UNDERSTANDING RELIEF REPRESENTATION METHODS IN SCHOOLS: EXPERIENCES IN HUNGARY AND ARGENTINA

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ANTECEDENTS OF THE INTERNATIONAL COOPERATION

A bilateral agreement for the support of scientific research, signed by the Argentine and Hungarian governments, was announced in 2003. Representing the fields of cartography, geography and pedagogy, Hungarian and Argentine specialists presented a common project entitled “Map reading by children in school age: Cartographic education and practice in Hungary and Argentina” for the institutions responsible of this cooperation in their respective countries. During our previous contacts, the general aims of the project were determined: analysis of the actual situation in the teaching of map concepts in both countries, research about the use of maps by teachers and pupils in elementary schools, the identification of difficulties to face during the teaching of map concepts and the recognizing of the positive experiences of teaching map concepts in the interest of their possible mutual adoption.

The project was approved for a period of two years between 2004 and 2005 and it was divided in two parts:

- 2004: study of the use of thematic maps in elementary and secondary schools, how pupils and teachers use these maps in their daily work after the study of the elemental cartographic concepts.
- 2005: study of the understanding of methods of relief representation in different kinds of maps (mainly atlases, wall maps and topographic maps).

The first part of the project included the making and applying of a survey on thematic maps in both countries. This task was completed during 2004. The analysis of the results was completed in the first three months of 2005, and the previous results were presented in the Joint ICA Commissions Seminar, "Internet-based cartographic teaching and learning: atlases, map use and visual analytics" in Madrid and in ICC2005 in A Coruña in 2005.

DESIGN AND STRUCTURE OF THE TESTS

Before making the test for the survey related to thematic maps, we studied the characteristics of both educational systems (specifically in which grades the pupils learn the elemental concepts related to maps, when they begin to apply theses concepts in practice and what kind of maps they use in the classroom, emphasizing which methods of thematic representation and methods of representation of relief can be found on these maps). Based on this study we took the decision of applying the planned test to 7th grade pupils of Elementary Schools in the case of Hungary and to 1st year pupils of Secondary School in Argentina. This same study was also the starting point to determine and design the content of the test during the second part of the project.

In the interest of planning a cheap (budget-priced) survey, we decided that the test should be printed in A5 format, with a maximum of four questions printed on both sides. The first test about the reading of thematic maps was printed entirely in black and white in both countries. In this second test, we faced a particular situation, namely, school atlases and physical wall maps represented the relief mainly using coloured hypsometry. The participant colleagues considered it very important to include a question measuring how pupils can read and understand information represented in a colour hypsometric map. However, this would have made the costs of production more expensive. Because the Argentine specialists did not have any kind of financial support to execute the survey, they had to simplify this question by printing it in black and white. This was the only question that was different in the Argentine and Hungarian test.

After numerous consultations, four questions of the test were penned after the following principles:

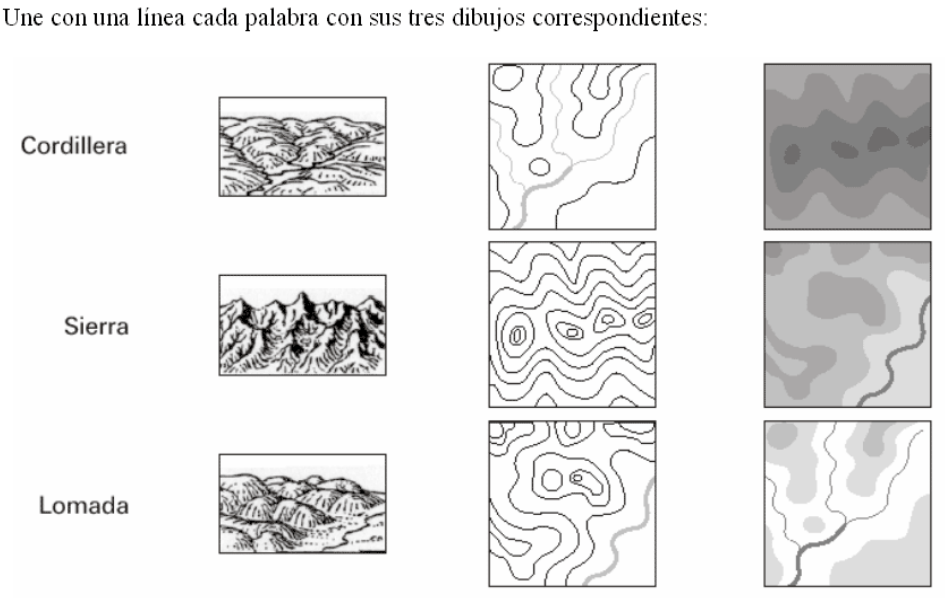


Figure 1: Connecting the name of landforms to their representations (Spanish version)

Question to connect the name of landforms to their representations using different methods

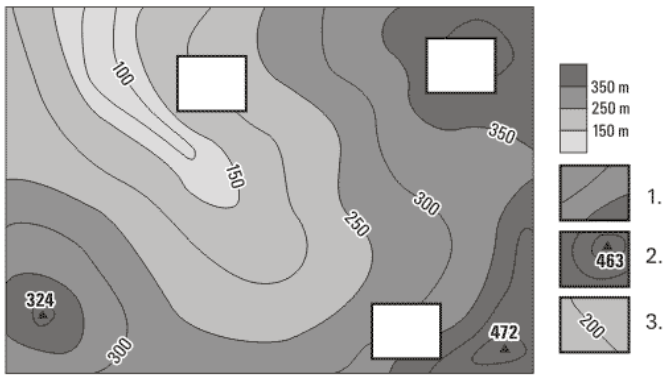
Hungarian colleagues planned this question as an introduction to the test by asking the pupils to identify three elemental landforms (high mountains, mountains and hills) with three selected methods of representation: Erwin Raisz's physiographic method, isolines and hypsometry (Figure 1). The content of the question was the same in both countries; the only difference was that the Argentine colleagues decided to include it at the end of the test.

We evaluated if the pupils can identify these landforms with their methods of representation and, simultaneously, how each method of representation is connected each to other. Thus, we could also see, for instance, how they correlate the method of isolines to hypsometry. This was one of the purposes of this question: to learn if pupils are able to draw a parallel between these two methods of representation and to realize that hypsometry is derived from isolines and they have a "similar meaning" in both fragments of maps.

Question on understanding the joint use of isolines and hypsometry

In this question, isolines and hypsometry were intentionally presented together (Figure 2). It was designed in black and white, and four tones of grey were used to differentiate the different hypsometric categories.

2. Írd be az üres téglalapokba a megfelelő részletek számát!



Az egyik hegycsúcs magasságát rosszul adtuk meg. Jelöld meg a térképen melyik az!
Indokold meg néhány szóban a döntésedet, és becsüld meg a magasságát!

.....

.....

.....

.....

A csúcs magassága ..... m és ..... m között van.

Figure 2: Second question in the Hungarian test

The first part of the question was designed as a puzzle: they had to place three numbered fragments in the map. One of the altitudes written n the map was erroneous and the pupil had to mark this wrong value in the map and explain shortly their decision. After it, the pupils had to estimate the correct altitude of the selected peak.

This was the only one question combining isolines and hypsometry, to picture how hypsometry is derived from the isolines, but not being the same method of representation. The tasks to fill in this question were better related to exercise concepts related to isolines, using the grey hypsometry as a help to identify easier the differences of altitude.

Question about the use of an isoline map

The main aim of this question was to measure competences related to the use of tourist maps (Figure 3). The pupils were asked to indicate the following in the map:

- The highest peak
- The ridge of the mountains
- The direction in which the creeks (watercourses) flow
- The shortest way connecting two settlements by-passing the neighbour mountains

3- Sabiendo que las cumbres más altas dividen aguas, marca en el mapa:
a) La cima más alta
b) La línea divisoria de agua
c) La dirección en que escurre cada arroyo con una flecha
d) Con una línea de puntos la ruta más corta que uniría las dos poblaciones evitando subir las montañas vecinas

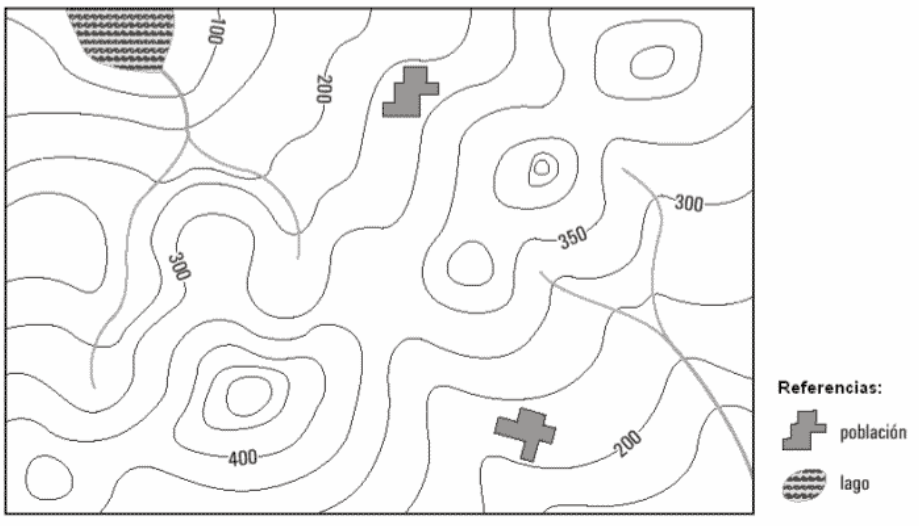


Figure 3: Third question in the Argentine test

Question on the use and understanding of hypsometry

This is an ineludible question when specialists are evaluating pupils' knowledge about the representation of landforms (Figure 4), because hypsometry can be considered the most widespread method of representation in school atlases and other maps in the classrooms all over the world. At same time, it was a technical challenge, because the colour printing of this small map raised considerably the costs of producing the questionnaire. Specialists of both countries considered it very important to present a map very similar to those maps that pupils find in their atlases or textbooks. But in consequence of economic factors the Argentine colleagues were obligated to design this question in black and white, trying to find the more correct solution to complete the more faithfully this task. They substituted the colours by numbers and simplified the question by omitting the last question related to the isobaths that can be found in the Hungarian test.

In the first part, the pupils were asked about what colour they would use to fill the area in white in the map. In the next step, they had to indicate the steepest coast of the island in the map by marking with an arrow to which cardinal point this steep side shows. In the second part of the question, the pupils were asked to determine the depth of the sea in the area demarked by dashed lines (only in the Hungarian questionnaire).

4. A színes térkép alapján válaszolj a következő kérdésekre:

Milyen színnel kellene kitölteni a fehérrel ábrázolt területet?

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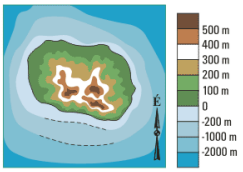

Melyik égtáj felé (észak, dél, nyugat vagy kelet) néz a sziget legmeredekebb oldala?

.....

.....

Jelöld egy nyíllal a térképen is!

Milyen mély a tenger a két szaggatott vonal közti területen?

A szaggatott vonalak közti területen a mélység ..... m és ..... m között van.

1- Contesta las siguientes preguntas basándote en el mapa que se encuentra a continuación:

a) ¿Con qué color deberiamos rellenar el territorio que no posee referencia?

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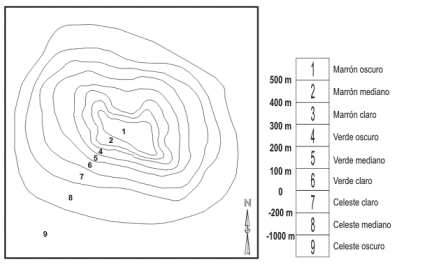

b) ¿Hacia dónde (dirección norte, sur, este u oeste) se encuentra la pendiente más inclinada en la isla?

.....

Figure 4: Question on hypsometry in the Hungarian (left) and Argentine (right) test

APPLYING OF THE TESTS

In Hungary, a total of 585 pupils participated in the survey, while in Argentina there were 484 pupils. The major part of the Hungarian pupils (365, that is 62.3%) were 13 years old,

Figure 5: Geographical distribution of participating schools in Hungary

followed by the 14 year old pupils (144 and 24.6%). In Argentina, the majority of the participants were also 13 years old (223 or 46%) and 14 years old (208 or 42.9%).

In Hungary, those schools were contacted that sent their answers to the first questionnaire about use of thematic maps during the previous year. The participation in this period was less active than in the first one: a total of fourteen from the thirty-eight contacted schools sent back their answers from Budapest and seven counties (Figure 5).

Twenty-nine Hungarian teachers answered to a test designed for them about the teaching of concepts related to landforms and other themes (see the last chapter of this paper). One of the questions was about how much time the pupils spent on responding the questionnaire; only 16 teachers answered this question. Based on the answers sent by them, 31.3% of pupils needed 15 minutes to answer the test, 43.2% of them needed 20 minutes and the rest spent even more time to complete the test.

The Argentine organizers faced the same difficulties collecting their data at a national level as they did during the last survey: the large extent of the country (the province of Buenos Aires is equivalent to the whole territory of Hungary) and the difficult communication with the remote regions represented a serious obstacle, and all this was aggravated by the unstable economic situation. They made and distributed the tests without any financial support, and collected the answers only from schools in Buenos Aires.

GENERAL RESULTS OF THE SURVEY FOR PUPILS

The obtained results are summarized in Table 1.

ANALYSIS OF THE RESULTS

Hungary

In the question ***to connect the name of landforms to their representations using different methods***, we can observe that there were no significant difficulties to identify the high mountains with its methods of representation. The result of the following two parts of this question reflects problems to give a correct answer, because the number of errors grew by more than 2.5 times. One of the causes of this error can be that the pupils did not pay special attention to those distinctive details which were added to differentiate both types of landforms. Both representations were quite similar, including a main river, but in the picture

RESULTS OF THE SURVEY FOR PUPILS (RESUME)						
	ARGENTINA			HUNGARY		
Connecting the name of landforms to their representations using different methods						
	Right answers	Wrong answers	No answer	Right answers	Wrong answers	No answer
High mountains	314 *(64,9%)*	135 *(27,9%)*	35 *(7,2%)*	509 *(87%)*	71 *(12,1%)*	5 *(0,9%)*
Mountains	171 *(35,3%)*	275 *(56,8%)*	38 *(7,9%)*	392 *(67%)*	189 *(32,3%)*	4 *(0,7%)*
Hills	164 *(33,9%)*	282 *(58,3%)*	38 *(7,8%)*	396 *(67,7%)*	185 *(31,6%)*	4 *(0,7%)*
Question on understanding of hypsometry and isolines (black and white map)						
	Right answers	Wrong answers	No answer	Right answers	Wrong answers	No answer
Filling the blank areas in the map	438 *(90,5%)*	33 *(6,8%)*	13 *(2,7%)*	562 *(96,1%)*	20 *(3,4%)*	3 *(0,5%)*
Identification of wrong altitude in the map	240 *(49,6%)*	126 *(26%)*	118 *(24,4%)*	123 *(21%)*	354 *(60,5%)*	108 *(18,5%)*
Explanation about wrong altitude	116 *(23,9%)*	221 *(45,7%)*	147 *(30,4%)*	353 *(60,3%)*	125 *(21,4%)*	107 *(18,3%)*
Determination of correct altitude	43 *(8,9%)*	321 *(66,3%)*	120 *(24,8%)*	239 *(40,9%)*	243 *(41,5%)*	103 *(17,6%)*
Use of an isoline map made in black and white						
	Right answers	Wrong answers	No answer	Right answers	Wrong answers	No answer
Indication of the highest peak in the map	148 *(30,6%)*	227 *(46,9%)*	109 *(22,5%)*	476 *(81,4%)*	72 *(12,3%)*	37 *(6,3%)*
Indication of the ridge of the mountains	46 *(9,5%)*	226 *(46,7%)*	212 *(43,8%)*	378 *(64,6%)*	77 *(13,2%)*	130 *(22,2%)*
Indication of the course of the creeks with an arrow	163 *(33,7%)*	178 *(36,8%)*	143 *(29,5%)*	486 *(83,1%)*	54 *(9,2%)*	45 *(7,7%)*
Shortest route between two settlements by-passing neighbour mountains	287 *(59,3%)*	65 *(13,4%)*	132 *(27,3%)*	448 *(76,6%)*	7 *(1,2%)*	130 *(22,2%)*
Question on understanding of hypsometry (in Hungary – coloured map)						
	Right answers	Wrong answers	No answer	Right answers	Wrong answers	No answer
Which colour should be used to fill the blank area?	375 *(77,5%)*	73 *(15%)*	36 *(7,5%)*	437 *(74,7%)*	94 *(16,1%)*	54 *(9,2%)*
Which is the steepest slope (side) of the island?	144 *(29,7%)*	285 *(58,9%)*	55 *(11,4%)*	451 *(77,1%)*	95 *(16,2%)*	39 *(6,7%)*
How deep is the sea within the area delimited by broken lines?	-	-	-	410 *(70,1%)*	141 *(24,1%)*	34 *(5,8%)*
Total of participants by country	**484**			**585**		

Table 1

showing hills two tributary streams can be found, while in the picture representing mountains there is no any affluent. Apart from the mentioned aspects, Hungarian specialists found that the number of wrong answers connecting the isoline map to the hypsometric one was relatively low (85 wrong answers and 25 pupils left it in blank). As a result, more than 81.2% of the pupils associated these two methods of representation correctly to each other.

The results of the next question (***joint use of isolines and hypsometry in the same map***) have

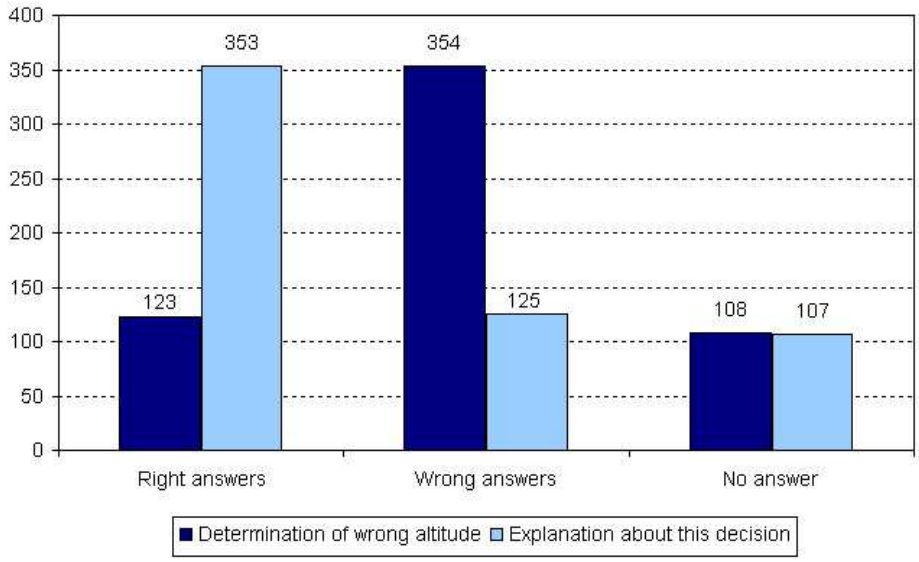

Figure 6: Comparison of answers given to the 2nd question of the test in Hungary

particular characteristics. Pupils did no present any problem when filling the blank areas in the map using the enclosed fragments: 95.9% of the pupils gave correct answers. This situation changed radically when they had to identify the wrong altitude represented in the map: only 21% of pupils answered correctly this question. An interesting detail is that this result is inversely proportional to the correct answer in the next point (explaining why the altitude is wrong), because 60.3% of the pupils explained it correctly. This result could be originated by two reasons: First, a considerable percent of the errors identifying wrong altitude could be provoked by the pupils' inattention comparing high areas filled in dark grey tones, and second a correct association of the darkest tones with the highest areas, but pupils did not take into consideration the 50 m interval between each isoline.

We accepted as correct answer the hypsometry or isoline based explanations, because both methods were used together in the map. In consequence, pupils could select erroneously a peak in an area coloured (filled) in the same dark grey tone than the wrong one, but the explanation can be correct if it is only based on hypsometric concepts. The pupils' answers reflected faithfully the more common arguments: "because the 324 m cannot be filled in that dark grey tone", "because the darkest grey marks areas higher than 350 m", "the opposite peak has the same colour and it is 472 m high", "based on the *'colour code'* this peak should be higher than 350 m", "counting the *lines*, the altitude should be more", "the values of the isolines change by 50 m" and " after the 300 m isoline there are two more lines, that is +100 m" (Figure 6).

Other particular detail in the results of this question is the number of pupils who did not give any answer (103-108 in Hungary). This fact can not be explained by lack of time, because the pupils answered the two questions following this one. Analyzing the questionnaires, we can note that the tests without answers to this question are mainly grouped in three of the 14 participant schools. Thus, it can be deduced that the reason could be a specific difficulty related to the understanding of this question or to the teaching of this theme.

The results of the 3rd question (***use of an isoline map made in black and white***) can be considered satisfactory and the majority of pupils completed correctly the different tasks based on the reading of isolines. Considering the number of blank answers (130), we can affirm that the main difficulties were drawing the ridge of the mountains in the map and indicating the shortest route between two settlements avoiding the neighbour mountains. This last fact could indicate some problems in the practical use (that is the reading and understanding) of concepts related to isolines.

The question designed ***to evaluate the understanding of hypsometry in a coloured map*** was also satisfactorily solved by the Hungarian pupils, keeping the percentage of wrong answers only between 16 and 24%, which was the second best result in the whole test.

Argentina

In the question ***to connect the name of landforms to their representations using different methods*** the results presented a tendency similar to the Hungarian test: the connection of the high mountains with its methods of representation had no significant difficulties, but the answers to the rest of this question presented inferior results. Only 35.3% of the pupils identified correctly the methods of representation for mountains and 33.8% of the answers related to methods representing hills was right.

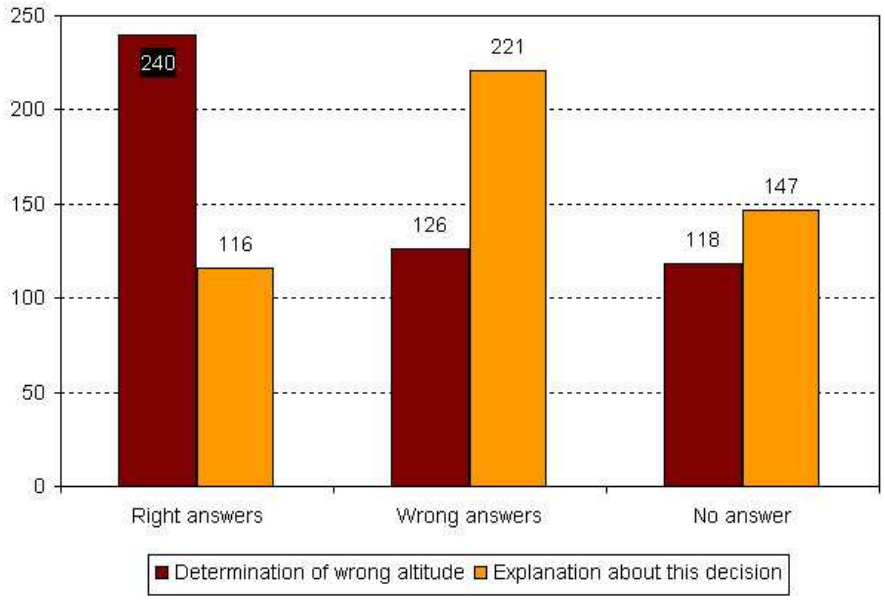

Figure 7: Comparison of answers determining the wrong altitude in the map and explaining the decision in the 2nd question of the test in Argentina

Evaluating the ***joint use of isolines and hypsometry in the same map*** we found that the results of answers to the first part of the question were similar to the Hungarian result (Figure 7). The answers to the second and third parts of the question conducted inversely proportional to the Hungarian ones: more pupils identified correctly the wrong altitude (49.5% of Argentine pupils against 21% of Hungarian answers), but fewer pupils explained properly their decision (23.9% in Argentina and 60.3% in Hungary). A more negative result was reflected by the answers to the last part (estimation of the correct altitude), obtaining only 8.8% of correct answers.

The results of the 3rd question (***use of an isoline map made in black and white***) infer difficulties with the reading and understanding of isoline maps (Figure 8). The worst result was obtained when pupils had to indicate the ridge of the mountains: only 9.5% of correct answers and 43.8% of blank answers (the highest value in the whole survey). The number of right answers to the first and third parts of the question was under 50% in both cases. After this situation, the results of the last part (marking the shortest route between two settlements by-passing the neighbour mountains) constituted a surprise for the specialists, when nearly 60% gave a right answer (the third best result in the Argentine survey).

The question designed ***to evaluate the understanding of hypsometry in a coloured map*** also presented contradictory results: the number of correct answers to the first part (determining colour to fill an area in blank) was higher (77.5%), but more than 58% of the pupils could not determine the steepest slope in the map. This last result can be traced back to problems understanding isolines, which are the base to understanding the hypsometry in a map.

SURVEY FOR TEACHERS

Simultaneously with the survey for pupils, we sent a questionnaire designed for the teachers and asked them about the teaching of methods of representation of landforms in the classroom, their suggestions to enhance the understanding of these methods and other themes related in general to the teaching of map concepts. In Table 2, some of the answers given by the teachers to this questionnaire in both countries are included. Although only a low number of teachers was asked in both countries, we can pick up two of these results:

RESULTS OF THE QUESTIONNAIRE FOR TEACHERS (RESUME)

Questions	Answers	
	Argentina	**Hungary**
What kinds of methods to represent the relief are used in the maps presented in the classroom?	Isolines – 3 Hypsometry – 11 Hypsometry combined with shading –1 Other – 3	Isolines – 16 Hypsometry – 5 Hypsometry combined with shading –5 Other – 3
Do you organize excursions or practices based on map use?	Yes – 6 No – 9	Yes – 15 No – 14
If your answer is positive, please specify: Where do you make the excursion?	In your own city or town – 4 Near your own city or town – 0 In other regions of the country – 3 In other country – 1	In your own city or town – 9 Near your own city or town – 7 In other regions of the country – 13 In other country – 2
What kinds of maps do your pupils use?	Tourist map – 4 Road map – 4 City map – 4 County map – 2 Other – 1	Tourist map – 13 Road map – 4 City map – 14 County map – 4 Other – 1
How often do you organize the excursion?	One time/year – 6 Twice/year – 0 Three times/year – 0 Other – 0	One time/year – 3 Twice/year – 1 Three times/year – 4 Other – 3
Do you use any other kind of didactic materials to explain the landforms?	Yes – 13 No – 1 No answer – 1	Yes – 27 No – 2 No answer – 0

If yes, specify which:	Cross-section – 12 Sand table – 0 Relief model – 2 Digital 3D models – 3 Others – 6	Cross-section – 10 Sand table – 11 Relief model – 11 Digital 3D models – 2 Others – 4
Do you consider the pupils' knowledge sufficient about relief acquired in subjects related to Geography?	Yes – 3 No – 11 No answer – 1	Yes – 13 No – 15 No answer – 1
If your answer is negative, specify which grade you consider more appropriate to teach these concepts.	3rd – 1 4th – 2 5th – 1 6th – 3 7th – 7 1st (high school) – 3	3rd – 1 4th – 5 5th – 9 6th – 10 7th – 4 8th – 2
In your opinion, which are the concepts related to relief that should be taught more detailed?	Coloured hypsometry, study of satellite images, aerial photos and cross-sections.	Increment of practical knowledge, e.g. practices of map reading and concepts related to relief
Total of asked teachers/country:	**15**	**29**

Table 2

- A similar percentage of teachers organize excursions based on map use: only 40% in Argentina and 51.7% in Hungary. This is a real obstacle for the pupils to practice the use of maps as an orientation tool, probably caused by the economic difficulties in these countries.
- Only 20% of Argentine teachers are satisfied with their pupils' knowledge about relief; in Hungary, this number is also relatively low, about 45%. Teachers in both countries consider that the grades indicated in the actual study plans to learn map concepts are appropriate (7th grade in Argentina and 5th grade in Hungary). In the specific case of Hungary we can note that a considerable percentage of teachers (42%) are inclined to teaching relief concepts a year later (in grade 6).

CONCLUSIONS

After our joint research, the participant teams worked out several proposals related to the teaching of map concepts in schools:

Common proposals:
- The development of map reading competences of the pupils cannot be considered enough at the present stage, the map understanding competences should also be developed. The benefits of these competences can be noted, first of all, during the use of thematic maps during the learning activities, embracing simultaneously different subjects, specialties and fields of literacy. The development of these competences actually is also included in the study plans of the participant countries, but the results obtained during this survey indicate its practical realization is not always materialized. The causes of this situation would need further investigation to propose more concrete solutions.

- An important requisite of publishing a school textbook should be a more careful selection (or edition) of the maps to be included, taking in consideration which concepts will be illustrated by maps and, if necessary, modifying the maps according to the pupils' knowledge. During the edition of textbooks, it is recommendable to request the service of a cartographer, e.g. to include one as a member of the Editorial Board.

- The use of satellite images in the textbooks and atlases is recommended, which help the pupils to understand the content of the physical maps by visualizing the represented territories in their natural dimension.

Specific proposals by country	
Argentina	**Hungary**
- The systematic edition of school atlases is very important in the interest of an integral geographic education: the atlases printed for the general public or the maps included in text- or workbooks cannot substitute them. The pertinent authorities responsible for the publication of textbooks for schools should consider the achievable proposals to find a solution to the absence of Argentine school atlases in the Argentine system of education. - The research team considers it useful to review the Hungarian experiences in the state financial support of the edition of textbooks and school atlases.	- Maintenance or increment of the actual level of quality of the Hungarian school atlases. - The actual study plans do not include any theme dedicated specially to the reading of thematic maps. Pupils read and use some types of charts in subjects related to Mathematics (it is a very positive experience that demonstrates the interrelation between different subjects), but in subjects related to Geography there is no any theme about other methods of thematic representation (dot, flow, non-physical use of isolines, etc). Considering that the maps are interdisciplinary learning tools (used in other subjects as History, Literature, etc.), we propose the analysis by pertinent authorities of a possible introduction of the teaching of these concepts.

People interested in this research can find free access to all the databases, documents, etc. related to this project visiting the following site: http://lazarus.elte.hu/hun/dolgozo/jesus/mag-arg/proyect1.htm. All the documents are available in the language of the participant countries (Spanish and Hungarian).

The final results were sent by the organizers to all the participating schools. A document presenting and analyzing the results of the survey was also placed on the website. This report sums up the positive experiences detected during the teaching and practical use of map concepts, drawing up those ideas and suggestions that could be applied mutually in both countries. These results have been presented in various national and international conferences, and the participating specialists are also promoting the results in Argentine and Hungarian institutions related to educational activities in the fields of geography and cartography

(ministries, research institutes, teachers organizations, etc.). The research teams plan to continue the collaboration also in other cartographic themes and their practical use (application) in activities closely related to the education of the young generations.

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