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FORMING AND ASSESSING THE COMPETENCE TO ELABORATE TOPOGRAPHIC PROFILES

GABRIELA OSACI-COSTACHE[1], MARIA ELIZA DULAMĂ[2], OANA-RAMONA ILOVAN[3]

ABSTRACT. – Forming and Assessing the Competence to Elaborate Topographic Profiles. We started our research when we noticed that university students graduating Geography made certain mistakes when building topographic profiles. The objectives of our research were the following: 1) analysing the knowledge integrated into the competence to elaborate topographic profiles; 2) analysing the procedure to elaborate topographic profiles; 3) analysing our students' topographic profiles and their mistakes when elaborating them; 4) analysing the causes of their mistakes; 5) establishing certain competence levels when elaborating topographic profiles, starting from assessment; 6) establishing certain ways to improve the educational process and our students' results. In order to accomplish these objectives, we studied the activity for forming the competence to elaborate topographic profiles and 48 topographic profiles realised by 48 of our students, during the 2012-2013 academic year at the specialisation Cartography. We described this competence and the procedure for its formation. We assessed topographic profiles using an analytic assessment grid with a dichotomous scale that included nine criteria, we identified students' main mistakes and looked for their causes, we established and analysed students' competence level. Finally, we proposed modalities to improve the activity for the formation of this competence.

Keywords: *topographic profile, competence levels, assessment grid and criteria, qualitative results, Geography teaching in higher education.*

INTRODUCTION

The topographic profile is a graphic representation of a vertical land section on a certain terrestrial surface, using a contour line (G. Osaci-Costache, 2008, p. 166) or the intersection of a vertical plan with the terrestrial surface (L. Aruta and P. Marescalchi, 2013, p. 65). In foreign scientific literature, they frequently call it altimetric profile (L Aruta and P. Marescalchi, 2013, pp. 65-84; M. Di Stefano *et al.*, 2011).

[1] *University of Bucharest, Faculty of Geography, Department of Geomorphology-Pedology-Geomatics, Bucharest, Romania, e-mail: gabrielaosaci68@yahoo.com.*
[2] *"Babeş-Bolyai" University, Faculty of Psychology and Sciences of Education, Department of the Didactics of Exact Sciences, Cluj-Napoca, Romania, e-mail: dulama@upcmail.ro.*
[3] *"Babeş-Bolyai" University, Faculty of Geography, Department of Regional Geography and Territorial Planning, Cluj-Napoca, Romania, e-mail: ilovanoana@yahoo.com.*

Topographic profiles are useful to study landforms, in territorial planning (G. Osaci-Costache, 2008, p. 166), in physical-geography and geology studies, to establish the accessibility degree of certain touristic routes, to plan and build communication routes, for car racing, athletic sports, ski or for bicycle routes where they use both profiles of the entire route and of each stage. Landform profiles are the starting point for a complex research of landforms (I.A. Irimuş, 1997, p. 29).

Taking into account the fact that it is crucial to have the competence to elaborate topographic profiles manually for future GIS activities, in this study we analysed the formation and assessment of our students' competence. At the Faculty of Geography in the University of Bucharest, students in Geography start to form this competence in their first year of study, the second semester, at the Topography course. Later on, they develop this competence during General Physical Geography courses (when they add new information to the topographic profile, obtaining the complex physical-geographic profile), during Geomorphology, in the second year (when they elaborate the geomorphologic profile), during Geology (when they elaborate the geologic profile), and during courses in other subjects (e.g. GIS).

We started our research when we noticed that, in order to form their competence, students in their first year of study find it very difficult to follow contour lines and to determine their elevation value (essential elements for using GIS later on) and to read landforms interpreting correctly contour lines and obtaining a three-dimensional mental representation of the landforms on maps. Even if during practical activities at Topography students took part at activities where they elaborated a series of topographic profiles using good quality auxiliary materials (a text book for the course and one for practical activities), each year, for each series of topographic profiles elaborated by our students, we identified mistakes, some of them more frequent than other. We noticed these mistakes when students presented their graduation thesis and their scientific papers during symposia and conferences, in the case of profiles realised in GIS, when students accepted without any selection everything that the program "proposed".

As we are interested in our students' formation of their competence to elaborate topographic profiles at the highest possible level and we are also interested in the increase of the educational process concerning the elaboration of these profiles, we established the following objectives for our research: 1) analysing the knowledge integrated into the competence to elaborate topographic profiles; 2) analysing the procedure to elaborate topographic profiles; 3) analysing our students' topographic profiles and their mistakes when elaborating them; 4) analysing the causes of their mistakes; 5) establishing certain competence levels when elaborating topographic profiles, starting from assessment; 6) establishing certain ways to improve the educational process and our students' results.

In order to accomplish the objectives of our research, we organised an activity for forming the competence to elaborate topographic profiles during practical activities at Topography and we analysed and assessed 48 topographic profiles realised by our students during an assessment activity reflecting the competence level our students reached. We focused on the qualitative results of our research – the assessment grid that we conceived and applied, students' mistakes and their causes – and quantitative results were only secondary. We think that these qualitative results could be relevant to improve the educational process and students' results in other contexts too.

THEORETICAL FRAMEWORK

In order to describe the competence – the first objective of our research – we started from the statement that a competence included a sum of declarative, procedural, and attitudinal knowledge that somebody activated when planning and solving a task (R. Brien, 1997). Moreover, a "competence is the capacity to explore one's own knowledge in order to solve a task" (M.E. Dulamă, 2009, p. 246).

When describing the competence to elaborate topographic profiles, we considered as a guide the analytical way of presentation used by M.E. Dulamă (2009, p. 247, p. 410; 2010, p. 323) who gave details in a table about the knowledge integrated into a certain competence (declarative, procedural, and attitudinal knowledge). When describing the procedure, we also used as a guide the one that M.E. Dulamă (2010, p. 323) and G. Osaci-Costache, M.E. Dulamă, and O.R. Ilovan (2013, pp. 169-171) presented using stages and steps. As in the scientific literature in our field we have not identified such analytical-descriptive presentations of a subject-specific competence, our research covers a theoretical and methodological gap. When forming the respective competence we followed the model for competence formation proposed by M.E. Dulamă (2011, p. 100), and structured into six stages: i) the preparation (cognitive) stage; ii) the realisation (associative) stage; iii) the integrating-self-assessment (initial assessment) stage; iv) the stage of re-doing the product or of repeating the action; v) the final assessment stage and vi) the stage for using the competence.

In order to assess the competence, we used an analytical assessment grid with a dichotomous scale that included a series of criteria and a list of noticeable elements (indicators) associated with each criterion (M.E. Dulamă, 2010, p. 86, p. 105; 2011, pp.106-107, pp. 120-122, G. Osaci-Costache *et al.*, 2013, pp. 173-174). In order to establish the competence level, we used as a guide the assessment grids presented by M.E. Dulamă (2013, p. 69). We have not identified either studies on assessing this competence using such grids or on establishing the competence level and that is why again our research fills in a gap in the respective scientific literature.

We considered the main features of a topographic profile and the fact that it was a graphic where, on the abscissa, we mentioned distance values and, on the ordinate, the elevation values for a certain section of the territory (M. Di Stefano *et al.*, 2011, p. 1). We underlined that the line "transecting" the respective land pointed out the aim of the person realising the topographic profile (e.g. to establish the difficulty of a touristic route in the mountains, one had to follow the path) and it was not compulsory that the line was perpendicular on the contour lines as in the case of geomorphologic profiles. We focused on this idea when teaching as in scientific literature we identified also contradictory opinions that considered that for topographic profiles "it was necessary that one drew the line of the profile on the topographic map perpendicular on contour lines" (M. Grigore, 1979, p. 38).

MATERIAL AND METHOD

Subjects and contents of research. We studied the topographic profiles realised by students graduating Cartography at the Faculty of Geography in University of Bucharest, in the 2012-2013 academic year. There were 48 students in the three groups of Cartography: 17 students in group 111 (35.42% of the total number of students graduating

Cartography), 15 students in group 112 (31.25%), and 16 students in group 113 (33.33%). These students represented the entire population that attended the lectures and practical activities in Topography with the same professor, they used the same text books for lectures and practical activities. We did not take a sample of this population as we considered that in order to reach the objectives of our research it was better to include all students and to analyse all their topographic profiles. Among the students that were part of this population (the subject variable) there were differences in what their initial education was concerned (competence level and knowledge level) and this fact influenced the quantitative results of our research and their generalisation. As we limited our study to one Faculty of Geography only, it was possible that statistical results were not representative for any population or sample of students graduating Geography. Despite the fact that each student elaborated eight profiles during practical activities, as an exercise in order to form his/her competence (thus resulting 384 profiles), we analysed only students' "final" profiles (one for each student) that they realised so that we might assess their competence and give them marks. That was why this study included all the 48 profiles that our students realised during the final assessment activity. Statistically, these topographic profiles were a representative sample for the analysed population, with a confidence interval (also called margin of error) of ±0.1% for a confidence level of 99% (we realised the calculations using applications available on-line:
http://www.surveysystem.com/sscalc.htm;
http://www.smarquest.ro/ro/resources.html).

Method. In order to analyse the competence to elaborate topographic profiles, we gave details and presented in annex 1 the internal resources (F. Voiculescu, 2010) or the knowledge integrated into the competence (*cf.* M.E. Dulamă, 2009, 2010). We generated the information in annex 1 after analysing and reflecting on our own competence to elaborate such charts and not too much on the basis of scientific literature.

We asked students to be involved in an activity of integration for forming the competence to elaborate topographic profiles where they observed the procedure for elaborating these profiles. This activity had the role of independent variable and we planned and organised it according to the model presented before. The integration activity for forming the competence to elaborate topographic profiles had the following stages:

a. Presenting theory. During our lectures, we explained how they should represent landforms through the contour lines method, we gave examples of topographic profiles (manual and computer-assisted ones) in slide-shows realised with PowerPoint and we created with students a heuristic dialogue starting from these. We also underlined the unusual use of topographic profiles for geographers (e.g. how to plan bicycle, motorcycle and car circuits, how to plan a touristic route for children and one for disabled persons, etc.) in order to make students understand the practical significance of these profiles.

b. Explaining how to elaborate topographic profiles. During practical activities, we explained how to build topographic profiles. We provided students with a text book for practical activities (G. Osaci-Costache, 2008), including both theory (what topographic profiles were, what was their use, what were the stages for building them), and 15 proposals for applications for topographic profiles. We explained to students *how to realise topographic profiles manually* on millimetre paper. In order to solve tasks, during their activity, students realised the process we gave details for in annex 1.

c. Presenting and realising the task. Although many students had the text book for practical activities, a week before the activity, we published the procedure on the page of the "Opengis" educational project (http://opengis.unibuc.ro), within the section on Topography. We told them that, in order to use time efficiently during practical activities, they should observe the construction stages from a written text (in the rhythm the professor gave explanations) and that they should not lose time writing them. Also a week before we gave students the black and white topographic plan (figure 1) on which they worked during the first two hours session (we printed the plan in order to avoid changes of scale as in the case of retrieving it from the "Opengis" page), and each student had to make one copy (format A4) of this plan for practical activities, without changing its scale. For the second session (also two hours), we used (colour) topographic maps belonging to the Cartography Lab. We told students which was the task they had to solve during our class (table 1) in order to form their competence. Students needed: millimetre paper, forwarder, black pencil, eraser, a white sheet of paper, coloured pencils, topographic plans and maps. The didactic activity lasted for four hours at each group, that was two sessions of practical activities.

Tasks for practical activities classes

Table 1.

Task	Time for work at the faculty	Realised topographic profiles
Task 1: Build on millimetre paper, using a pencil, a transversal topographic profile between points A and B using the offered topographic plan (the scale is 1:20,000; the equidistance of the normal contour lines is 20 m). For the vertical scale of the profile, choose an exaggerated scale (1 cm = 20 m). Note: the professor established points A and B and they were the same for all students in the group.	During the first practical activities session for elaborating profiles	1 profile
Task 2: Build on millimetre paper, using a pencil, a longitudinal topographic profile between points C and D using the same topographic plan. For the vertical scale of the profile, choose an exaggerated scale (1 cm = 40 m). Note: the professor established points C and D and they were the same for all students in the group.	During the first practical activities session for elaborating profiles	1 profile
Task 3: Build on millimetre paper, using a pencil, a transversal and a longitudinal topographic profile (with a length of 5 km in the field) between two points that you choose, using the same topographic plan. Notice the exaggerated vertical scale of the first two profiles you realised and choose a normal vertical scale.	During the first and second practical activities sessions for elaborating profiles	2 profiles
Task 4: Build on millimetre paper, using a pencil, a transversal or a longitudinal topographic profile (with a length of 5 km in the field) between diverse points that you choose, using topographic maps with the following scales: 1:25,000, 1:50,000, 1:100,000, and 1:200,000. Choose for each of them a normal vertical scale or a very little exaggerated one.	During the second practical activities session for elaborating profiles	4 profiles

d) *Verifying the formation of the competence to build topographic profiles* (topographic profiles – dependent variable) was the activity we realised immediately after the two sessions (four hours altogether) targeting the formation of the competence. We assessed it during an assessment test lasting for 30 minutes and that we announced our students about two weeks before. For this assessment (a topographic profile realised manually at first sight, on millimetre paper, between two points that the professor chose on a 1:25,000 scale topographic map; figure 2), the maximum *number of points* students could receive (for the final mark at this subject matter) was 1. Students copied maps at the beginning of the practical activities class (they delegated one of their colleagues to go to the copy centre). Those (white and black) maps already had the profile lines drawn. The assessment was organised on three rows.

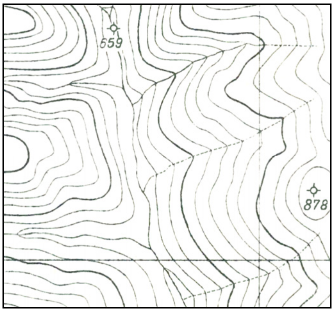

Fig. 1. Fragment of the 1:20,000 scale topographic plan used in order to solve the first two tasks

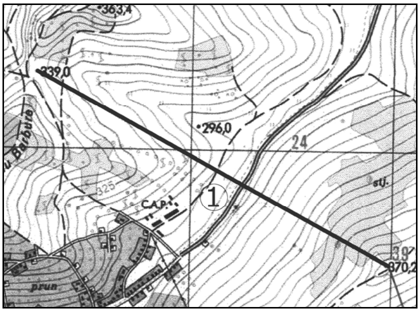

Fig. 2. Fragment of the topographic map (1:25,000) used during assessment

In order to analyse the topographic profiles elaborated by our students, we conceived and used an analytical assessment grid with a dichotomous scale. This assessment tool included nine assessment criteria. To simplify assessment, we used abbreviations for indicators (table 2). Taking into account the features that topographic profiles should have had, for each criterion we mentioned one or more indicators (noticeable elements or descriptors).

Analytical assessment grid with a dichotomous scale for topographic profiles

Table 2.

Criteria	*Abbreviation*	*Indicators/noticeable elements/descriptors*	*Points*
Correctness of the profile line	C	The student determined correctly the value of the contour lines. The student determined correctly the elevation values. The student determined correctly the elevation value where the thalweg is intersected. The student drew correctly the profile line.	0.4

Vertical scale	VS	The student chose the extreme values of the scale close to the extreme height values of the profile. The student wrote height values using a constant unit. The student wrote rounded values in the divisions of the vertical axis. The student wrote the explanation of the altitude.	0.05
Horizontal scale	HS	The student represented correctly the horizontal graphic scale of the profile (either directly on the horizontal axis, or nearby, according to case). The student wrote correctly the measurement unit.	0.1
Vertical exaggeration	Ex	The student realised the profile with an appropriate exaggeration according to the equidistance of the contour lines, to the map scale, and to the landforms.	0.1
Cardinal orientation of the profile	O	The student wrote correctly on the profile the cardinal orientation (with abbreviation and correctly in relation to the used map).	0.1
Writing the toponyms	WT	The student wrote correctly the toponyms (their names and place on the profile).	0.05
Title	T	The title renders location, route of the profile, cardinal orientation and the profile type (longitudinal, transversal, complex) if necessary.	0.1
Measureme nt unit for elevation values	M	The student wrote the measurement unit (m) on the vertical axis.	0.05
Layout and aesthetics of the profile	Ae	The student used a correct layout on the page. It has all the necessary elements (e.g. hachures, position of placing the cardinal orientation) and they observe aesthetic rules.	0.05
Total			1 point

In order to assess profiles, we realised a synthesizing table (table 3). As we had noticed during previous years that the number of mistakes was lower than of the elements realised correctly, we preferred to mark with X when students did not observe the indicators for criteria (they made mistakes), and we obtained the mark by deducting mistakes from the maximum possible number of points.

Fragment of the table used for assessment

Table 3.

Group 111	*Criteria and points for each criterion*									
	C	*VS*	*M*	*HS*	*T*	*O*	*WT*	*Ae*	*Ex*	*Total*
	0.4	*0.05*	*0.05*	*0.1*	*0.1*	*0.1*	*0.05*	*0.05*	*0.1*	*1*
Student 1				X					X	0.8
Student 2		X	X				X		X	0.75
Student 3		X		X	X	X		X		0.6

FINDINGS

1) We presented the *knowledge integrated into the competence to elaborate topographic profiles in* annex 1. In the category of declarative knowledge, we included eight concepts, four profile types, and 23 rules that students had to observe when elaborating topographic profiles manually. We included three attitudinal knowledge actions and five procedural knowledge actions integrated into this competence.

2) We presented the *procedure to elaborate a topographic profile* in annex 1. In the procedure to use the competence, we established three stages, each of them including several steps.

3) *Students' mistakes when elaborating a topographic profile*. To analyse and assess correctly and efficiently topographic profiles, we used the analytical assessment grid with a dichotomous scale (table 1). In figure 3, one may notice that of the total of 150 mistakes the 41 students made (that did not observe one or more criteria), the most frequent ones were the following: mistakes related to the horizontal scale of the profile (HS = 16.67%; 25 mistakes); no measurement unit on the elevation scale (M = 16%; 24 mistakes); wrong writing or not mentioning the cardinal orientation directly on the profile (O = 14%; 21 mistakes); aesthetics of the topographic profile and/or wrong layout on the page (Ae = 14%; 21 mistakes); no toponyms or writing them incorrectly (WT = 13.33%; 20 mistakes); much too big an exaggeration of the profile (Ex = 11.33%; 17 mistakes); giving an inappropriate title or no title (T = 10%; 15 mistakes).

Other two mistakes were less frequent: inappropriate values for the elevation scale (VS = 3,33%; 5 mistakes) and correctness of the profile line (C = 1,33%; 2 mistakes). For the whole specialisation of Cartography (figure 4), the lowest number of mistakes were at group 113 (39 mistakes; 26% of the total number of mistakes), followed by group 111 (49 mistakes; 32.67%), and by group 112 (62 mistakes; 41.33%).

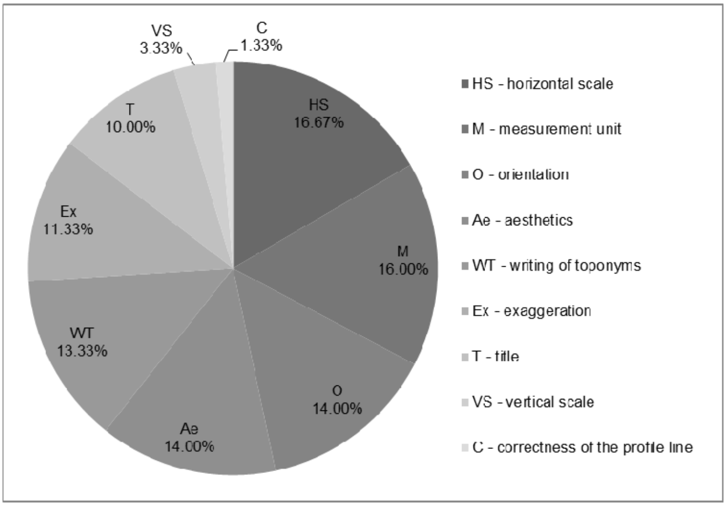

Fig. 3. Frequency of mistakes, grouped on criteria. For details on the legend, see Table 2

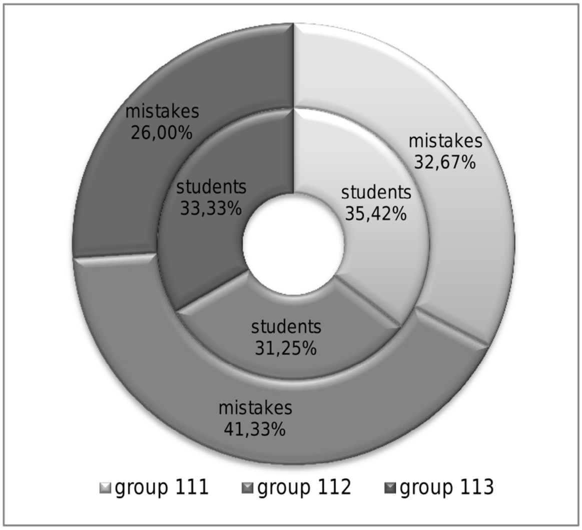

Fig. 4. Repartition of students and mistakes, on groups

In figure 5, we noticed that there were differences between the frequency of mistakes related to different criteria at the three groups. For instance, the distance scale had 30.77% of the mistakes at group 113, 14.29% at group 111, and 9.68% at group 112. Groups 111 and 113 made no mistakes related to the correctness of the profile line, while at group 112 we noticed that 3.23% of the mistakes of this group were related to this criterion. The lowest number of mistakes related to layout on the page and the aesthetics of the profile were at group 111 (8.16% of the total number of mistakes at this group), while at group 112 students made three times more mistakes, reaching to 20.97% of the mistakes at this group. Related to the exaggeration of the profile, with the lowest number of mistakes were the profiles belonging to group 113 (with only 5.13% of the total number of mistakes), and with the highest number of mistakes were those at group 111 (18.37% of the total number of mistakes at this group). For all three groups, the most uncommon mistake was related to the vertical scale of the profile (between 2.56% and 4.08%).

4) *Causes of mistakes in elaborating topographic profiles*.

(a) Some of these causes related to students: low synthesis capacity; their daily level of fatigue; low level of aesthetic education; students' current behaviour (no attendance to lectures; self-sufficiency; lack of interest; lack of attention to professors' explanations; attending lectures without writing; their habit to use information without quoting the source; not observing requests and rules; considering that it was not important to observe the requested rules and steps; students' deficiencies in perceiving correctly distance, elevation, surface; students' deficiencies in perceiving correctly the real situation, from the field.

(b) Some causes related to the curriculum in the pre-university system: no activities related to cardinal orientations during high school; in high school they did not learn to observe rules and to follow certain steps when solving tasks.

(c) Some causes related to the organising of the educational process: placement of practical activities classes at the end of the day when students were already tired; no drawing classes during high school; relatively many students in each group; only one hour for the lecture in Topography scheduled as a two hours lecture every two weeks and this situation interrupts the rhythm of teaching and of correlating the lecture with practical activities.

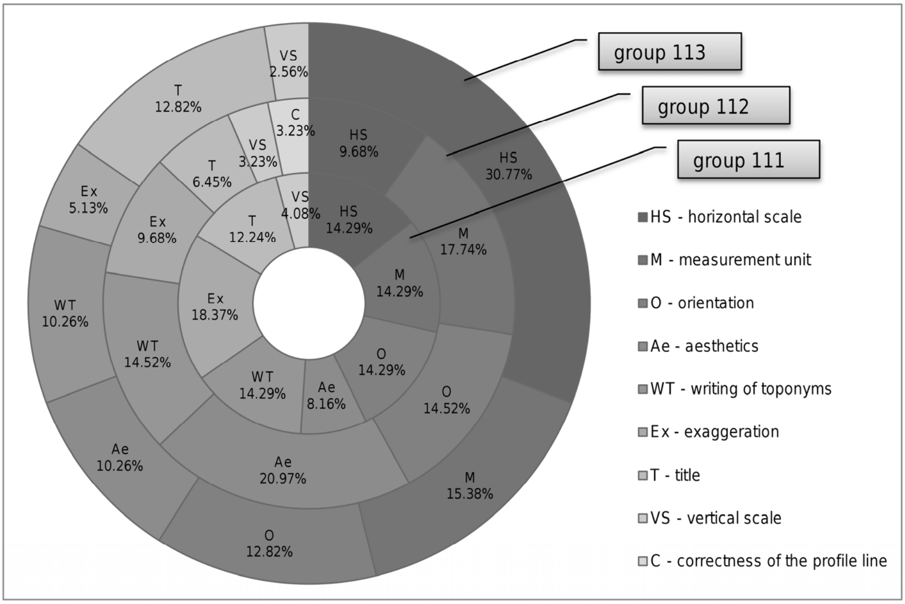

Fig. 5. Comparative situation of mistakes, criteria, for the three groups of students graduating Cartography specialisation. For details on the legend, see Table 2

5) *The competence level in elaborating topographic profiles*. We established four competence levels in elaborating topographic profiles (figure 6): incompetence (0-0.5 points or under 50% of the total number of points); inferior competence level (0.51-0.7 points, that was 51-70% of the total number of points); average competence level (0.71-0.94 points, that was 71-94% of the total number of points); superior competence level (0.95-1 points, that was over 95% of the total number of points). More than half of the students (56.25%) had an average and superior competence level (the average competence level predominated – that was the case for 16 of our students), while only 18.75% were incompetent.

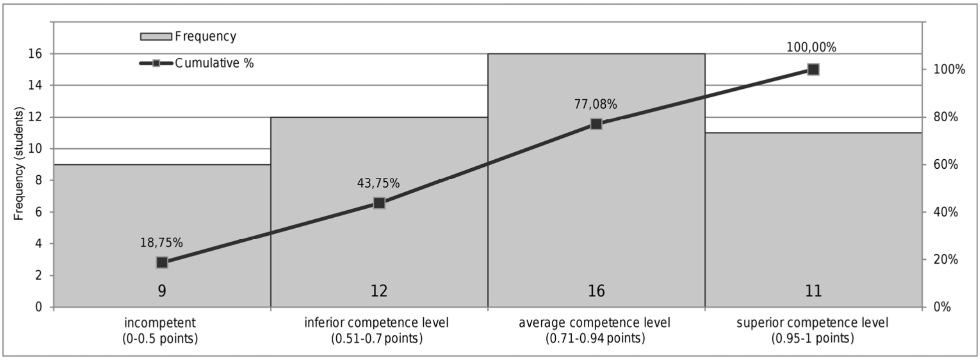

Fig. 6. Frequency of the four classes of points for the research subjects and competence classification

6) *Ways to improve the educational process and students' results.*

(a) Some of these modalities belong to professors: optimum scheduling of Topography classes in their timetable; determining students to attend lectures and practical activities classes; asking them to write; asking them to observe the given requests and rules; when teaching, insisting on those aspects that caused the most mistakes; discussing with students the assessment grids used to assess them before elaborating topographic profiles; creating and offering students a check list correlated to the assessment grid; students' undergoing the two assessment stages mentioned in the model for the formation of the competence: initial assessment and final assessment (M.E. Dulamă, 2011, p. 100).

(b) Some of these modalities belong to students: paying more attention to professors' explanations and directions and to those from the recommended literature; observing rules and steps; paying more attention to assignments within tasks and observing them.

DISCUSSION

1) Analysing the knowledge integrated into the competence to elaborate topographic profiles. Using the analytical way of presentation (annex 1) offered us a series of advantages: breaking down the competence into the pieces of knowledge necessary for students to activate in order to elaborate a topographic profile and prove that they had this competence helped us analyse and make sure that students had in their own knowledge base all the knowledge integrated into that competence. Classifying the knowledge integrated into the respective competence according to three categories (declarative knowledge, procedural knowledge, and attitudinal knowledge) was useful to distinguish rigorously the necessary concepts, types of profiles, rules that our students should have observed, the attitudes they should have had while achieving competences and solving tasks.

During the process of identifying the components of a competence, we had to cope with the difficulty of naming competences because, in this case, we helped students form and develop five competences: (a) the competence to extract the necessary data from maps or from topographic plans; (b) the competence to establish an appropriate elevation scale; (c) the competence to draw the profile line within a Cartesian system of axes; (d) the competence to elaborate the legend if it was necessary; (e) the competence to finish the profile with all the necessary elements. When describing these competences, we had to select one of the following two possibilities: describing the five competences separately or describing the five competences in an integrated manner. We selected the second variant because when elaborating profiles all these competences were necessary.

Despite these difficulties and the possibility of existing different opinions about the knowledge integrated into the competence to elaborate topographic profiles, we considered that this way of presentation of the knowledge integrated into that competence allowed creating instruments that determined an increase in the efficiency of professors' and students' activities for forming and for developing competences. This instrument is necessary and useful in both the planning and organising stage of the forming activity and in the stage for assessing the competence.

2) Analysing the procedure to elaborate topographic profiles. We gave details on the procedure that students elaborating topographic profiles underwent and we systemised it into stages and steps (*cf.* M.E. Dulamă, 2010, p. 323). This description was useful for us during the planning and organising stage of the integrating activity for the formation of this competence because we made sure that we underwent the process in the described order, without omitting any sequences. When we described the procedure, we selected from the following two descriptions used in scientific literature (M.E. Dulamă, 2009; 2010, p. 323; G. Osaci-Costache *et al.*, 2013): the one in which we could use the imperative verb (e.g. "Draw") and the one in which we could use the noun ("drawing"). We chose the first variant so that we got as close as possible to the procedure that the professor used face to face with students during the activity of forming the respective competence.

We fragmented the activity for forming the competence in reality so that we discussed some issues during our lectures and others during the practical activities classes (table 1) and this determined the existence of a period when students started to forget especially in the case of students who did not read the text book for the course or who did not take notes during our lectures. During practical activities, after evoking certain previous knowledge, necessary for the formation and development of the competence to elaborate topographic profiles, students received the task and solved it undergoing the procedure described in annex 1. During this activity, we monitored students and they received feedback (also when not asking for it) individually in order to correct mistakes.

Starting from our previous experience, we noticed that the formation of the competence to build topographic profiles was easier and might be kept for a longer time (a proof was our colleagues' feedback, those who taught Geomorphology in the second year of study) if the theme was associated to extracting the hydrographical network and realising a relief map. Thus, the subject "topographic profiles" was included in a module of practical activities in Topography after teaching during our lectures the theoretical notions related to representing landforms using the contour lines method. This model included the following activities:

(a) *Extracting the permanent and temporary hydrographical network* (2 hours) using a white and black 1:20,000 scale topographic plan (in Romania, representations with a scale of 1:20,000 and below this value are called plans, while representations with a scale higher than 1:20,000 – such as 1:500,000 – are called maps) that included only elevation values, contour lines (without values) and part of the hydrographical network (figure 1). Students focused on identifying the temporary hydrographical network (that was not drawn on the map/plan) and the flow orientation that they deduced by interpreting differences in elevation values and the arching of the contour lines from downstream to upstream.

(b) *Realising a relief map* (4 hours) using a colour 1:25,000 scale topographic map, on an area of 9 km^2. This task required that students identified the value of each contour line and followed it (G. Osaci-Costache, 2011, p. 39).

(c) *Realising topographic profiles* (4 hours) by first using the 1:20,000 scale topographic plan from which they extracted the hydrographical network (figure 1) because – except the grid (also called the rectangular of kilometric network) – there were no other such elements (i.e. lines) that might have confused them (e.g. transport network, electrical, aerial, transmission lines, pipes). During this stage, students determined the values of contour lines knowing the equidistance of the intermediate contour lines and elevation values. After they realised four profiles on this map, they worked on colour topographic maps with diverse scales (1:25,000; 1:50,000; 1:100,000; 1:200,000) and with diverse equidistance of the intermediate contour lines, from each map realising a 5 km long (in the field) profile. The 1:25,000 scale map that they used during classes for exercises was the same map from which they realised the relief map, and they elaborated the profile having in front of them also that relief map they had realised before. We assessed whether our students achieved this competence during a previously announced assessment test. We wanted that the maps during the assessment test, that our students saw for the first time, were simple, without many elements that could confuse them (figure 2), taking into account the fact that they studied conventional signs only in the second semester of their first year of study, at Cartography.

Because our students had graduated no GIS course before, they realised the topographic profile manually, but during the lecture we also showed them the way to obtain it working directly in the Open Source GRASS program and underlining that it was essential that geographers or cartographers that digitised contour lines followed them without making any mistakes and wrote correctly each elevation value in the attribute table because otherwise the program will provide wrong results.

Taking into account the fact that nowadays we realised topographic profiles in a GIS program, we focused on understanding the way we realised profiles and not on their aesthetics. That was why we did not ask our students to draw profiles with china ink. The aim was that students formed their competence to realise a topographic profile from any contour map especially at the mental level, immediately after they looked at such a map, so that students were not only able to read maps at once, but they also anticipated the result of the GIS program and noticed possible mistakes (caused by incorrect digitising of contour lines or by something else). In order to offer assistance, students worked only during our classes, at the faculty, but we also offered and recommended topographic maps (on the Opengis educational platform) for those who wanted to finish their activity at home with other profiles.

3) Analysing the mistakes university students make in elaborating topographic profiles. We analysed topographic profiles using the assessment grid in table 2. This tool helped us assess students' topographic profiles in a correct, uniform, and objective way.

Some of these mistakes were more frequent than others. The most common mistakes related to the horizontal scale of the profile (up to 30.77% of the total number of mistakes for group 113). In fact, 99% of the students in this group wrote the distance scale, but in a fractional or verbal form, not in a graphic form as they should have.

Many students did not write the measurement unit for elevation values, and some of them did not write what they represented on the vertical axis, the elevation values (16% of the total number of mistakes). In other countries (e.g. Italy), the writing on the elevation axis is even more detailed compared to Romania, by adding the mentioning "s.l.m.", meaning "above sea level".

Correct mentioning of the cardinal orientation for the profile (directly on the drawing, not in the title) was a request that almost 43% of our students had difficulties to observe. The most common mistakes were: lack of orientation, writing it nearby the profile and not at the ends of the profile, writing it only in the title, not on the profile too (figure 7), wrong abbreviations (e.g. N-N-W instead of NNW), wrong orientations (e.g. NW at one end of the profile and S at the other end).

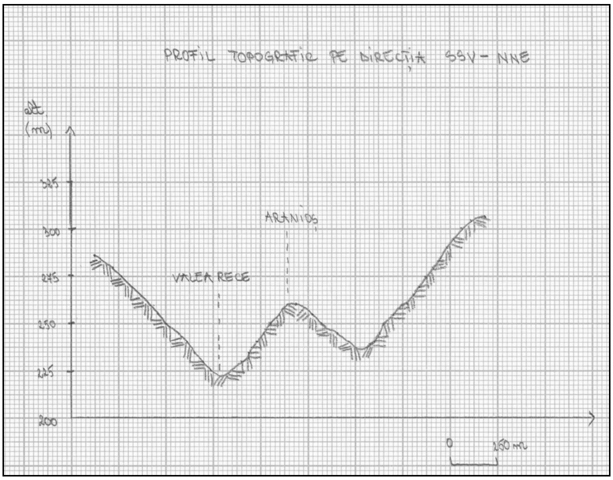

Fig. 7. Topographic profile with an incomplete and uncentred title, without orientation near the profile line, anaesthetic placement of the graphic scale (subject 3 in group 113)

Layout on the page and the aesthetics of the profile was deficient for about 40% of our students, their main mistake being placing the profile in a corner of the millimetre paper and writing the title centred in relation to the page and not to the profile. Although in the practical activities text book there were many examples, in addition to the ones we showed during classes, 14% of the mistakes consisted of incorrect placement of toponyms or omitting to write them. Incorrect placement meant absence of location through interrupted vertical lines and no writing of toponyms on the West-East direction. Some of the students used arrows or wrote using *Italic* (figure 8) or they wrote under the profile line, etc., not observing the rules we presented them.

Too big an exaggeration of the profile (figure 9) was mainly a result of students' fear to make mistakes adopting another elevation scale than the one initially imposed by the task, because students made mistakes at this criterion during assessment and we drew their attention several times during practical activities classes to adapt the elevation scale.

Students' mistakes related to title consisted of no title or of an incorrect phrasing that did not allow us to identify the route, the represented place, and the topographic profile type. Here are some examples: "Transversal topographic profile from the Căpoşi Hill to the 240 m contour line on the WSW-ENE direction", "Direction WNW", "Profile realised on the NW-SE direction", "Contour lines profile", "Topographic profile of the Bouraş Hill".

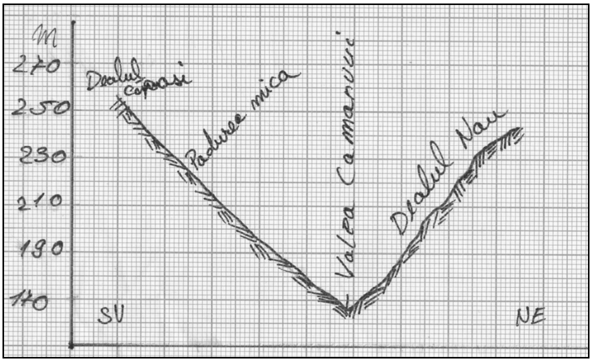

Fig. 8. Anaesthetic topographic profile, untidy aspect, with a big exaggeration of the elevation scale, deficiencies of values on the elevation axis (no value in the origin of the axis, no gradation signs), toponyms placed incorrectly (subject 9, group 112)

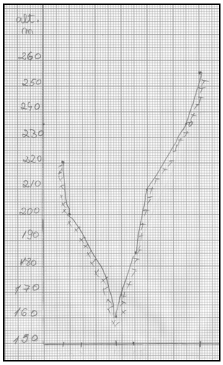

Fig. 9. Unfinished, anaesthetic topographic profile, with much too big an exaggeration (subject 13, group 112)

Related to the vertical scale there were students that chose the inferior limit much too low as compared to the minimum value of the elevation on the profile (remaining much too large a space between the horizontal axis and the profile line), much too close to this value (in this case the profile line touched the abscissa). Another mistake was marking unequal intervals on the elevation scale.

Students learnt the procedure to extract data from the topographic map and how to draw the profile line, and only two students drew incorrectly the profile line. In both cases the mistake consisted of decreasing the altitude of the contour lines also after the intersection with the hydrographical organism, so that on the millimetre paper they represented what seemed to be a slope while they had to represent a transversal valley profile instead.

4) Analysing the causes of mistakes in elaborating topographic profiles. During our research, we were interested in identifying the causes that determined differences between students' results and their competence level. We identified certain causes by noticing students' current behaviour: their daily level of fatigue; no attendance to lectures; self-sufficiency; lack of interest; lack of attention to professors' explanations; attending lectures without writing. We deduced some causes by analysing and interpreting profiles: certain students' lack of aesthetic sense; low synthesis capacity; not correlating the information we gave them during lectures with the ones during practical activities classes; no observation of given requests; inappropriate perception of the real situation in the field; wrong perception of distance, elevation, and surface. Talking to our students, we identified other causes: many students confessed that during high school they did not work with cardinal orientations and they could hardly remember them from the secondary grades; other students said that they did not consider important to observe rules and steps, and observing those was a novelty for them as nobody told them to do that during high school.

We identified the causes that we could not eliminate: no drawing classes during high school; relatively many students in each group; the fact that during high school they had not taken part at activities necessary for the formation of this competence; certain students' lack of aesthetic sense. We identified the causes that we might probably eliminate: bad scheduling of Topography classes in their timetable; no external obligation for students to attend lectures and practical activities classes; no request to write; no request to observe the given requests and rules.

5) ***Analysing the competence level.*** Using this grid (table 1 and 2) allowed us to assess objectively students' topographic profiles. Each profile they realised during the test received between 0 and 1 point, the maximum (total) of one point represented 10% of the maximum final mark for this subject matter (Topography). In order to establish the thresholds between different competence levels it was necessary to decide which were the most important criteria for a topographic profile. Thus we offered the highest value to the correctness of the profile line (0.4 of the total of 1 point) because a paper that had all elements unless the profile line could not be considered a profile, and the level of realising the product was that of incompetence. We offered the other criteria 0.1 or 0.05 points according to their importance.

The second problem we had to solve was establishing competence categories/ levels and their names. We decided to establish only four groups and to use names as simple as possible so that they were easy to use in practice. We established the threshold between incompetent and inferior competence level taking into account the assessment system in Romania in university and in the pre-university educational system where marks and average marks below 5 (out of the maximum of 10) did not ensure graduating in a certain subject matter. It was interesting to establish the threshold between the average and the superior level of competence. We asked ourselves: what can be missing in a certain profile and still consider it a well elaborated one? We reached the conclusion that for a superior competence level the threshold should be very close to the maximum number of points. Taking into account partial number of points and also the elements they referred to (more important and less important in the structure of the profile), we thus established the four competence levels or competence categories in elaborating topographic profiles (figure 10) and we gave details in the results section of this paper.

In all the three groups, in the "incompetent" category there were nine students (18.75% of the total number), while the other students representing 81.25% had different competence levels: 12 had an inferior competence level (25%), 16 had average competence level (33.33%) and 11 had superior competence level (22.92%). Over a half of the students at the Cartography specialisation had superior and average competence level (56.25%; figure 6), with the highest percentage (68.75%) at group 113 (figure 10). One may notice a big difference between group 112 (figure 10) and the other groups related to the inferior competence level, the situation of this group being not too good (33.33% of the students had this competence level). This same group (112) had a quite good position for the average competence level (41.18% of its students reached this level). Group 111 had an inferior position related to the average competence level (only 17.65% of its students had an average competence level), but also group 111 had the highest number of students with a superior competence level (29.41%; figure 10).

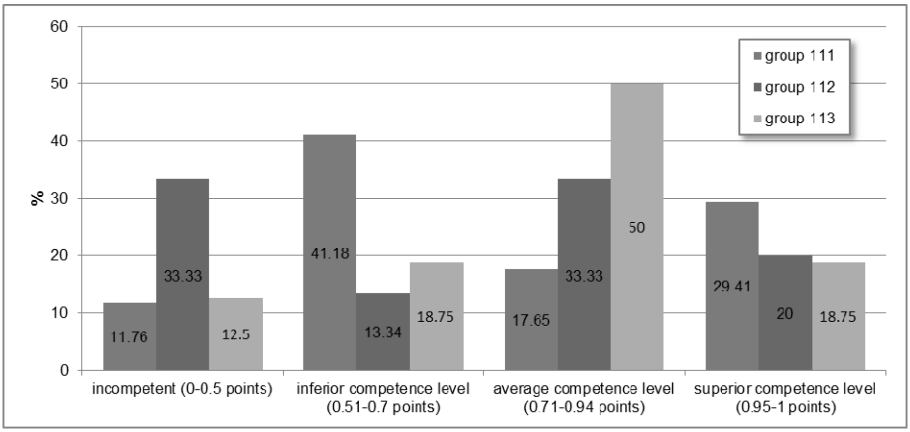

Fig. 10. Frequency of the four competence levels (on groups) and competence classification

The average for the number of points for all three groups was 0.71 points, and this falls in the average competence level. We noticed a difference in what the group average was concerned: group 111 obtained 0.71, group 112 got 0.67, and group 113 got an average of 0.76. From this point of view, groups 111 and 113 fell, as average, in the average competence level, while group 112 fell in the inferior competence level. Those results correlated with results at other courses as well as with those from the entrance exam, group 112 having in general worse results. Group 113 was "privileged" as it hosted a student who won the Olympiad in Geography and other several students with very good results at assessments and these motivated others too. Some students from the other groups wanted to move in group 113 in order to benefit from their superior competence level colleagues' co-operation.

6) Analysing the ways to improve the educational process and students' results. We noticed that some of these modalities focused on improving institutional management: optimum scheduling or Topography classes in their timetable and determining students to attend lectures and practical activities classes. Other of these modalities focused on improving teaching and the organising of the process for the formation of competences: discussing with students, during classes, their topographic profiles, their mistakes and how to correct them; when teaching, insisting on those aspects that caused the most mistakes; asking them to write; asking them to observe the given requests and rules; discussing with students the assessment grids used to assess them before elaborating topographic profiles; creating and offering students a check list correlated to the assessment grid; students' undergoing the two assessment stages mentioned in the model for the formation of the competence: initial assessment and final assessment.

Nevertheless, in order to form this competence, the most important is our activity with students, so, there are several changes necessary in their behaviour and attitudes: first of all, it is important that they pay more attention to professors' explanations and directions and to those from the recommended literature; that they observe rules, stages and steps when solving tasks; that they use the check list and that they get involved actively in the process of forming and assessing a certain competence.

CONCLUSIONS

On the basis of our research, we drew the following conclusions:

1) Using the analytical description way helped us analyse and make sure that our students possessed all the knowledge integrated into the respective competence;

2) Giving details about the procedure that students had to undergo (stages and steps) when elaborating a topographic profile was useful for planning and organising the activity for the formation of the competence as we could be sure to follow the process in the described order, without omitting any sequences;

4) The assessment grid we conceived helped us assess correctly, in a uniform and objective manner the topographic profiles elaborated by our students and to identify students' mistakes;

5) In order to identify the causes that determined mistakes in the profiles we assessed we paid attention to our students' behaviour, we discussed with them, we

analysed and interpreted the respective profiles. We identified causes that we could possibly eliminate and other that we could not;

6) Among the ways to improve the educational process and students' results, the most important one was students' responsible involvement into the formation of their competences.

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Annex 1.

Components of the competence to elaborate topographic profiles manually

Declarative knowledge	*Concepts*: topographic profile, Cartesian coordinates, abscissa, ordinate, elevation scale (vertical scale), distance scale (horizontal scale), profile line, exaggeration. *Types of topographic profiles*: longitudinal topographic profile, transversal topographic profile, complex topographic profile, profile with change of orientation. *Rules for elaborating topographic profiles manually*

	R 1: Use trustful sources for plans or topographic maps with contour lines. *R 2*: You should quote the cartographic source that you used for realising the topographic profile. *R 3*: The line we take into account in order to realise the profile may not be perpendicular on contour lines (for instance, it may follow a path). Do not make a confusion between the topographic profile and the geomorphologic profile as in the case of the latter one it is compulsory that the line intersects perpendicularly contour lines! *R 4*: You should choose the most appropriate topographic profile (be it transversal, longitudinal, or complex) according to your aim (it may follow a stream, a road, an interfluve, etc.). *R 5:* You should choose the extreme values on the elevation scale (represented on the vertical axis) in the following way: the minimum value (usually a rounded value) should be lower than the lowest elevation value on the profile, and the maximum value may coincide with the highest elevation value from the line of the profile or it may be a little higher. *R 6*: If you realise a series of topographic profiles that you will place one beside another, you should choose the same elevation scale and the same distance scale, in order to facilitate comparisons. *R 7*: Usually, the distance scale (represented on the horizontal axis) does not change, as this is the scale of the map, except the situation represented in R 6. *R 8:* The person building the profile should choose the elevation scale so that it (usually) will be a normal elevation scale (equal with the map scale) or a very little exaggerated one (higher than the map scale). In the latter case, you should choose the scale according to the map scale, the equidistance of contour lines, the relief amplitude. Usually, for geomorphologic profiles, you should exaggerate the scale in order to underline slope breaks or other elements. *R 9*: It is advisable that topographic profiles have both scales (the distance scale and the elevation scale) in a graphic form, not in fractional or verbal form. *R 10:* Representing the profile may begin from the vertical axis (the ordinate), and in this case you should write the graphic distance scale directly on the horizontal axis (abscissa), starting from the origin of the system of coordinates. *R 11*: If the representation of the profile does not begin from the vertical axis (ordinate), then you should draw the graphic distance scale within the topographic profile, placed aesthetically in relation to the system of axes and the line of the profile. *R 12*: You should always mention the measurement unit. *R 13*: On the axis, you should mark elevation values at equal intervals (e.g. 250 m), they should be easy to read and aesthetic, avoiding to link them as it happens when you use an inappropriate font. *R 14*: Usually, topographic profiles do not have a legend, but if necessary, you should place it aesthetically (e.g. in the case of topographic profiles having a touristic purpose, in order to explain the line that represented the road type: asphalt, foot path; in the case of symbols for shelters or chalets, first aid locations, points of spectacular views, etc.). *R 15:* You should draw the system of coordinates and the graphic distance scale (if you represent it separately and not directly on the abscissa) using drawing instruments (e.g. band, forwarder).

	R 16: You should draw the line of profile resulted from uniting points without drawing instruments (e.g. band, forwarder), and thus without straight segments, because the topographic surface is not a broken line. *R 17:* The result of uniting two (or more) successive points with the same elevation value is not a horizontal line except the case when the line according to which you realised the profile overlaps exactly on the respective contour line. *R 18*: For most topographic profiles you should hachure under the line of the profile. In other cases, under the line of profile you may insert other information using symbols and colour (e.g. geology, soils, difficulty degree of the route, time for journey, slope, etc.). *R 19*: You should write inscriptions (values, titles, legends, etc.) neatly, with uppercase, using a pattern if possible. *R 20*: You should write toponyms on the West-East direction, correctly and using diacritics (according to the respective language), at the end of an interrupted vertical line that starts at the place where the toponym is place on the map. In special cases, you may place toponyms in some other ways (e.g. on the South-North direction). *R 21*: Toponyms should refer to mountain peaks, mountains, hills, etc. and you should place them on a higher alignment than the toponyms that render names of water streams. *R 22*: It is compulsory that you write on the profile its cardinal orientation (either above or below the line of the profile), and also mark through vertical lines any changes of orientation. *R 23*: The title should render the location, type and route of the topographic profile. In certain situations you should not write the profile type, but you may present other information.
Attitudinal knowledge	Observe the requirements for elaborating topographic profiles. Elaborate topographic profiles through personal effort. Finish the topographic profile before the deadline.
Procedural knowledge	Extract the necessary data from the topographic map or plan. Establish an appropriate elevation scale. Draw the line of the profile in a Cartesian system of axes. Elaborate the legend (if it is necessary). Finish the topographic profile with all necessary elements.
Procedure	**Stage 1. Identify the necessary cartographic data** Step 1. Establish the aim and the destination of the profile. Step 2. Establish the scale of the map/plan that you are going to use. Step 3. Identify the sources of the necessary cartographic data. **Stage 2. Process the topographic map/the topographic plan** Step 1. Establish which is the detail level that you want to achieve when rendering data in a graphic manner, verifying if all contour lines are necessary or only the index contour ones (according to aim, destination, scale, and morphography). Step 2. Establish on the map the route of the profile and mark characteristic points: the ends of the profile and the points of orientation change (if the latter exist). Step 3. Identify the equidistance between intermediate contour lines and between index contour lines. Step 4. Determine the elevation of the points at the ends of the profile (if there are no known elevation points), maximum and minimum values, as well as the elevation of other necessary points (e.g. intersections with the transport network, with the hydrographical network, shelters, first aid locations,

	mountain passes, etc.). Write these elevation values on the map. Step 5. Decide whether you will represent topographic profiles independent from one another or in a comparative series (R 6). Step 6. Choose the scale of your topographic profile/profiles according to the analysis from Step 5. **Stage 3. Elaborate topographic profiles manually** Step 1. Unite the characteristic points you established on the map with a thin line using pencil and band. In the case of a road for instance, mark it on the map through a wavy line. Step 2. Overlap on the line of the profile the edge (it should be perfectly straight) of a piece of paper or even the edge of an entire sheet of paper. It should be long enough as to comprise the whole length of the route. Step 3. Mark – using short perpendicular lines on the edge of the sheet of paper – the intersection between the line of the profile (of the respective route) and: elevation points, contour lines, and streams. For the last ones, use a special symbol (a wavy line) or blue. Step 4. Write on a piece of paper for each intersection its elevation value. Step 5. Write on a piece of paper the cardinal orientation of the profile and mark with a vertical line the points with change of orientation (if there are any). Step 6. Extract on the piece of paper the position of other necessary elements (according to the aim and destination of the profile), such as settlements, chalets, isolated trees that have the role of landmarks, rest areas, etc. Step 7. Write on a piece of paper the necessary toponyms placing them in the same way like on the topographic map. Step 8. Draw the Cartesian system of axes on millimetre paper. Step 9. Establish a graphic scale of elevation according to the learnt rules and mark it on the vertical axis. Step 10. Place the piece of paper with the data along the horizontal axis and mark point by point, according to each elevation. Step 11. Unite the obtained points. Step 12. Write the toponyms. Step 13. Write the cardinal orientation of the profile. Step 14. Complete with the other elements you took from the map. Step 15. Finish the profile (hachure or colours, title, legend if it is necessary, the distance scale, measurement unit, etc.).