

Geography University Students' Competence to Elaborate Column Charts: A Case Study for Romania

Gabriela OSACI-COSTACHE¹

University of Bucharest, Bucharest, ROMANIA

Maria Eliza DULAMĂ²

"Babeş-Bolyai" University, Cluj-Napoca, ROMANIA

Oana-Ramona ILOVAN³

"Babeş-Bolyai" University, Cluj-Napoca, ROMANIA

Abstract

We started this study after noticing that university students make certain mistakes when elaborating column charts. The objectives of our research were to: 1) analyse the knowledge integrated into the competence of elaborating column charts; 2) analyse the procedure(s) to elaborate these charts; 3) analyse the mistakes that university students make in elaborating these charts; 4) analyse the causes leading to their mistakes; 5) identify ways to improve the educational process and students' performance results. In order to achieve these objectives, we studied the activity for forming students' competence to elaborate column charts and we analysed 704 such charts realised by 410 students at the Faculty of Geography within the University of Bucharest, Romania, during the 2010-2011 and 2011-2012 academic years. In this paper, we describe the competence to elaborate column charts and present an analytical assessment grid with a dichotomous scale according to the way of presentation proposed by Maria Eliza Dulamă. In the analysis, we assessed charts using this assessment grid that included 20 criteria. We conclude by proposing ways to better the activity that underlies the formation of elaborating column charts (e.g. discussing chart types with students, discussing mistakes and how to correct them, discussing causes of their mistakes and an assessment grid before elaborating charts, creating a check list, etc.).

Keywords: Geography teaching in higher education, competence, column chart, assessment criteria, indicator, assessment grid

¹Dr. Gabriela Osaci-Costache, Department of Geomorphology-Pedology-Geomatics, Faculty of Geography, University of Bucharest, Nicoale Bălcescu Blvd. 1, sector 1, 010041, Bucharest, Romania, gabrielaosaci68[at]yahoo.com

²Dr. Maria Eliza Dulamă, Department of the Didactics of Exact Sciences, Faculty of Psychology and Sciences of Education, "Babeş-Bolyai" University, Sindicatelor Str. 7, 400029, Cluj-Napoca, Romania, dulama[at]upcm.ro

³Corresponding author: Dr. Oana-Ramona Ilovan, Department of Regional Geography and Territorial Planning, Faculty of Geography, "Babeş-Bolyai" University, Clinicilor Str. 5-7, 400006, Cluj-Napoca, Romania, ilovanoana[at]yahoo.com

Introduction

Charts (also known as graphs or diagrams) are very important for “representing information” (Mazza, 2007) in general, not only for representing statistical or geographical data. In order to elaborate correct charts, it is important to transmit correct and complete information. Therefore, it is necessary that students acquire the competence to create charts starting with their first year university education. In the process of elaborating charts, geographers may make a lot of mistakes, either when analysing and reorganising data using tools from Statistics, Mathematics, and Informatics, or in the process of converting the respective data in easy to understand, strong visual impact charts and they run the risk of losing from the initial statistical information.

We started this study after noticing that university students make certain mistakes in elaborating charts, some of these mistakes being more frequent than others. We noticed those mistakes in students' problem-solving tasks during practical work in Cartography, during presentations of scientific papers at symposia and conferences, and when presenting their graduation theses. At the Faculty of Geography in the University of Bucharest, Romania, we developed this competence across diverse courses, but especially in Cartography (during the first year, the second semester), where, in the syllabus of the course, we included two hours of lecture and four hours of practical work dedicated to statistical methods of representation. In the syllabus of the Cartography course, we included activities for elaborating diverse chart types and we realised these activities with students whom we provided quality auxiliary materials (a textbook for course activities and another one for our seminars). Despite this, each year, students' charts have certain mistakes.

Because we are concerned about increasing the quality of the university educational process related to elaborating charts and developing students' competence to elaborate them at the highest possible level, we took into account several research objectives:

- 1) to analyse the knowledge integrated into the competence of elaborating column charts;
- 2) to analyse the procedure(s) to elaborate these charts;
- 3) to analyse the mistakes that university students make in elaborating these charts;
- 4) to analyse the causes leading to their mistakes;
- 5) to identify ways to improve the educational process and students' performance results.

In order to achieve the objectives of our research, we organised an activity to develop students' competence to elaborate diagrams in columns during the practical work in the Cartography course. We collected and analysed 704 column charts that students themselves created during this activity. Those charts reflected the level of competence that our students achieved. We focused on the qualitative results of our research – on the assessment grid we created and used, on students' mistakes and their causes – while quantitative results were second as importance. The qualitative results could be relevant for improving the educational process and students' achievement in other contexts too.

Theoretical framework

In order to achieve the first objective of our research, the one that referred to the description of the competence, we took into account the statement that a competence included a sum of declarative knowledge, procedural knowledge, and attitudes that somebody activated in planning and performing a certain task (Brien, 1997). We also took into account the fact that “a competence is the capacity to exploit knowledge from one’s repertoire in order to realise a task, and the noticeable behaviour is the external manifestation of the respective competence” (Dulamă, 2009, p. 246). In addition, we also considered recent research on generic and subject-specific competences in Geography higher education in Europe (Wall, Donert, 2004).

While describing the competence to elaborate columns charts, also called charts in “organ pipes” (Béguin, Pumain, 2003, p. 82) or rectangular charts (Di Donna, 2007, p. 85), including the procedure that we wanted our students to form and develop, we imported Maria Eliza Dulamă’s analytical way of presenting a competence (2009, p. 247, p. 410), who gave details in a table on the associated declarative, procedural, and attitudinal knowledge integrated into the respective competence. That way of describing a competence was further developed for procedural knowledge and the procedure was presented and systemised in stages and steps (Dulamă, 2010, p. 323). In the researched scientific literature we did not find such analytical-descriptive presentations of competences and that is why our research fills a gap both in theory and methodology.

For the formation of the competence we analysed a model applied at the University of Mauritius by A. Q. Mohabuth (2011, pp. 3-5) and *the model for the formation of a competence* proposed by M. E. Dulamă (2011, p. 100). The latter author identified 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. This latter model is more appropriate for the formation of this competence. In order to assess the competence to elaborate column charts, in this study, 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 (Dulamă, 2010, p. 86, p. 105, 2011, pp.106-107, pp. 120-122). We have not found studies about assessing this competence using grids and thus our research fills a gap.

Cartographical literature used in academic research brings plenty of clarifications about processing geographical data statistically, elaborating charts, and the rules of visual perception. Still, it is not rich enough at the international level (Năstase, 1983; Tufte, 1983; Cardoso, 2012; Osaci-Costache, 2008a, 2008b, 2009, 2012; Béguin, Pumain, 2003, Di Donna, 2007; Mazza, 2007, Poidevin, 1999, Spence & Lewandowsky, 1990, Field, 2012) and through our study we bring forward many theoretical and methodological details useful for increasing efficiency in the formation of this competence and of other subject-specific competences too (e.g. it is useful for analysing competence development using Geography text books as presented in a recent study by C. Martinha, 2011, and for analysing spatial competences as presented by E. Sarno, 2012).

We focused on the main features of the column chart, which was a chart realised in a system of rectangular coordinates where only the vertical axis (ordinate) had mathematical value (frequently an arithmetical scale), while the abscissa had the role “to support” the bases of the columns, in contrast with the histogram which had both axes divided and with mathematical value. It was possible that, on the horizontal, the bases of the columns *were not supported by an axis* (Béguin, Pumain, 2003, p. 82) as they represented *qualitative*, not quantitative aspects. In scientific literature, they recommended that the values (on the ordinate in case of this chart type) were rounded (to memorise them more easily), having maximum a decimal, while an exception included certain situations when exactly those decimal values indicated the threshold between categories (Poidevin, 1999). Moreover, it was necessary to mention the measurement unit on the ordinate (Osaci-Costache, 2008a, p. 117, 2009, p. 118, Poidevin, 1999).

Methodology

Respondents

This study included the column charts realised by 410 undergraduates at the Faculty of Geography, University of Bucharest, Romania, in the following specialisations: Geography of Tourism, Meteorology-Hydrology, and Cartography, during the 2010-2011 (270 students) and 2011-2012 (140 students) academic years. The 16 groups included between 21 and 32 students (Figure 1).

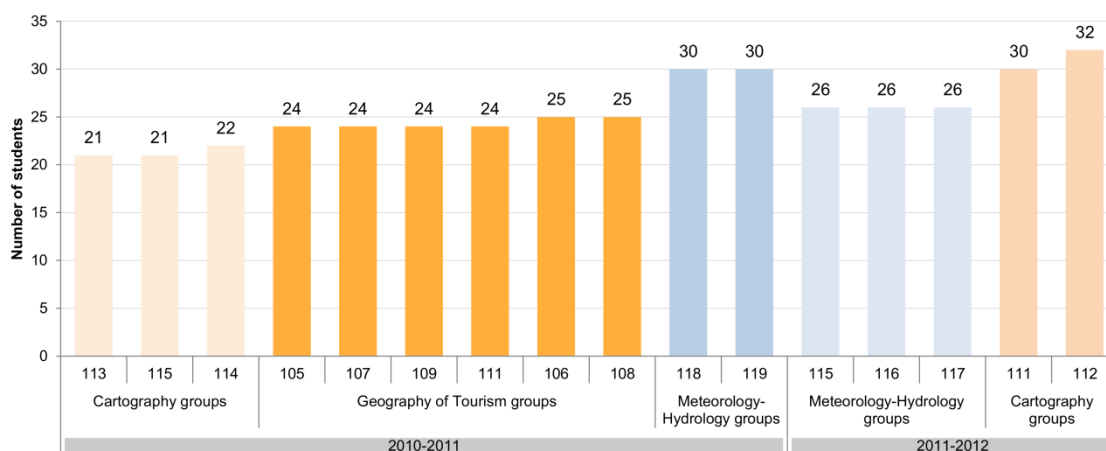


Figure 1.
Structure of the students' sample

These students were in the first year of their university studies (so, they graduated high school) and represented the entire population that attended the lectures and seminars of Cartography with the same professor (the first author of this research), and they used the same course and practical work materials. In order to achieve the objectives of our research, we did not take a sample of this population, but we considered that it was better to extend the study to as large a number of students and charts as possible. Nevertheless, because of the large amount of work, we did not analyse all the 1,230 charts that our students realised (each student elaborated three charts), but only 704 (for some students

we did not analyse all charts) that we chose randomly. These charts are the representative sample for the analysed population, with a confidence interval (also called margin of error) of $\pm 2.42\%$ for a confidence level of 95% (we realised the calculations using applications available on-line: <http://www.surveysystem.com/sscalc.htm>; <http://www.smarquest.ro/ro/resources.html>). The percentage of the analysed charts is approximately the same for all three specialisations (Figure 2.).

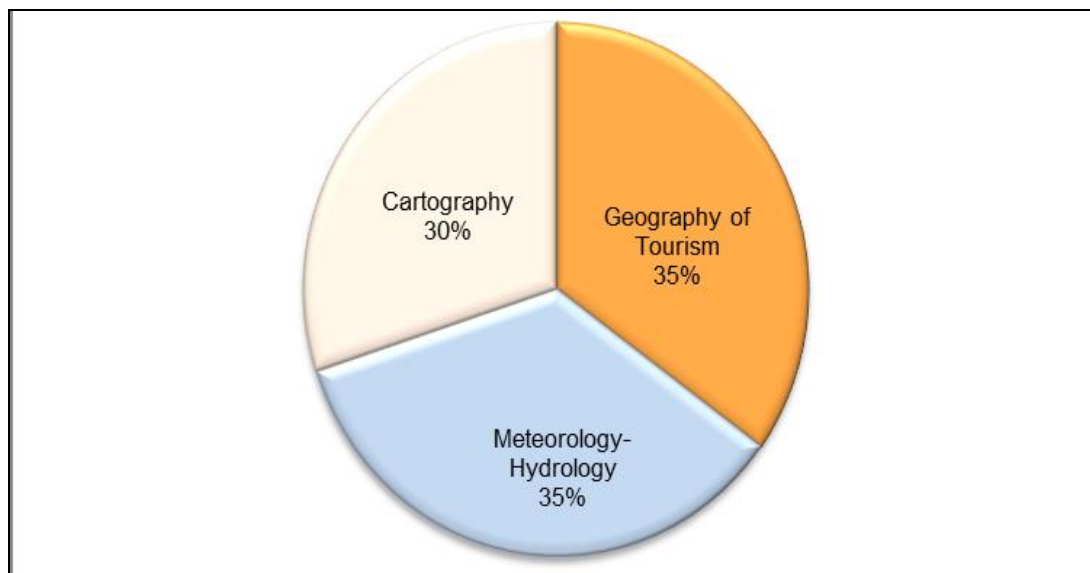


Figure 2.

The structure of the sample of analysed charts according to students' specialisation

There were differences in the initial training (competence level, knowledge level) of the students that represented this population (the subject variable) and these influenced the quantitative results of our research and their representativeness. As we confined our research to one Faculty of Geography only, it is possible that statistical results are not representative for any population or any sample of students in Geography.

Procedure

In order to analyse the competence to elaborate column charts, we used the analytical way of presentation in a table proposed by Maria Eliza Dulamă (2009, p. 247, p. 410, 2010, p. 323). Thus, we gave details and presented in Table 1 the internal resources (Voiculescu, 2010) or the knowledge integrated into the competence to elaborate column charts manually and in Table 2 we presented the ones integrated into the competence to elaborate column charts in a computer-assisted way. We generated the information in Table 1 and in Table 2 after analysing and reflecting on our own competence to elaborate such charts and not too much on the basis of scientific literature as it did not have the requested detail level on this subject (Osaci-Costache 2008b, Béguin, Pumain, 2003, Di Donna, 2007).

Table 1.

Components of the competence to elaborate column charts manually

Declarative knowledge	<p><i>Concepts:</i> chart, column chart, rectangular coordinates, abscissa, ordinate, scale, legend, column.</p> <p><i>Types of charts:</i> chart in afflux columns, united columns chart, distanced columns chart.</p> <p><i>General rules (GR) for elaborating charts manually or in a computer-assisted way</i></p> <p><i>GR 1:</i> If trusted institutes (e.g. National Institute for Statistics) publish data on their web pages, we recommend that you use those data as it is easier (some are exactly in the format accepted by Microsoft Excel, OpenOffice Calc and LibreOffice Calc).</p> <p><i>GR 2:</i> Do not use statistical data from distrustful web sources.</p> <p><i>GR 3:</i> Always quote the source of the statistical data that you use for realising the chart.</p> <p><i>GR 4:</i> It is compulsory that you mention on the chart the calendar date when they registered the statistical data you use.</p> <p><i>GR 5:</i> You should choose the most appropriate chart type according to the statistical data type.</p> <p><i>GR 6:</i> If you realise a single chart or if you represent charts independent from one another (separate charts), you should analyse for each of them the following elements in order to establish the size of the future chart, depending on the space available on the sheet of paper: the minimum value, the maximum value, the mean value, the existence of positive and negative values, the difference between the minimum and the maximum value, the difference between extreme values (minimum and maximum ones) of the reference years.</p> <p><i>GR 7:</i> If you place charts one beside another, you should observe GR 6, but you should compare data from all measurement points, in order to show the minimum and the maximum values etc. for all analysed data.</p> <p><i>GR 8:</i> If the charts are for a chart map or you intend to represent them on a single board, choose the same scale for all charts in order to facilitate comparisons.</p> <p><i>GR 9:</i> If the charts represent the same phenomenon, choose the same scale for all charts even if you insert them separately in your paper (so that the reader can make comparisons).</p> <p><i>GR 10:</i> Simple charts should have columns displayed in an ordered manner (in chronological order; increasing/decreasing according to values or to other criteria dependent on the respective case).</p> <p><i>GR 11:</i> If you render dynamics through afflux columns, the shorter column should be in front of the taller one (to make it visible).</p> <p><i>GR 12:</i> You should not place the shorter column in the front irrespective of situation (e.g. in case of charts in afflux columns that you draw one beside the others for comparisons). For instance, in the case of charts rendering chronological series of data, you should observe the chronological order. Similarly, when you put together charts that represent the same element/phenomenon/process, you should reproduce in all charts the succession of columns in the first chart or the first point of measurement, in order to favour comparisons.</p>
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	<p><i>GR 13:</i> You should always mention the measurement unit on the axis.</p> <p><i>GR 14:</i> You should write values so that anyone can read them, do not unite the written values, and, if possible, use transformations that will eliminate very long numbers (e.g. transforming number of inhabitants into thousands of inhabitants).</p> <p><i>GR 15:</i> Complex charts always have legends.</p> <p><i>GR 16:</i> It is compulsory that you order values to show an increasing or decreasing trend.</p> <p><i>GR 17:</i> Colour or hachure columns.</p> <p><i>GR 18:</i> You should write inscriptions correctly and using diacritics (according to language).</p> <p><i>GR 19:</i> The title should render the contents of the chart, not its type.</p> <p><i>Characteristic rules (CR) of elaborating charts manually</i></p> <p><i>CR 1:</i> Draw charts (axes, columns, hachures, etc.) only with drawing instruments (e.g. use a band, a forwarder).</p> <p><i>CR 2:</i> You should not create legends in case of charts in simple columns, if their titles mention the represented elements/phenomena.</p> <p><i>CR 3:</i> You should write inscriptions (values, titles, legends, etc.) neatly, with uppercase, using a pattern if possible.</p> <p><i>CR 4:</i> Place the title centred as related to the chart-legend system so that you obtain an aesthetic and correct layout on the page.</p>
Attitudinal knowledge	<p>Observe the requirements for elaborating charts in columns.</p> <p>Elaborate charts through personal effort.</p> <p>Finish the chart before the deadline.</p>
Procedural knowledge	<p>Identify statistical data.</p> <p>Process statistical data.</p> <p>Draw the rectangular system of axes.</p> <p>Draw the columns.</p> <p>Elaborate the legend.</p>
Procedure	<p>Stage 1. Identify statistical data</p> <p>Step 1. Establish which is the feature/phenomenon/process that you should realise a graphical representation for.</p> <p>Step 2. Establish which are the statistical data that you can use.</p> <p>Step 3. Identify the sources of the necessary statistical data.</p> <p>Stage 2. Process statistical data</p> <p>Step 1. Establish which is the detail level that you want to achieve when rendering data in a graphical manner.</p> <p>Step 2. Establish which are the elements/statistical individuals/geographical units (e.g. stations, settlements) for which you should get statistical data.</p> <p>Step 3. Analyse the data, take into account the measurement unit and, if it is necessary, that they undergo transformations for levelling.</p> <p>Step 4. Sort ascendingly or descendingly the data (if their type allows you to) so that you use ordered columns later on.</p> <p>Step 5. Choose the most adequate chart type according to the statistical data type.</p> <p>Step 6. Establish whether you can represent the same type of data independently (GR 6) or in a comparison, whether you should place charts in columns one beside the other (GR 7).</p> <p>Step 7. Choose the scale of your chart/charts according to the analysis from Step 5 and to available space.</p>

Stage 3. Elaborate charts in columns manually

- Step 1. Draw the rectangular system of axes.
 Step 2. Draw the ordinate according to the chosen scale.
 Step 3. Write the measurement unit.
 Step 4. Establish the width of the columns and draw them.
 Step 5. Write the significance of columns on the abscissa.
 Step 6. Create the legend if it is necessary.
 Step 7. Place legend correctly and aesthetically.
 Step 8. Finish the chart drawing the lines with black china-ink and colour columns observing the established rules.
 Step 9. Write the title (it should render the contents of the chart) placing it so that you obtain an esthetical and correct layout on the page (it should be centred according to the chart-legend system).
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Table 2.

Components of the competence to elaborate column charts in a computer-assisted way

Declarative knowledge They are identical to the ones integrated into the competence to elaborate column charts manually. Beside these, students should possess knowledge integrated into the competence of using diverse computer programs (Microsoft Excel, OpenOffice Calc and LibreOffice Calc).

The general rules are the ones for elaborating charts manually (GR 1 – GR 19) (Table 1).

Characteristic rules (CR) of elaborating charts in a computer-assisted way

CR 1: If it is necessary to sort data, introduce them with a new variable on each column as this is the only way the program will be able to sort values ascendingly or descendingly.

CR 2: If the title explains the significance of the columns (in the case of simple charts), do not create any legend for that chart, and if the program inserts it automatically, you should delete it.

CR 3: For inscriptions (values, title, legend, etc.) use the Arial font (or another similar font), but never Times New Roman.

CR 4: In order to publish charts in a country using the Anglo-Saxon system, decimals should be written with full stop instead of comma.

CR 5: If the chart is for a poster/slide-show, place the title so that you centre it as related to the chart-legend system and its layout on the page is both esthetical and correct.

CR 6: If the chart is for a paper, for a graduation thesis, for a book, etc., do not write the title of the chart in the program you use (e.g. Microsoft Excel), but place it within the text (below the chart, as an explanation of the respective figure), according to the established rules for publishing.

Attitudinal knowledge They are identical to the ones integrated into the competence to elaborate column charts manually.

Procedural knowledge Identify statistical data.
 Process statistical data.
 Elaborate charts in the following programs: Microsoft Excel, OpenOffice Calc, and LibreOffice Calc.
 Elaborate legends in the following programs: Microsoft Excel, OpenOffice

	Calc, and LibreOffice Calc.
Procedure	<p>Stage 1. Identify statistical data (see the competence to elaborate column charts manually).</p> <p>Stage 2. Process statistical data (see the competence to elaborate column charts manually, without Step 4).</p> <p>Stage 3. Elaborate column charts in a computer-assisted way</p> <p>Step 1. Introduce the data with a new variable for each column.</p> <p>Step 2. Select the appropriate chart type for the introduced data.</p> <p>Step 3. Modify, if necessary, the values of the ordinate (minimum value, maximum value, interval between values).</p> <p>Step 4. Modify, if necessary, the appearance of the columns (e.g. united, at a certain distance).</p> <p>Step 5. Insert the legend (if it is necessary) and establish its features.</p> <p>Step 6. Write on the ordinate the measurement unit (e.g. mm, tonnes, ha, km²).</p> <p>Step 7. Dispose the appearance for the explanations of columns (on the abscissa).</p> <p>Step 8. Modify the colours of the chart (columns, background, basis, etc.).</p> <p>Step 9. Write the title so that you obtain a chart as a single image (CR 5).</p> <p>Step 10. For inscriptions on the chart, use Arial or any other similar font.</p> <p>Step 11. Save the chart either as .pdf, or as an image in .png format.</p>

We asked students to be involved in an activity of integration for forming the competence to elaborate column charts. This activity has the role of independent variable. We planned and organised this activity according to Maria Eliza Dulamă's suggestions (2010, pp. 75-82, 2011, pp. 98-108). Students realised an individual task that consisted of elaborating several types of charts (with columns, with bands, areolar charts, etc.). For achieving maximum relevance, we decided to analyse separately the diverse types of charts and, as a result, this paper focused only on column charts. The integration activity for forming the competence to elaborate column charts had the following stages:

a. Presenting theory. During our lectures, we explained theoretical issues, we gave examples of charts in slide-shows realised with PowerPoint and we built with students a heuristic dialogue starting from these. In the text book for our course (Osaci-Costache, 2008a), we explained the theories of identifying statistical data, processing statistical data, describing these charts, the procedure to elaborate them, when we used them (for what kind of data), what rules we had to observe, etc.

b. Explaining how to elaborate column charts. During practical work, we explained how to realise column charts. We provided students with a text book for practical work (Osaci-Costache, 2008b), including both theory and proposals for applications, many of them together with the necessary statistical data. First, we explained to students *how to realise column charts manually* on millimetre paper. In order to solve tasks, during their activity, students read the process in Table 1. In order *to realise column charts in a computer-assisted way*, we explained to students that irrespective of the program they used (*Microsoft Excel, OpenOffice Calc or LibreOffice Calc*) they had to undergo the stages presented in Table 2. Although Microsoft Excel had considerable potential for manipulating and processing statistical data and although we could use it successfully in

didactics in order to elaborate charts (Cardoso, 2012, p. 67), we insisted on using Open Source alternatives (OpenOffice Calc or LibreOffice Calc) when students had no license for the respective program (Osaci-Costache, 2012, p. 129).

c. Presenting and solving the task. A week before the activity, we provided students with the procedure, both printed and in digital format. They either made a copy of the respective sheet of paper or they read it on the screens of their laptops. During practical work, after evoking certain previous knowledge necessary for forming the competence to elaborate column charts, we told students what tasks they had to solve during our classes and those they had to finish at home. Students needed a PC (laptop), Microsoft Excel, LibreOffice Calc or OpenOffice Calc, statistical data, millimetre paper, a band, a forwarder, a black pencil, coloured pencils, writing instruments with china-ink. Students had two hours during the practical work class and other two weeks at home, when they had time to finish the charts or to elaborate them again. They started solving the task observing the procedure described in Table 1 and Table 2. During the practical work, we monitored students and they had the possibility to ask for and receive feedback about the procedure or receive feedback also without asking for it.

The tasks were the following:

1. *Elaborate manually a chart in united columns that should represent mean multiannual rainfall at a meteorological station of your choosing. For this, use the data in the text book for practical work (applications no. 299 or 300, page 307 in Osaci-Costache, 2008b).*

2. *Elaborate a column chart in a computer-assisted way, using the following data in the text book for practical work:*

i) the population of several villages in Argeş County in the year 1835 (application 302, page 308 in Osaci-Costache, 2008b; realise a column chart);

ii) the evolution of the number of inhabitants in three rural settlements at three reference years (application 303, page 308 in Osaci-Costache, 2008b or use data of your choosing from the web page of the National Institute for Statistics; realise a chart with afflux columns) or the evolution of the forested area for two interfluves in the Hills of the Argeş (Muşcelele Argeşului) (application 305, page 308 in Osaci-Costache, 2008b; realise a chart with afflux columns);

iii) mean multiannual rainfall at a meteorological station of your choosing (students should do the before manually realised application in a computer-assisted way, but they should change the station; realise a simple chart).

We verified students' products (charts – dependent variable) after two weeks since elaborating them during the classes for practical work. During this time they had the possibility to elaborate them again. Each student had to realise three column charts: two of them in a computer-assisted way (of their own choosing, from the above-mentioned task) and one manually. To solve the task (one chart realised manually and three assisted by the computer), the maximum *number of points* they obtained was 0.5 (in the final mark of their assessment for the respective academic course). *Conditions* for

presenting individual work were the following: (a) charts should be printed/realised on paper (even several charts on the same sheet of paper) and (b) identifying identical charts from different students meant excluding the task from their assessment.

In order to analyse charts, we conceived an analytical assessment grid with a dichotomous scale (according to Dulamă, 2010, p. 86, p. 105, 2011, pp. 106-107, pp. 120-122). The assessment tool we created (Table 3) included ten assessment criteria. Taking into account the features that column charts should have had, for each criterion we specified one or several indicators (noticeable elements or descriptors). To simplify assessment, we used abbreviations for each of the 20 indicators (Table 3).

Table 3.

Analytical assessment grid with a dichotomous scale for column charts

Criteria	Abbreviation	Indicators/noticeable elements/descriptors
Conception	Co	The student chose the correct chart type.
Title	T1	The title reflects correctly the contents of the chart.
	T2	The title renders the contents of the chart, not its type.
	T3	The student placed the title in the upper part of the chart, centred in relation to the chart, in order to obtain a separate figure.
Order of data	O1	The student placed columns in an ascending or descending order (in case of data that should be ordered).
	O2	The student observed the criterion <i>time</i> when ordering data.
Chromatics	C1	The student used pastel shades and combined them in a harmonious manner.
	C2	The student chose appropriate colours according to the type of the represented elements (e.g. blue for rainfall).
	C3	The student chose nuances of the same colour in order to represent a certain ordering of data.
Legend and its arrangement	L1	The chart has a legend (if necessary, for complex charts).
	L2	The student arranged the elements of the legend in a certain ascending or descending order (e.g. values, years).
	L3	The student placed the legend correctly and aesthetically.
	L4	There is no legend if the title of the chart is enough to understand a simple chart.
Measurement unit	M	The student mentioned correctly the measurement unit on the vertical axis.
Moment in time of the statistical data	MT	The student mentioned the moment in time when statistical values were collected by others (either in the title, or in the legend, depending on the respective situation).
Source	S	The student mentioned the source of the statistical data.
Writing the chart	W1	The student used an appropriate font (e.g. Arial, not Times New Roman), an appropriate font size, and for the manually realised charts, he/she wrote neatly, with uppercase.
	W2	The student wrote the significance of columns and he/she paid attention that its layout on the page is correct and related to the chart too.
Layout and	E1	In the case of manually realised charts, the student used the

aesthetics of the chart	E2	band, and the drawing is neat. The whole image (chart, title, legend, source of the data) has a correct and aesthetic layout on the page.
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Findings

1) *The knowledge integrated into the competence to elaborate column charts.* In Table 1, first, we presented the declarative knowledge integrated into the competence to elaborate column charts manually. We included nine concepts, three chart types, 19 general rules for elaborating charts manually and in a computer-assisted way, and four rules characteristic of elaborating charts manually. Then, we presented the attitudinal and procedural knowledge integrated into this competence. We identified three stages for the procedure, each of them including a series of steps.

In Table 2, first, we presented the declarative knowledge integrated into the competence to elaborate column charts in a computer-assisted way. Concepts, chart types and general rules are identical to the ones for the competence to elaborate column charts manually. We included six rules characteristic of elaborating charts in this way. We identified three stages for the procedure and the first two are identical to the ones for the competence to elaborate column charts manually.

2) *Procedure for elaborating column charts.* We presented in Table 1 the procedure for elaborating column charts manually. In Table 2, we presented the procedure for elaborating column charts in a computer-assisted way.

3) *Students' mistakes in elaborating charts.* We used an analytical assessment grid with a dichotomous scale (Table 3) in order to analyse the 704 charts that students realised during the two academic years and we looked for mistakes.

In Figure 3, one may see students' most common mistakes out of the total number: no mention of the source for statistical data (S); no mention of the measurement unit (M); insertion of legend although it was not necessary (L4).

Ten other mistakes are common: wrong title that did not reflect the contents of the chart (T1); inappropriate chromatics (C2); choosing a chart type that was not appropriate for the respective data (Co); using an inappropriate font type and font size (W1); incorrect and inaesthetic layout on the page (E2); incorrect and inaesthetic placement of the legend (L3); students did not place the title in the upper part of the chart and they did not centre it in relation to the chart in order to obtain an independent figure (T3); students did not write the significance of the columns (W2); students did not place columns in an ascending or descending order when needed (O1); using too many colours, unpleasant colours (C1).

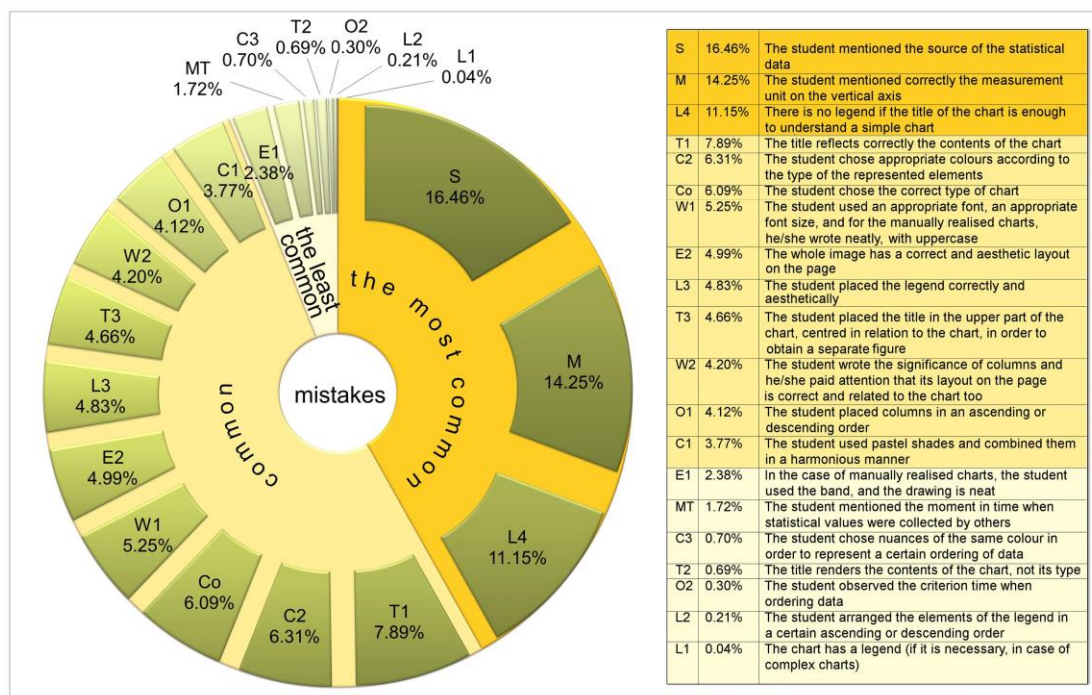


Figure 3.

Frequency of the criteria where students made mistakes (for details check Table 3.)

The least common mistakes were the following seven ones (Figure 3): untidy drawing, realised without any pattern instruments (E1); not mentioning the moment in time for statistical values (D), students did not choose nuances of the same colour for ordering the same data type (C3); the title contained the chart type (T2); students did not observe the *time* criterion when ordering data (O2); lack of order for the elements of the legend (L2); the chart had no legend although it was necessary (L1).

In Figure 4, we noticed that there were differences in the frequency of the mistakes dependent on students' specialisation. For instance, not mentioning the source for the statistical data accounted for 14.14% of the total number of mistakes made by students in *Cartography*, 16.35% in *the Geography of Tourism*, and 18.87% in *Meteorology-Hydrology*. Students in *Cartography* made the lowest number of mistakes when choosing the correct chart type, the appropriate colours, and the correct placement of the title. Students in *Meteorology-Hydrology* had the best results in choosing the correct title, the correct font, pleasant colours and ordering them according to values, and in choosing the correct and aesthetical place of the legend, etc. Students in *Geography of Tourism* made the lowest number of mistakes when mentioning the measurement unit, ordering columns, mentioning the moment in time when those statistical data were collected by other people, etc. Altogether, the students in *Geography of Tourism* made the lowest number of mistakes and students in *Cartography* on the opposite.

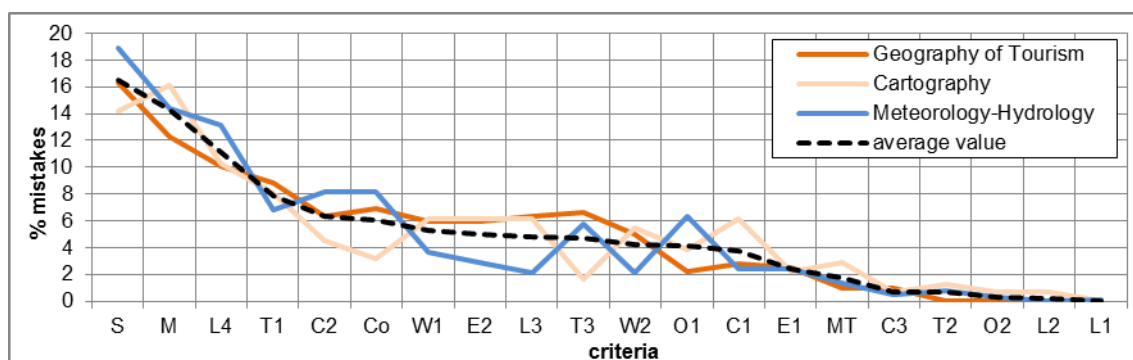


Figure 4.

Comparison between students' mistakes according to students' specialisation

4) *Causes of mistakes in elaborating charts*

(a) Some of these causes related to students: low level of competence in Mathematics for students that graduated a humanistic profile in high school; low level of aesthetic education; insufficient knowledge of the computer program; lack of experience; low synthesis capacity; their daily level of fatigue; 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; accepting all that the program "proposed" as correct; imitating features of incorrect charts that they saw in magazines or in advertisements).

(b) Some causes related to the organising of the educational process: no drawing classes during high school, many students in each group and placement of practical work classes at the end of the day when students were already tired.

5) *Modalities to improve the educational process and students' results*

(a) Some of these modalities belong to professors: discussing with students each chart type, mistakes and the way to correct them; when teaching, insisting on those aspects that caused most of the mistakes; discussing with students the assessment grids used to assess them after elaborating charts; creating and offering students a check list correlated to the assessment grid; undergoing the two assessment stages mentioned in the model for the formation of the competence: initial assessment and final assessment (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; paying more attention to assignments within tasks and observing them.

Discussion

Analysing the knowledge integrated into the competence to elaborate column charts

We described in Table 1 and in Table 2 the knowledge that students should use to elaborate column charts manually or in a computer-assisted way according to the

analytical way of presentation used by Maria Eliza Dulamă (2009, p. 247, p. 410, 2010, p. 323) as we identified no other such ways of presentation in the literature we studied. We used this analytical way of presentation as it offered us a series of advantages: decomposing of the elements necessary for students to use in order to prove their competence to elaborate column charts; it helped us pose the questions whether our students possessed in their own knowledge base all the knowledge integrated into the respective 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 and rules that our students should have observed, the attitudes they should have had while achieving competences and solving tasks; the chronological ordering of the procedure with stages and steps was useful for planning and organising our activity, because we made sure that we observed the respective stages and steps, without omitting any of them.

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 four competences: (a) the competence to identify statistical data; (b) the competence to process statistical data; (c) the competence to elaborate column charts manually; (d) the competence to elaborate column charts in a computer-assisted way. When describing these competences, we had to select one of the following three possibilities: describing separately the four competences; describing in an integrated manner the four competences; describing the competence to elaborate column charts manually independent of the competence to elaborate them in a computer-assisted way. We selected the third variant because, irrespective if competent students elaborated by themselves a column chart manually or in a computer-assisted way, they had to identify and process statistical data and that was why we also integrated those competences in Table 1 and in Table 2. In these tables, one may notice that we distinguished between certain declarative knowledge and certain procedural knowledge integrated into the competence to elaborate column charts manually and those integrated into the competence to elaborate them in a computer-assisted way because the material means and procedures differed.

Despite these difficulties and the possibility of existing different opinions about the knowledge integrated into the competence to elaborate column charts, we considered that this way of presentation 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 any subject-specific competence and we recommend it to be used in assessing the results of learning in other subject matters too.

Analysing the procedure to elaborate column charts

We gave details on the procedure that students elaborating column charts underwent and we systemised it into stages and steps after the way of presentation used by Maria Eliza Dulamă (2010, p. 323). This description was useful for us during the planning and

organising stage of the integrating activity for forming this competence. When we described the procedure, we selected from the following two descriptions: the one in which we use the imperative verb (e.g. "Analyse!") and the one in which we use the noun ("Analysis"). Maria Eliza Dulamă used both ways of describing this process (i.e. the procedure) (2009, p. 247, p. 410, 2010, p. 323). In this case, we preferred 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 work classes 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. Taking into account the fact that Romanian scientific literature was not enough, we used the course as a very good opportunity to transmit students the theoretical part elaborated on the basis of European scientific literature which was at the basis of forming the competence to elaborate column charts (for this, very useful was Field, 2012, pp. 317-349, and Spence & Lewandowsky, 1990, pp. 13-57). During our activity with students, the main difficulty for us was that there were too many students in the room and we could not verify what each student worked in order to give each of them appropriate feedback at once.

Analysing column charts, the mistakes university students make in elaborating them and the causes leading to their mistakes

We analysed the 704 charts using the assessment grid presented in Table 3. Our purpose was not to assess the competence level our students achieved, because, in that case, we would have used another grid or we would have structured the present one in another way, but we wanted to identify students' main mistakes visible in their column charts.

In terms of students' mistakes at elaborating column charts, the authors reached the conclusion that *some of them were more frequent than others*. We analysed them.

We considered that frequent omission of the source reflected students' habit (since high school) to copy information (including the Internet as a source) without quoting their source and this compelled us to their careful education for changing this undesirable behaviour. During lectures, we discussed with our students the features, the phenomena, and the processes that we could represent using column charts (e.g. variation of rainfall in the Carpathians and in the Sub-Carpathians) and we mentioned that in order to elaborate that column chart it was necessary that we established the statistical data that we might use (e.g. mean multiannual values between 1900 and 1990, at meteorological stations in the researched area). We also discussed the sources of the necessary statistical data (e.g. the National Administration for Meteorology, meteorological statistical data already published for a series of years, meteorological atlases, PhD theses, statistical books for each year, censuses, the National Institute for Statistics, etc.) and the rules they had to observe (Table 1). Nevertheless, some students still forgot to mention their source.

Not mentioning the measurement unit (M) was a more frequent mistake in the case of computer charts than in the case of the manually realised ones and this made us decide that a cause of omission was students' insufficient knowledge of the program and of the steps that they should have made in order to place the respective measurement unit on the axis. We showed students in a concrete way how to do this using a certain program (e.g. Microsoft Excel, OpenOffice Calc, and LibreOffice Calc), but those who took no notes and did not know the respective program since high school (i.e. graduates of the humanistic profile) used it with difficulty.

Placing an unnecessary legend was another frequent mistake (L4) again especially in the case of computer charts. For elaborating charts in a computer-assisted way, we noticed that some versions of the program inserted the legend automatically, and students did not delete it. When asking them why they did not delete it although one could understand from the title what columns represented, we found out that they thought that everything the program proposed was good ("If the program inserted it, it meant that that was how it should have been"). The students that made this mistake did not observe the rule that they should omit the legend for simple charts where the title included the significance of the columns. They did not differentiate this situation from the one where not inserting a legend was a serious mistake if the title did not explain the contents of the chart and the reader could not decode the significance of the columns. Students should have known that within the legend it was compulsory to order ascendingly or descendingly numerical data, moments in time, etc. (Năstase, 1983, p. 327).

For instance, students mentioned frequently in the title the type of graphical representation, although we mentioned during our lectures that was a mistake to write "Chart with..." or "Column chart of rainfall ..." (Osaci-Costache, 2008a, p. 119), or "The graphic about ..." and that a correct phrasing could be for instance "Mean multiannual monthly rainfall ...". We noticed that students had difficulties in phrasing a short, clear, and complete title in which to include the represented feature and the territory it referred to. Their impossibility to phrase titles correctly so that they reflected the contents of the column charts had as causes both gaps in their geographical knowledge and in their knowledge about requirements or rules for phrasing titles, and students not being able to synthesise because they did not have either an already formed geographical thinking, or enough knowledge that helped them extract the essential and transmit it through titles.

Choosing inappropriate colours (inappropriate chromatics, C2) in relation to the represented data (e.g. red for rainfall) had as a cause insufficient geographical and cartographical knowledge, as well as the fact that students were tempted to accept everything the program "proposed". It was not clear for some students that usually they should have coloured or hachured charts observing certain rules. For instance, when representing a single phenomenon (e.g. mean annual rainfall), columns should all have had the same hachure or colour so that there were no distortions of the perception of length differences because of their changed appearance (Osaci-Costache, 2008a, p. 119), and when they wanted to draw the readers' attention to the variation of a phenomenon, it was recommended to use darker nuances for higher values.

Choosing an inappropriate chart type for data (Co) was a mistake caused by insufficient cartographical and geographical knowledge, by students' lack of attention when we explained theory during lectures, or by their absence from classes.

Some students used an inappropriate font type and font size (W1). They chose Times New Roman for charts, either because it was the most known one (from the papers they wrote during high school years), or because they did not want to change what the program "proposed", or because they did not consider that to be an important "detail". In some cases, they chose very inappropriate font types, omitting the fact that writing a chart should have been simple and austere. Choosing the right font size was another difficulty caused by their lack of aesthetic education and experience.

Students had difficulties in deciding upon an aesthetic layout of their charts on the page, as well as of the legend, and of the title. Causes were diverse: no drawing lessons during high school, no aesthetic sense, and no experience. More exactly, the aesthetic placement of the legend in relation to the chart depended also on the program which proposed a certain placement and students were tempted not to modify it. The correct and aesthetic placement of the title did not pose big problems for computer-assisted charts, but, in the case of manually realised charts, students frequently positioned titles in relation to the format of the millimetre paper and not in relation to the whole image (chart and legend) as they should have.

In few cases, students omitted the significance of the columns (W2), especially in the case of computer charts where the program did that operation automatically. Usually, their mistakes consisted of wrong orientation of the writing related to the axis and of wrong use of symbols (e.g. writing the months of the year with Arabic numbers instead of writing them with Roman ones). In the case of the charts they realised manually, students sometimes forgot to write the significance of columns or they wrote it only at the second column or even more rarely.

Similarly, in few cases, students omitted (O1) ordering columns either descendingly or ascendingly (although compulsory in many cases), but this was a common mistake also for professors or PhD candidates, etc., as we noticed at paper presentations during conferences, in certain published papers over the last 20 years, in university exam papers, in teachers' papers. For students it should have been very clear that, in this case, geometrical figures were rectangles and that they should have represented each variable through a rectangle (a column), having fix width and length (placed on the vertical) corresponding to the value they should have represented. Students should have ordered the data represented by columns either in a chronological order, or ascendingly and descendingly (e.g. depending on what to transmit to the reader or depending on the data type), but never randomly. Students should have ordered columns to facilitate reading (Béguin, Pumain, 2003, p. 81) and using them, not only taking into account the aesthetics. They should have placed columns one beside another (contiguous, united), superposed (in afflux), and at a distance (isolated).

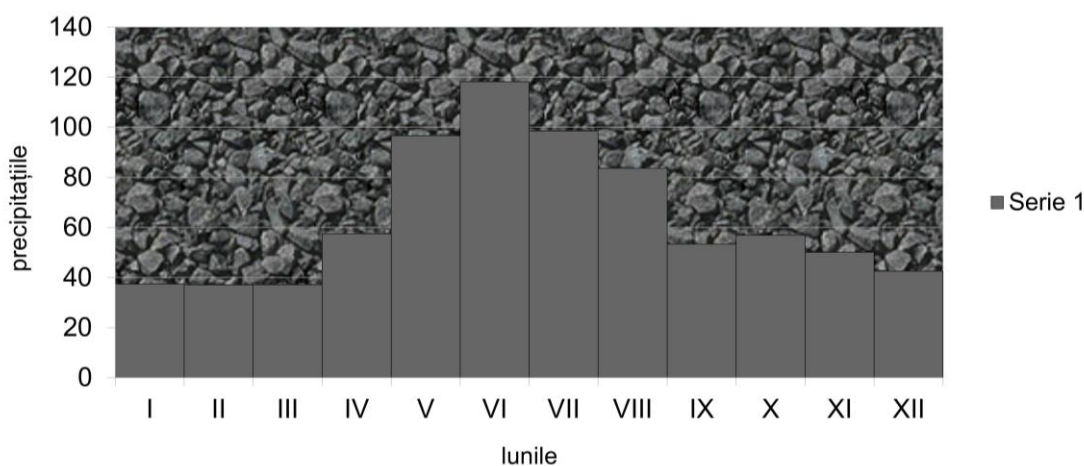
Some students were tempted to imitate the charts they saw in magazines, in advertisements, etc., to choose too many colours, violent, unpleasant and contrasting colours, like "Arlechino's clothes" and this made representation "unpleasant" (Traversi,

1970, p. 318). Some preferred not to change the colours that the program “proposed”, although it observed no cartographical rules. They did not know or were not aware of the importance of choosing colours appropriate to the category in which we integrated the analysed element or phenomenon, colours that should have suggested the respective phenomenon (Figure 3). They did not know the rule that in case of representing different phenomena they should have used different colours, but not violent ones.

According to students’ specialisation, as a paradox, students in *Cartography* made the most frequent mistakes. The cause was their low level of previous knowledge compared to that of students’ in the other specialisations and because most of them graduated a humanistic specialisation in high school and thus they were not used to the rigour of Mathematics. Another cause of their high number of mistakes was the fact that, during the 2011-2012 academic years, groups included a higher number of students than usual and this was not in favour of quality.

Many students’ charts had no mistakes, some had only one mistake, and others had many mistakes. For instance, in Figure 5, we reproduced a student’s chart with an incomplete (the student did not mention place, time, and rainfall type) and wrong title (because it contained the word “chart”). There was no measurement unit (in its place the student wrote “rainfall”). The legend was wrong and futile as it gave no explanations for the represented elements (“Series 1”), and the students chose inappropriate colours for the chart and the visual effect was unpleasant. In addition there were no data labels and thus the transmitted numerical information was minimum.

Diagrama precipitațiilor



Sursa datelor: Osaci-Costache, 2008, p. 307

Figure 5.

Chart realised for task 2. iii) by a student in *Geography of Tourism* (2010-2011)

In the second example (Figure 6), although the chart had a correct title (“Mean monthly rainfall at Curtea de Argeș meteorological station, 1900-1990”), the student did not place it aesthetically on the page. Moreover, the student wrote both title and other

writing on the chart with Times New Roman instead of Arial or a similar font type. The student wrote explanations on the abscissa (months) using much too big a font size, and the result was that the writing naming one month almost unites with the one naming the following month (e.g. July and August). The legend, wrong and futile, was a result of processing data incorrectly within the computer program. In fact, this was the most obvious mistake for this chart: different colours (but also unpleasant and violent for each column, this being a typical example of “Arlechino” chart type), meaning a wrong representation of data. The student did not mention the source of the statistical data.

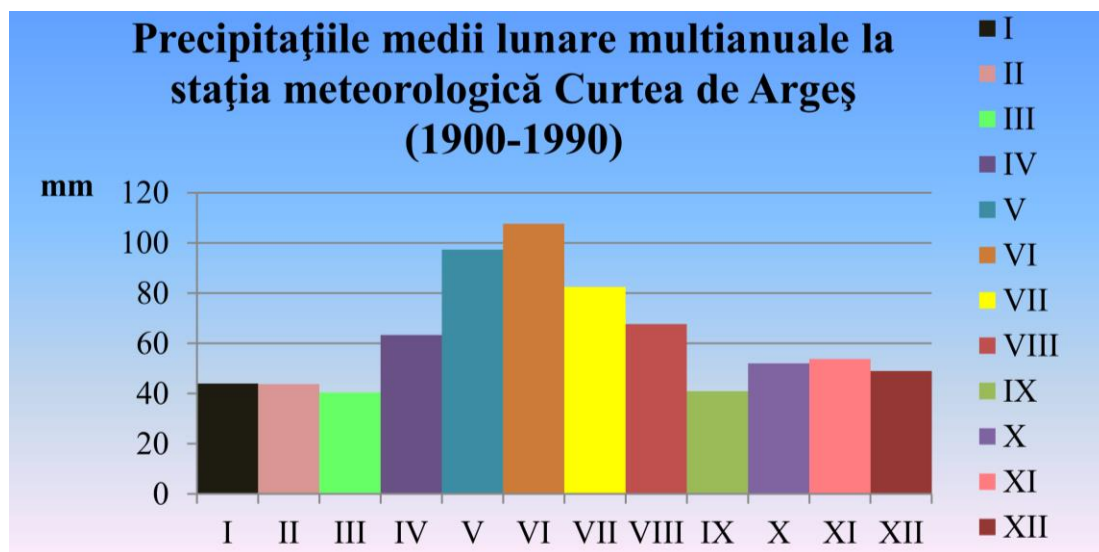


Figure 6.

Chart realised for task 2. iii) by a student in Meteorology-Hydrology (2010-2011)

The third example (Figure 7) is a chart with an incomplete title: “Number of inhabitants (1835)”. We noticed that the student did not order increasingly or decreasingly numerical values so the graphical message was not efficient. Beside the futile legend (in terms of contents), the student made some other mistakes, too: placement on the page and aesthetic of the chart, inappropriate colours, inappropriate font size for the size of the chart, and no measurement unit.

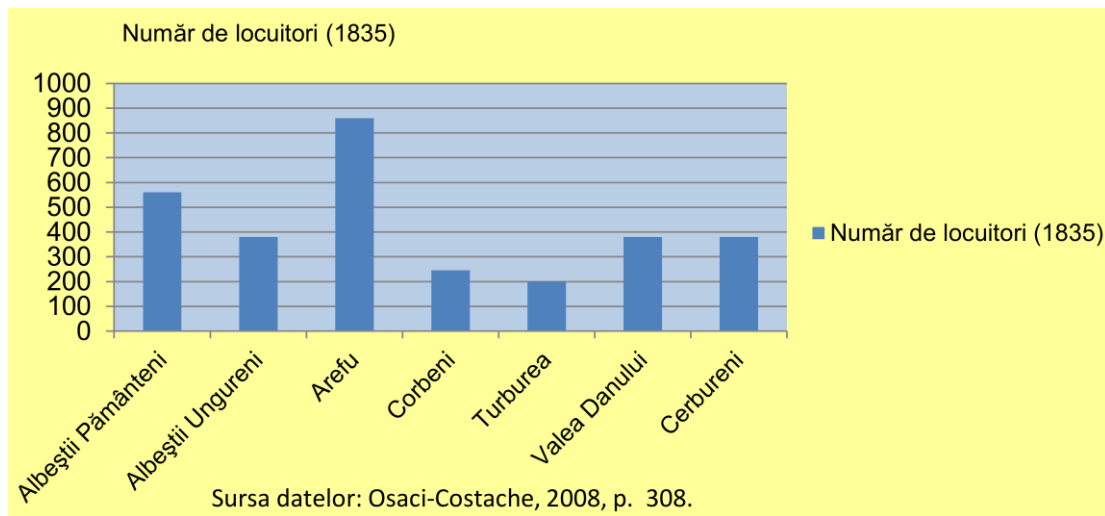


Figure 7.

Chart realised for task 2. i) by a student in Geography of Tourism (2010-2011).

A fourth example (Figure 8) is of a chart without title, with pleasant colours resulting in a good visual effect, but the gradual use of colours is wrong. Moreover, it is recommended that we avoid blue when representing total population because we usually associate it with elements of hydrography, with rainfall, with male population, etc. Thus, interpreting the chart as it is may produce confusion.

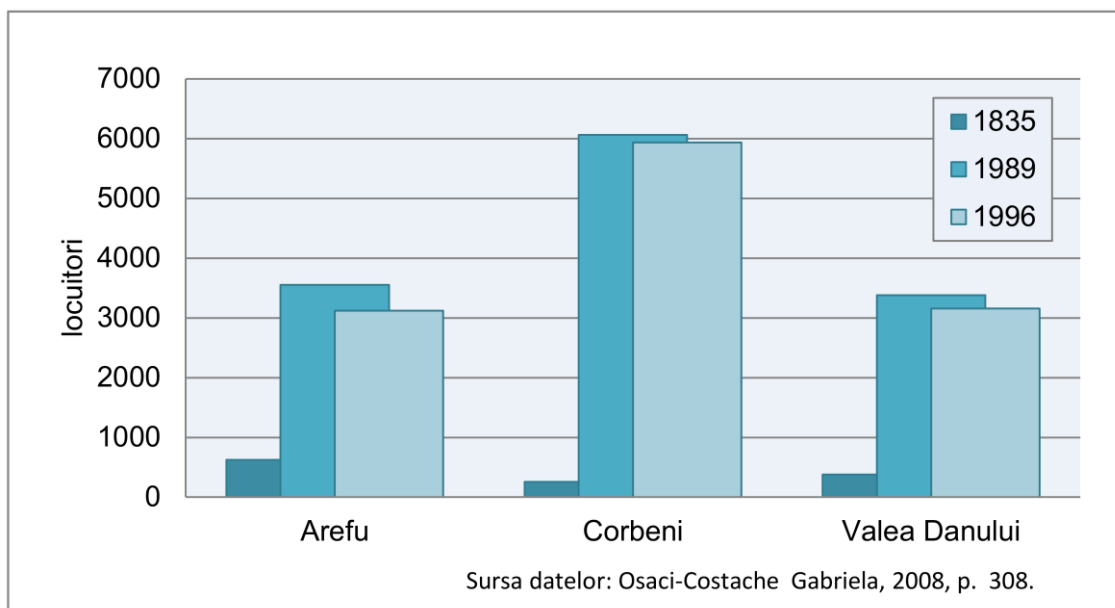


Figure 8.

Chart realised for task 2. ii) by a student in Cartography (2011-2012)

Identifying ways to improve the educational process and students' results

One of the objectives of our research was to identify the ways to improve the educational process. We identified the weaknesses of the process for forming a competence that we

could improve in future activities. When teaching, it would be efficient to discuss with students not only each chart type, but to focus on the causes of most of their mistakes, to exemplify mistakes and discuss how to correct them.

Another direction for improving the educational process could be discussing with students the assessment grid before elaborating charts, the grid that we tested during this research and that the students involved into this research did not benefit from.

In this research, identifying mistakes in a systematic way with the help of the created instrument – the analytic assessment grid of the competence to elaborate column charts – helped us offer direct and individual feedback when students presented their charts for assessment. Through this participatory assessment, students identified the mistakes they made and understood what they had to change and correct so that their products were correct and observed aesthetic requirements. Still, we noticed that it was difficult for our students to identify certain mistakes even if they had these tools. For instance, in order to be assessed as products elaborated by individuals with high competence level, charts should have a so called “graphical elegance” (Tufte, 1983) that could be obtained when complexity of data came together with simplicity of drawing (Tufte, 1983, *apud* Mazza, 2007, p. 14). Elegant graphics are those drawn in a professional manner, paying attention to details, without futile ornaments (e.g. borders, background colour, 3D effects, etc.) and while choosing an appropriate format and design (Mazza, 2007, pp. 13-14). When necessary, students should also place the legend so that the chart is aesthetic as a whole.

It is important to offer students a check list correlated to the assessment grid. Students' use of these tools could increase the quality of their results and mistakes would decrease. Still, although students are involved in an activity for the formation of the competence under optimum circumstances for achieving good results, we noticed that some students were not responsible enough in order to obtain the wanted results. That is why we consider that some ways of avoiding mistakes when elaborating column charts and of improving results belong to students themselves: they should pay more attention to professors' explanations and directions and to those from the recommended literature, as well as to assignments within tasks. And what is even more important is that students observe them.

We want to include the results of this research in a new text book for practical work which will help students – through graphics (e.g. symbols that draw their attention to the importance of a certain element, charts to be used as models that should highlight the importance of certain elements) and modality of organising information (rules, steps, highlighted suggestions, etc.) – learn more easily and have better results.

After analysing over 700 charts, mistakes and their causes, we drew the conclusion that the ways to better the educational process and students' results could be the following: (a) discussing with students, during classes, each chart type, possible mistakes and the way to correct them; (b) focusing, while teaching, on those aspects that determined most mistakes; (c) discussing with students the assessment grid before realising charts; (d) students' use of checklists.

Conclusions

In this paper we reached several conclusions. First, the analytic instrument where we gave details about the knowledge integrated into the competence to elaborate column charts, conceived after the way of presentation created by Dulamă (2009, p. 247, p. 410, 2010, p. 323), was very useful for planning and organising our activity for forming students' competence to elaborate column charts. On the basis of previous and current research, we consider that this analytical tool could be conceived and used efficiently for detailing any subject-specific competence.

Secondly, by observing the stages and the steps of student work, the details and the systematization of the procedure that students underwent when elaborating column charts, created according to Dulamă's way of presentation (2010, p. 323), we could rigorously assess their work. This helped us to plan and organise the integration activity for forming this competence in a more efficient way. This way of presenting the procedure students should undergo for the formation of a certain competence could be transferred for giving details and chronologically systemising the formation of any subject-specific competence. In order to elaborate a superior quality tool, professors or researchers should possess at the expert level the competence they describe.

Thirdly, the basis of the presentation ways conceived by Dulamă (2010, p. 86, p. 105, 2011, pp. 106-107, pp. 120-122) informed development of the analytic assessment grid with a dichotomous scale including ten criteria and 20 indicators. This grid helped us assess efficiently and correctly the charts that our students elaborated during practical work. Taking into account the references mentioned for this paper and the results of our research, we noticed that criteria and indicators are different from one competence to another and that they had to allow the assessment of the entire product and of the competence, respectively. In order to achieve the objectives of our research, we conceived and used this grid and on the basis of each indicator we established whether the assessed chart had or did not have the respective feature. For our future research on the competence to elaborate charts, in order to expand our study, we want to create and use assessment grids through which to assess the competence level. We could elaborate these grids by restructuring the already created one or by creating a whole new grid type (for instance, the global assessment grid). Moreover, we want to elaborate and use grids for assessing the competence to elaborate other chart types, too. In this case, it would be interesting to identify similarities and differences among assessment grids and among students' results.

Fourthly, some of students' errors were more frequent than others. The highest frequency referred to not mentioning the source of the statistical data ($S = 16.45\%$), followed by not mentioning the measurement unit ($M = 14.25\%$), and by inserting a legend although it was not necessary ($L4 = 11.15\%$). Frequency between 5% and 10% was characteristic of the following mistakes: wrong title that did not reflect the contents of the chart ($T1 = 7.88\%$); inappropriate chromatics ($C2 = 6.30\%$); choosing a chart type that was not appropriate for the data type ($Co = 6.08\%$); using an inappropriate font and an inappropriate font size ($W1 = 5.25\%$). The frequency of the other mistakes was

below 5%. It would be interesting to study what mistakes make students from other university centres in Romania or abroad in elaborating column charts.

Finally, related to the causes of mistakes, we noticed that some of them focused on students' previous knowledge: lacunae and low level of geographical and cartographical knowledge; low competence level in Mathematics or students who graduated the humanistic profile in high school; low level of aesthetical education; insufficient knowledge of the program and of the steps to make; lack of experience; low synthesis capacity. Two causes were related to the organizing of the pre-university and university educational process: lack of drawing classes in high school; high number of students (30) for a practical work class. We correlated many causes to the students' behaviour that we noticed (there are no quantitative data available): no presence at academic lectures; students' lack of attention to professor' explanations; listening to lectures without taking notes; students' habit to use information without quoting the source; students did not observe the requirements and the rules they received; accepting all the program "proposed" as being correct; imitating "charts" seen in magazines and in advertisements although they did not observe any cartographical rules.

A future research direction could be investigating the causes of mistakes in elaborating charts by means of discussions with each student starting from their charts. Through these discussions, identifying causes would be objective, not only interpretative or qualitative, and a statistical processing of causes would be possible. In this case, it would be interesting to establish the link between students' absence from lectures or from practical work classes and their results obtained only due to individual study.

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Biographical statements

Dr. Gabriela OSACI-COSTACHE is a lecturer at the Department of Geomorphology-Pedology-Geomatics, Faculty of Geography University of Bucharest, Romania. Her didactic activity focuses on teaching Cartography, Thematic Cartography, and Techniques and Methods for Cartographical Representation. Her fields of interest for research are Historical Cartography, Thematic Cartography, Landscape Dynamics, GIS, the Didactics of Geography, and Toponymy. She is also the Cartography editor of the online journal *Romanian Review of Geographical Education* and organiser of the international conference *Contemporary Trends in Teaching and Learning Geography*, Cluj-Napoca, Romania.

Dr. Maria Eliza DULAMĂ is an associate professor at the Department of the Didactics of Exact Sciences, Faculty of Psychology and Sciences of Education, “Babeş-Bolyai” University, Cluj-Napoca, Romania. Her didactic activity focuses on Geography teachers’ initial and continuous formation. Her main fields of interest for research are the Didactics of Geography, the educational process in Geography, and forming and assessing competences. She is also the editor in chief of the online journal *Romanian Review of Geographical Education* and coordinator of the international conference *Contemporary Trends in Teaching and Learning Geography*, Cluj-Napoca, Romania.

Dr. Oana-Ramona ILOVAN is a lecturer at the Department of Regional Geography and Territorial Planning, Faculty of Geography, “Babeş-Bolyai” University, Cluj-Napoca, Romania. Her didactic activity focuses on teaching General Regional Geography, Research Methods in Regional Geography, Regional Planning and Local Development. Her main fields of interest for research are Regional Geography, Research Methods in Regional Geography, Territorial identity and its role in regionalisation, and the Didactics of Geography. She is also the executive editor of the online journal *Romanian Review of Geographical Education* and organiser of the international conference *Contemporary Trends in Teaching and Learning Geography*, Cluj-Napoca, Romania.