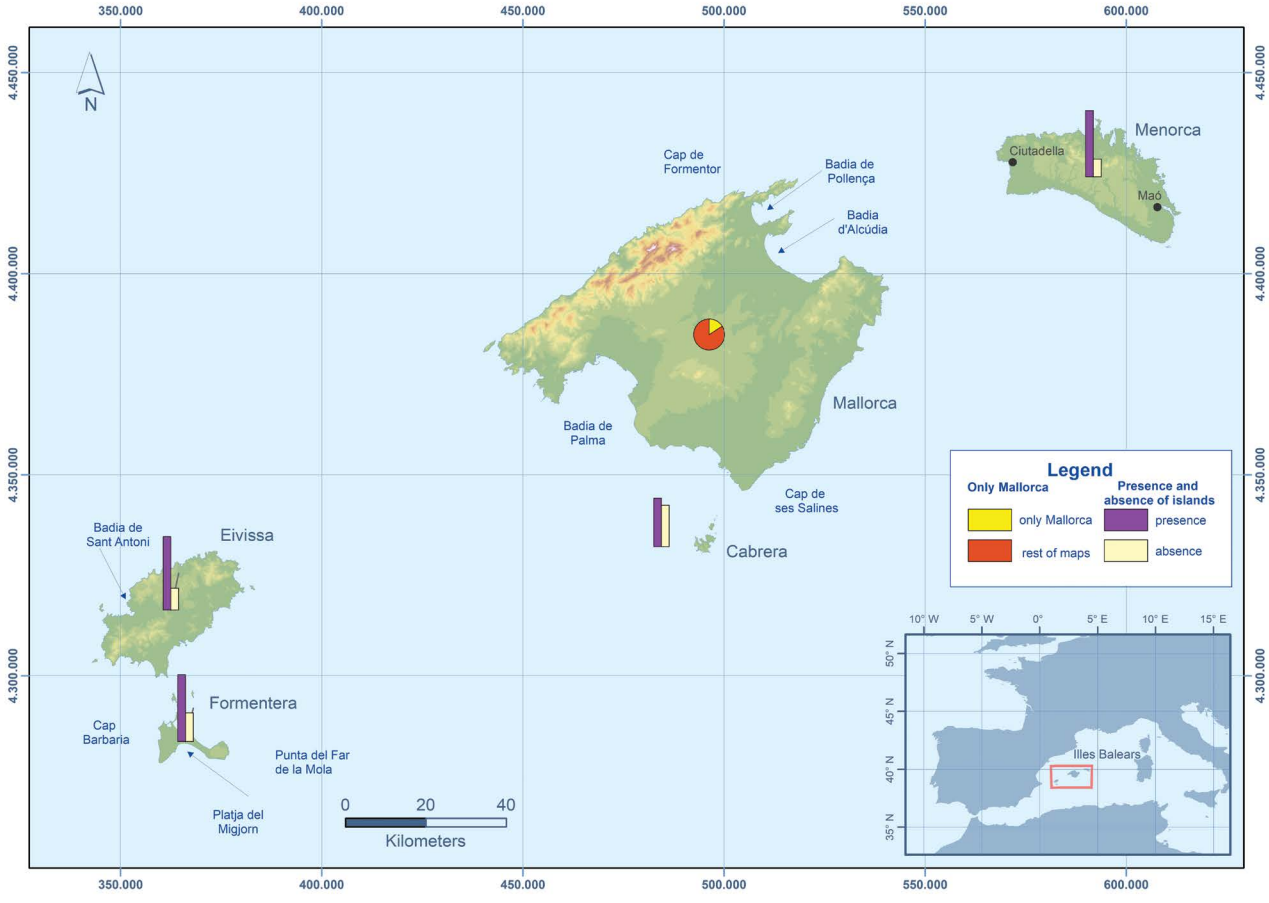

Figure 2. Presence of each of the islands on mental maps of the Balearic archipelago

are the worst located in the group of studied maps (Eivissa, 64.6%; Formentera, 61.1%), while Cabrera (68.5%) and Menorca and Mallorca are the best positioned. There is, on the other hand, a small group of 16 maps where none of the islands is correctly situated (Fig. 3).

The sketches are characterized by inaccuracy and misplacement of their elements. The absence of islands can be noticed in more than half of the mental maps examined, Cabrera being the most overlooked by schoolchildren (only present in 53% of the sketches). In addition to this failure of inclusion, misplacement with respect to reality is another handicap that defines the mental images of the Balearic archipelago. Only 31.5% of the total included the correct location of the five islands.

This first impression offered by the data shows that the forms and outlines of the maps are also characterized by their remoteness from the reality they represent. In this case, not only are the five islands misplaced regarding the whole of the archipelago, but many maps even have marked absences.

There are methodological rudiments that quantify, even, the relative position of the elements (islands) within the whole (archipelago), as regards location and presence, that have been used in exercises with similar purposes to ours (Wiegand, 1997b), which have already been described in the methodology section.

Results of the weights matrix of relative locations.

Following the explanation in the methodology section, this matrix measures the relative weight of the position of each island on the archipelago. The results of its application on the group of analyzed maps show an equitable partition where the maps with high numbers of correct relative locations (8-10) account for 11.5%, second place is taken by those with an average number (5-7), accounting for 22.3% and, finally, the last group would be made up of the map sketches with a low number (0-4), accounting for 66.2%. The majority of maps display a low number of correct relative locations and those with a high number are very scarce (Tab. 2).

Table 2. Categorization of mental maps on the weights matrix of relative locations

High (3)	64	11.5%
Average (2)	124	22.3%
Low (1)	368	66.2%
Total	556	100.0%

These criteria led to a first categorization of the maps according to the number of correct results scored on the matrix, a figure that gives a global value to the location and presence of the islands on the archipelago. The findings show the poor geographic knowledge of the schoolchildren examined using the mental images of the Balearic Islands that they have produced. More than 66% of the maps have fewer than 4 correct relative locations. Missing islands (very frequent in most of the maps) and incorrect locations explain the results yielded by the application of the matrix of relative locations.

Despite this, it is a partial view to assess the formal correction of the map sketches. Hence, they are only some initial results for the formal aspects of the sketches drawn by the primary education students. Knowledge about the insular outline is the second aspect to be addressed.

Knowledge about the outline of the islands

Ten outstanding features that mark the concavities and convexities of the insular coastline were identified and assessed, leading to a second distribution of the mental maps into 3 categories according to the number of correctly drawn coastal landmarks. The first group comprises the most accurate, with a high rate of correct answers (8-10) as regards coastline singularities (14.6%); the second group, with an average rate of correct answers (5-7), accounts for 28.9% of the total; the third place corresponds to the worst

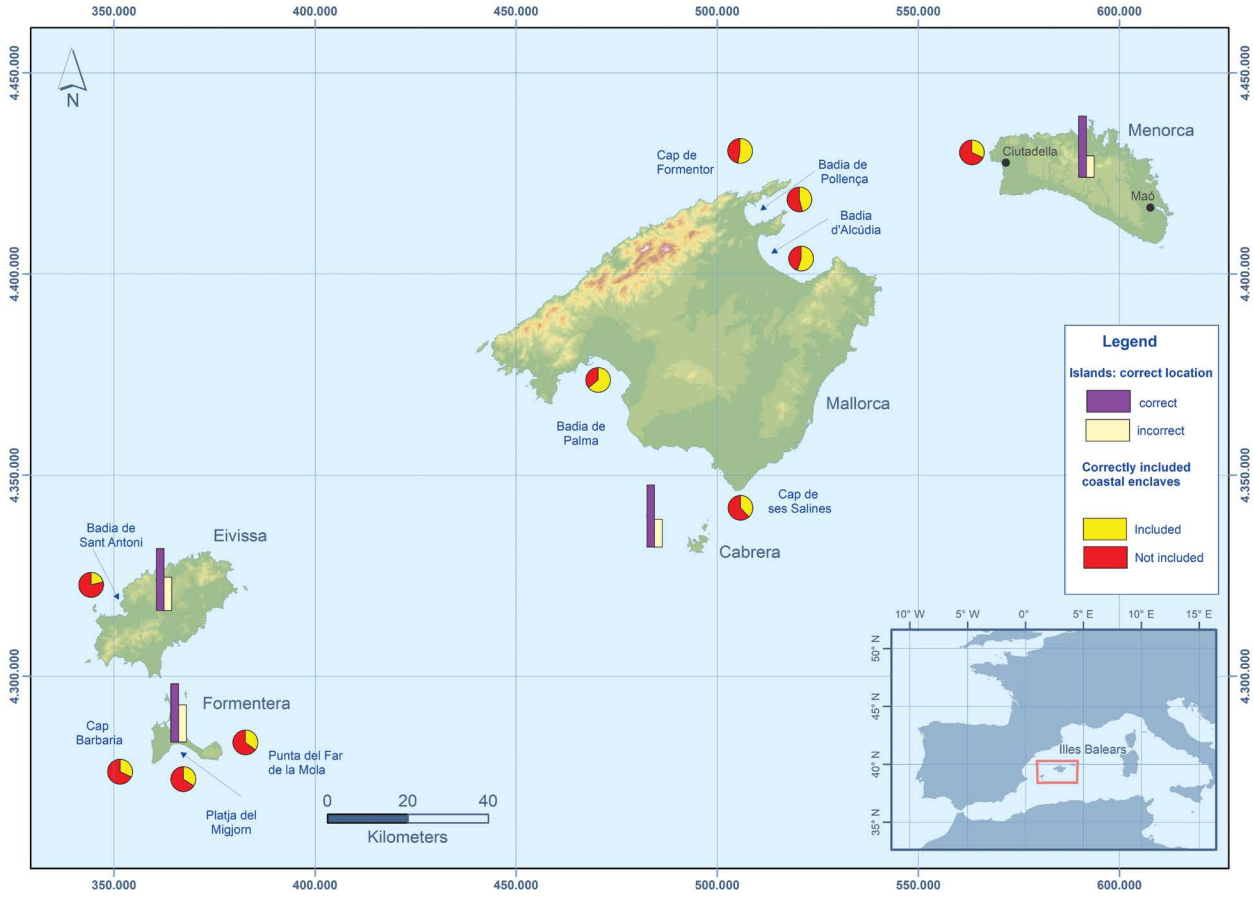

Figure 3. Correct location of the islands and number of correctly included coastal enclaves on the mental maps of the Balearic archipelago

accomplished sketches, with low guess rates (0-4 coastline enclaves, 56.5%). In general, maps with outlines that are hardly or not at all correct, with marked inaccuracies, predominate over maps with high or intermediate rates of correctness (Tab. 3).

Table 3. Categorization of mental maps according to the accuracy of the coastline outline

High	81	14.6%
Average	161	28.9%
Low	314	56.5%
Total maps	556	100.0%

The map sketches show their authors' ignorance of the outline of the isles. In general, the Badia de Palma is the convexity that is best reflected on the sketches analyzed (present on almost 64%), followed by the bays on the northeastern coast of Mallorca (Badia d'Alcúdia and Badia de Pollença, with 55.4% and 53.1% of the total, respectively). Besides, the Cap de Formentor, as the most northern landmark is drawn on more than half of the examined sketches (53.1%). However, the Cap de ses Salines was only drawn on 38% of the total maps. Conversely, the landmarks of the smaller islands' coast are the least well-known. Ciutadella (N40°0' 8'') is, correctly, placed at a higher latitude than Maó (N39°53'17.2") on 31.5% of the maps; Formentera's convexities and concavities are identified on one-third of the maps (Cap de Barbaria, 31.7%; Platja del Migjorn, 34.4%; and Punta del far de la Mola, 35.3%). Finally, the Bay of Sant Antoni de Portmany in Eivissa stands as the least-known coastal landmark in the mental images that schoolchildren hold of the archipelago. They are clearly less familiar with the characteristics of the outline of the smaller islands than with those of Mallorca due to the Majorcan origin of the participating students, as well as the fact that Mallorca is clearly at the center of some of the characteristics examined on the maps. These data prove a minimalist perception of the islands since, because they were not included in any of the analyzed maps, other outstanding geographic landmarks, such as the ports of Sóller, Porto-Colom, Maó, Ciutadella or Badia de Fornells were not even considered as assessable variables of the outline (see Footnote 3) (Fig. 3).

Therefore, the mental maps represent profiles that are far from reality and inaccurate, and there is a majority with scarce correct information as regards the coastal landmarks that are considered to be basic in the definition of the islands' outline. Only the Bay of Palma, the Badia d'Alcúdia and the Cap de Formentor are drawn on more than half of the maps. On the other hand, the least known coastal outlines are those of Formentera and Eivissa.

Cluster analysis categorization of the mental maps

Nonetheless, the mental maps were further subjected to a new categorization based on the variables that define the profiles. This was done using cluster analysis (Ward's method), and principal components analysis, whose result yielded a scatter graph of factors 1 and 2 to graphically illustrate the results of the cluster analysis (Fig. 4).

Factor 1 is defined as Correction in the outline of the smaller islands, since all the landmarks and characteristics on the outlines of these islands' profiles score high or at least average on the matrix of components. The weights of the variables related to the coastal characteristics of Mallorca are low and negative. On the other hand, factor 2 is defined as Correction in the outline of Mallorca, since all the variables related to the coastal landmarks of the largest island score high. The weights of the variables related to the Pityuses in this second factor are very low or negative on the components matrix (Tab. 4).

The scatterplot (see Fig. 5) groups the maps according to their weight on both factors and their belonging to the clusters defined in the cluster analysis. The maps encompassed by cluster 1 (see Fig. 4) maintain a negative weight in factor 1 and a positive weight in factor 2, being maps whose

Figure 4. Map 0700724303. Its weight on the relative weights matrix is 10 (Category 1: high) and it belongs to cluster 1

Table 4. Principal component analysis rotation matrix

Variables	Factor 1	Factor 2
Badia de Palma	-0.009	0.667
Badia d'Alcúdia	0.038	0.774
Badia de Pollença	0.124	0.756
Cap de Formentor	0.100	0.788
Cap de ses Salines	0.057	0.656
Menorca (Ciutadella-Maó latitude)	0.575	0.178
Badia de Sant Antoni	0.689	-0.052
Cap de Barbaria	0.879	0.054
Platja del Migjorn	0.913	0.080
Far de la Mola	0.903	0.070

correctness is confined to the largest island. Cluster 2 gathers the maps with positive weights in both factors, maps, therefore, with an accurate outline. Cluster 3 comprises those maps whose sign is negative in both factors, their outlines being inaccurate and imprecise and missing some of the archipelago's islands. Finally, cluster 4 consists of maps whose outline of Mallorca is correct but have significant mistakes in the outlines drawn for the rest of the islands (Fig. 6).

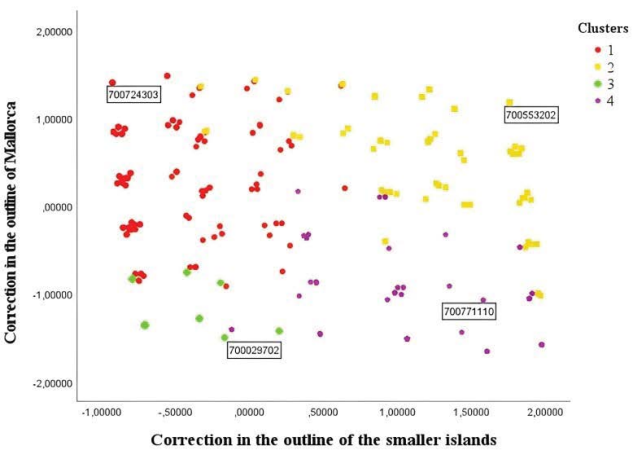

Figure 5. Categorization of mental maps according to the cluster they belong to and weight on the factor scores matrix (Factors 1 and 2)[3]

[3] Codes 700724303, 700553202, 700029702 and 700771110 correspond to the maps shown in Figures 4, 6, 7 and 8.

Figure 6. Map 070053202. Its weight on the relative weights matrix is 10 (Category 1: high) and it belongs to cluster 2

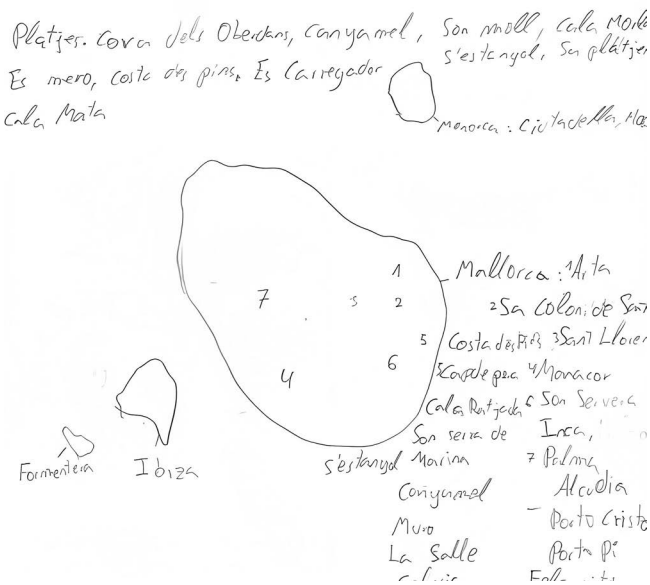

Figure 7. Map 070029702. Its weight on the relative weights matrix is 3 (Category 3: low) and it belongs to cluster 3

The analysis conducted compares the highly correct maps (126 samples belonging to cluster 2) (see Figure 6) with those whose outline of the largest island is more accurate (248 sketches belonging to cluster 1). There is also a considerable number of maps that are incorrect and inexact in the drawing of all the islands (182 maps belonging to clusters 3 and 4) (see Figs. 7 and 8), albeit those under cluster 4 show an unmistakable lack of quality in the drawing of Mallorca's outline.

Relationship between the presence and location of the islands and the characteristics of the outline

Two of the aspects of the map sketches were studied separately: on the one hand, the

Figure 8. Map 0700771110. Its weight on the relative weights matrix is 0 (Category 3: low) and it belongs to cluster 4

presence and adequate location of the elements that make up the group and, on the other, correction or accuracy of the concavities, convexities or other features of the insular outline. This was approached through the use of several descriptive and analytic procedures, although there were finally two outstanding categorizations for the maps: the matrix of weights of correct locations allowed the subdivision of maps into three categories, and cluster analysis categorized the maps into four clusters according to the characteristics of their outlines.

Table 5. Crosstabulation between the results of cluster analysis and categorization according to the matrix of weights of correct locations

Clusters	Categories according to weight on the matrix of relative locations			Total
	1	2	3	
1	157	66	25	248
2	66	32	28	126
3	98	13	5	116
4	47	13	6	66
Total	368	124	64	556

Neither of the two indicators that define the formal correction of the map sketches is independent. The association of these variables using crosstabulation (Table 5) leads to a new arrangement that, in turn, allows the calculation of Pearson's chi-square, which is 37.830, a value with a statistical significance of $p = 0.000$, so that $p < 0.05$ and, therefore, the result is statistically significant. Conversely, on the crosstabulation tables, there are no cells with expected counts below 5, which further validates the test's results. Hence, the null hypothesis is rejected and the relationship between the two variables is proven.

Relationship between formal and content aspects on the map sketches

In the methodology section we already explained that, in addition to analyzing the map sketches' formal aspects (presence, location and outline of the islands), our goal was to analyze the relationship between formal aspects and their content.

Content is analyzed based on the toponyms or placenames mentioned. The relationship between students' origin and the frequency which toponyms were quoted with was

proven in its time (Binimelis Sebastián et al., 2021). On the other hand, the matrix of relative locations is a method that (Wiegand, 1997b) has provided a synthetic indicator as regards the adequate location and presence of the elements (islands) that make up the whole (archipelago). The distribution of both variables is not normal (statistical significance according to the Kolmogorov-Smirnov test being 0.000 in both cases). Because of this, we used Spearman's nonparametric correlation to test the relationship between both variables. The result was 0.275, an average-low, although statistically significant, correlation (the statistical significance level is 0.000, below 0.01). Therefore, even if average-low, there is a correlation between the two variables.

Conversely, evidence shows that the average number of mentioned placenames grows larger as the results of the matrix of relative location increase (Table 6). Hence, goodness in formal elaboration corresponds with a greater geographic knowledge of the archipelago.

Table 6. Average number of placenames according to category on the matrix of relative locations

Category according to weight on the matrix of relative locations	Average number of placenames
Low (0-4)	12.6
Average (5-7)	14.3
High (8-10)	19.4

Additionally, the Kruskal-Wallis test[4] for independent samples shows that the distribution of the number or placenames is not the same across the categories defined by the weight on the matrix of relative locations (statistic value 32.001 and statistical significance level $p < .0001$; therefore, $p < 0.05$). Thus, the samples are not independent and there is a relationship between the number of placenames and the score on the matrix of relative locations.

The relationship between the categories that that the maps belong to as defined by cluster analysis and their number of placenames provides new leads to the relationship between form and content. The clusters that are characterized by greater precision and accuracy (2 and 1, in this order) are those which include a larger average of placenames. Meanwhile, the most imprecise groups (4 and 3, also in decreasing order) are also those whose average as regards the number of mentioned placenames is lower (Tab. 7).

Conversely, the Kruskal-Wallis test[5] for independent samples verifies that the distribution of the number of mentioned placenames is not the same across the different clusters of map (statistical value 13.518 and statistical significance level $p = .004$; therefore, $p < .05$). The result obtained once again proves the relationship between outline and the number of placenames mentioned by the participating schoolchildren.

Table 7. Average number of placenames according to the cluster they belong to, as defined by cluster analysis

Cluster	Average number of placenames	Number of maps
1	14.08	248
2	15.44	126
3	12.16	116
4	12.21	66
Total	13.77	556

Discussion and conclusions

Few references systematically approach the assessment of the outline, location and presence of geographic features on mental maps. Studies, with only a few exceptions (Saarinen

[4] Nonparametric test used because the distribution of the number of placenames per map on each of the categories created according to the weight of relative locations is not normally distributed according to the Kolmogorov-Smirnov test.

[5] See explanation in footnote 4.

et al. 1996, Wiegand & Stiell, 1997a, 1997b; Harwood & Rawlings, 2001), have always focused on measuring geographic knowledge through the study of mental maps, devoting their efforts to analyzing the places mentioned on the analyzed map sketches rather than the correct outline of political borders or coastlines. As noted at the time, there was a conviction that cartographic production from memory was more related to skills than to knowledge (Bell, 2004).

The analysis contributed by this work addresses formal aspects of mental maps as alternative methodological tools to the ones used by Wiegand and Stiell (1997b), or Harwood and Rawlings (2001), in their day, both studies assessing mental maps using qualitative techniques. The first two authors introduced the relative locations matrix, a synthetic measure of the correct presence and location of the elements that are part of a group, taken up again in this study. The second two authors conduct an educational intervention exercise based on assessing the accuracy of location, outline and size of countries and continents on maps of the world drawn by 11-year-old students. However, this work sidesteps a large part of such assessment methods and introduces quantitative solutions against the use of the more descriptive methods mentioned (Wiegand & Stiell, 1997b; Harwood & Rawlings, 2001).

On the other hand, it has been proven that the formal aspects of the map sketches, as well as drawing skills, reflect the idea stored in the mind of the geography of the represented place. The article approaches the study of formal aspects (presence, location and outline of the main islands of the Balearic archipelago) and content (number of quoted placenames) of 526 maps prepared by sixth-year primary education students.

The study reveals poor knowledge of the archipelago among the participating schoolchildren. First, a large part of them fails to include at least one of the five main islands in their map proposal. In fact, only 44% of the maps include all the main islands of the Balearic archipelago, Cabrera being the most omitted island (only present in 53% of the maps).

Secondly, the location of the insular group is correct in only 31.13% of the total maps, with Eivissa and Formentera being the islands that are most frequently misplaced. Furthermore, barely 11.5% score high on the matrix of weights of relative locations, which in this case, in fact, assesses the presence and relative location of the isles.

Thirdly, poor knowledge of the outline of the Balearic coastline is widespread. Indeed, barely around 14.6% are accurate in drawing the archipelago's coastal outline. The Bay of Palma, the Bay of Alcúdia and the Cap de Formentor are enclaves whose presence is noted in more than 50% of the examined sketches. The rest of the enclaves assessed reveal percentages of around 30%, or even lower (the Bay of Sant Antoni Abad is only drawn on 21% of the map sketches).

On the other hand, there is proof of the interrelationship between the results of the matrix of relative weights and locations and the cluster analysis categories. Such interrelationship is statistically significant and reveals that two formal indicators as are the presence and correct location of the isles, and their outline are not independent features.

There is also an interrelationship between the variables that indicate the formal goodness of the maps and their content, measured through the number of placenames mentioned. Firstly, there is a significant average-low correlation between the latter variable and the weight of each map on the relative locations matrix, with a Spearman correlation of 0.275. The same relationship is confirmed with the Kruskal-Wallis nonparametric test, which proves that the distribution of the average of the number of placenames according to the category on the relative locations matrix is variable rather than homogeneous, the number of toponyms increasing in the categories with greater formal goodness. On the other hand, there is proof (Kruskal-Wallis nonparametric test) of the relationship between the coastal outline of the isles and the number of placenames mentioned in the cluster

analysis categories. Briefly, several measures have revealed the relationship between goodness of formal construction of the mental maps and their geographic content (names of the identified places), this being the initial working hypothesis of the article.

In short, as well as confirming the participating students' poor knowledge of the archipelago, the study provides evidence of the interrelationship between formal features and content aspects in mental maps. This entails significant progress in the use of map sketches as valid tools to assess students and schoolchildren's cartographic knowledge, and at the same time verifies that mental maps are not only a display of schoolchildren's drawing skills but also a means to express acquired geographic knowledge. The articles based on sketch map analyses have led to the development of a quantitative method. However, this is an extremely laborious process, because it implies breaking the mental maps down into their different parts. In addition, the analysis must be adapted to the represented region and its order of magnitude or scale of representation. Nevertheless, the overall results of this article convey conclusions about the respondents' geographic and spatial competences. This line of research will be further pursued, at a crucial moment in the development of the Geography curricula, with the progress of the LOMLOE and the approval of the new University System Law (LOSU). Moreover, the results obtained using this methodology to approach different education stages will allow the comparison of geographic knowledge across groups at different learning stages. This will lead to achieving a temporal balance of the geographic knowledge that is acquired in the compulsory education system. Hence, new fronts are open and new questions arise starting always with the use of mental maps as a study and analysis tool.

This tool may continue to be an instrument of great validity to be used among schoolchildren and students and encourage the move from everyday geographies to a geography with a more academic content, which should be an unquestionable aim in our compulsory education system.

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Unless otherwise stated, the sources of tables and figures are the authors', on the basis of their own research.

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