Thematic Cartography: a Key Course in Geospatial Engineering

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Abstract. In this paper a new revised undergraduate course on Thematic Cartography is presented as a 5 ECTS integral compulsory core course of the undergraduate curriculum of the School of Rural and Surveying Engineering at the Aristotle University of Thessaloniki, which leads to the homonymous five years engineering degree, after the submission of the diploma dissertation. The paper is focused mainly on the exercise and implementation part of the web-based course targeted to the familiarization of the students with a series of relevant software applications in relation to the data mining from the EUROSTAT provider. It is shown how this key course covers the educational and student needs of a spectrum of other courses in the engineering curriculum and raises the overall interest of engineering students for cartography.

Keywords. Thematic Cartography, University Education, Engineering Curriculum

1. Introduction

The School of Rural and Surveying Engineering (SRSE) at the Aristotle University of Thessaloniki (AUTH) is one of the seven independent Schools of the Engineering Faculty, providing engineering degrees. It was established third in 1962, after the School of Civil Engineering (1955) and the School of Architecture (1957),[1] consisting now of three Departments: Geod-

[1] The other AUTH Engineering Faculty Schools are: Mechanical Engineering (1973), Electrical and Computer Engineering (1973), Chemical Engineering (1973) and Spatial Planning and Development (2004)

ICA European Symposium on CARTOGRAPHY
VIENNA, 10–12 NOVEMBER 2015

Published in "Proceedings of the 1st ICA European Symposium on Cartography", edited by Georg Gartner and Haosheng Huang, EuroCarto 2015, 10-12 November 2015, Vienna, Austria

esy and Surveying (DGS), Cadastre, Photogrammetry and Cartography (DCPC) and Transportation and Hydraulic Engineering (DTHE), all dealing with the teaching and research in the relevant fields of engineering sciences and technologies. The five years/ten semesters curriculum of studies in SRSE,[2] which is the second School in Greece offering this field of engineering, together with the counterpart at the National Technical University of Athens (NTUA), leads to the homonymous engineering degree at a Master of Engineering level and to the professional engineering license after a legal examination at the Technical Chamber of Greece. The engineering degree in this field defines a historical track of studies and profession in the country with solid roots in the early 20th century Greek higher education system and even older, as the first relevant studies offered at the military academy and established in the 1830s after the foundation of the modern Greek state, were affined to subjects now under the SRSE concern.

Cartography in Greece is traditionally treated among the core subjects of the studies and research in the two SRSE in Athens and Thessaloniki, covering the whole spectrum of the field in the sense of ICA; both as a discrete scientific field and as a field having strong relevance and ties with geodetic, surveying, photogrammetry, remote sensing, cadastral and geoinformation matters focused on the engineering points of view. Cartography in Greece is definitely engineering-born and historically related to engineering education development (Livieratos 1993), also because, in contrast to other European countries (including the neighbouring countries), the geography high education studies started very late in this country, only in the 1990s. The AUTH-SRSE treated Cartography at a privileged level, mainly since the early 1980s after the relevant Chair of *Higher Geodesy and Cartography* was first established in 1979, headed by Prof. Evangelos Livieratos, who since then and for the next 36 entire years dedicated efforts, energies and resources in developing cartographic teaching and research in Thessaloniki.[3] From the first three cartographic courses introduced in 1979: *General Cartography, Thematic Cartography* and *Mathematical Cartography* -all three backed by relevant lecture-notes, the 2014-15 curriculum of the AUTH-SRSE counts seven "pure" cartography-based undergraduate compulsory and elective courses for a total of 38 ECTS, to which a number of cartography and mapping relevant courses should be also considered, of-

[2] For the AUTH-SRSE undergraduate curriculum of studies, see: http://www.topo.auth.gr/main/index.php/en/studies-atm-2/undergraduate-studies

[3] Thematic Cartography was taught for the first time in Greece by E. Livieratos, at the NTUA in 1978; his book *General Cartography and introduction to Thematic Cartography*, Ziti Editions, Thessaloniki (2nd ed, 1989), is a basic reference in Greek for teaching introductory courses in cartography

fered in association with subjects of geodesy, surveying, photogrammetry and remote sensing, cadastre and geoinformation as well as the post-graduate courses of the programme offered in map production and geographic analysis.

It is no coincidence that a number of institutional cartographic structures dedicated to cartography were founded there: the *Hellenic Cartographic Society* (HCS), representing Greece since 1995 in the International Cartographic Association,[4] the *National Centre for Maps and Cartographic Heritage* established as independent legal entity in 1997, which since 2013 operates as the *Archives of Cartographic Heritage*, section of the General State Archives of Greece, always housed at Thessaloniki, together with other international cartographic activities as it is e.g. the ICA Commission on *Digital Technologies in Cartographic Heritage* and the international web journal *e-Perimetron* on sciences and technologies affined to the history of cartography and maps, both operating since 2006.

Having such a background, the approach to the Thematic Cartography (Imhof 1972, Dent 1996, Slocum et al 2005) key undergraduate compulsory course is a highly demanding and challenging issue for the overall educational and training process in the SRSE, taking into account the synthetic and multidisciplinary profile of this unique engineering degree which combines a very strong geodetic-geospatial engineering component with a component related to the engineering of infrastructures.

2. Thematic Cartography in AUTH-SRSE

2.1. Theory and practice

Thematic Cartography (TC) is a basic course in all geospatial engineering related curricula of the university engineering and geography and of the technological institutions Schools of tertiary education in Greece. The AUTH-SRSE core course on TC (Course ID 20052253) is compulsory in the list offered at the 4th semester programme of studies under the general-synthetic course description, reading as: “The object and history of TC; thematic data and classification; the issue of scale and projection in thematic maps; standards, rules and practices in the graphic and image representation of thematic information; acquisition, process and representation of thematic data; symbolism of qualitative and quantitative information; the issue of ordering information; classes of thematic maps (choropleths, isarithmic contouring, topologic maps, atlases); statistics in TC; graphics

[4] Before the establishment of the HCS, the AUTH SRSE-DCPC was an affiliate member of the ICA.

and design in TC". This general description is associated with relevant cartography, in the curriculum courses offered, in consequential logic in higher semesters, i.e. the courses of map use, map production, cartographic visualisation and non-conventional cartography.

But, as required and expected in an educational process, the main didactic effort for the consolidation of knowledge in a complex field like TC, which apart from its imposing theoretical background, requires implementation strategies and practical experience, is to focus on a efficient plan of exercises targeted at the advancement of the students efficacy in approaching integrally a TC project. Following this principle, we preformed recently a reform in the TC exercise–practical work of the students, focusing on the gaining on-line experience in the chain of data acquisition, processing and cartographic representation. The basic idea is the in-situ implementation of an integrated project by the students, using on-line an institutional web provider of thematic data familiarizing themselves with a series of software applications for data analysis, vector- and raster-wise graphic design, image processing etc, which are assembled in a working flow.

A team of three academic staff members,[5] assisted by two volunteers,[6] and a senior student,[7] guides the class, supported remotely, by a networked researcher, who contributed in the initial development of the project and now is based abroad.[8]

The TC course is backed by a dedicated web page,[9] which is the on-line reference of the students for downloading the exercises and get general and targeted information on the course and relevant student activities, also with links to relevant sites.

2.2. Steps and targets – The data provider

The main concern of this plan in the teaching strategy of TC for engineering students is to make them aware of the great importance of the linking with the underlying geospace of the ordered data coming either from the physical (natural) world or/and from the human world; all data requiring a TC

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[8] Dr. Angeliki Tsorlini, Post-doc fellow at IKG-ETH Zurich

[9] The TC course web site: http://cartography.web.auth.gr/Thema_Carto

referenced mapping and visual monitoring. This is achieved perfectly using e.g. a valid institutional data provider as it is the EUROSTAT (2015a), selected for our project among other arguments due to the prestige and authority of this institution, which also attracts the interest and the attention of the students from the very beginning of the process *(Figure 1)*.

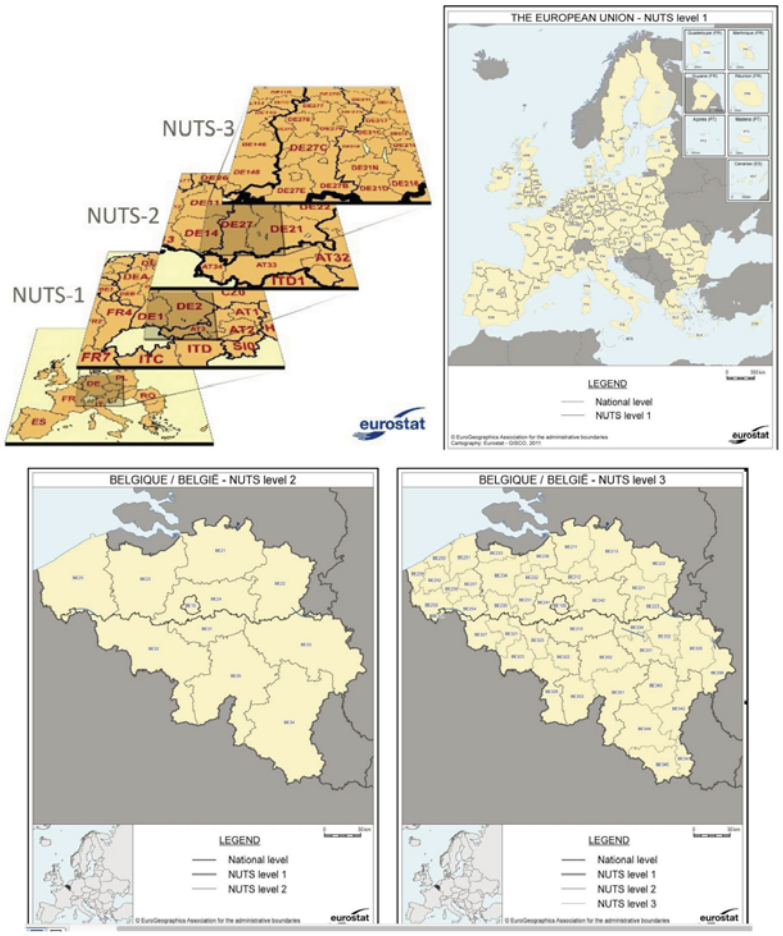

Figure 1. The NUTS classification (Nomenclature of territorial units for statistics) as a hierarchical system for dividing up the economic territory of the EU (Source: EUROSTAT portal)

The EUROSTAT (2015b) website gives the possibility to students to meet and browse the huge crowd of geospatial information collected over time and to familiarize themselves with the ordering of spatial units, which is a

basic concept in TC *(Figure 2)*. This gives the students the direct view and understanding about the European geospatial arrangement in areal units for the better classification and management of information. The examples of good practices, including proper cartographic visualisation and the contexts of thematic issues treated, concerning the demographic, social, political, cultural and economic situation in Europe, easily retrievable and downloadable from the EUROSTAT (2015c) provider, familiarise students with the themes and show them the importance of organising properly the geospatial data in tabular and/or pictorial media the latter in terms of diagrams, cartograms and maps helping the students to consolidate the theoretical teaching and to draw "real life" conclusions on the spatial distribution of phenomena.

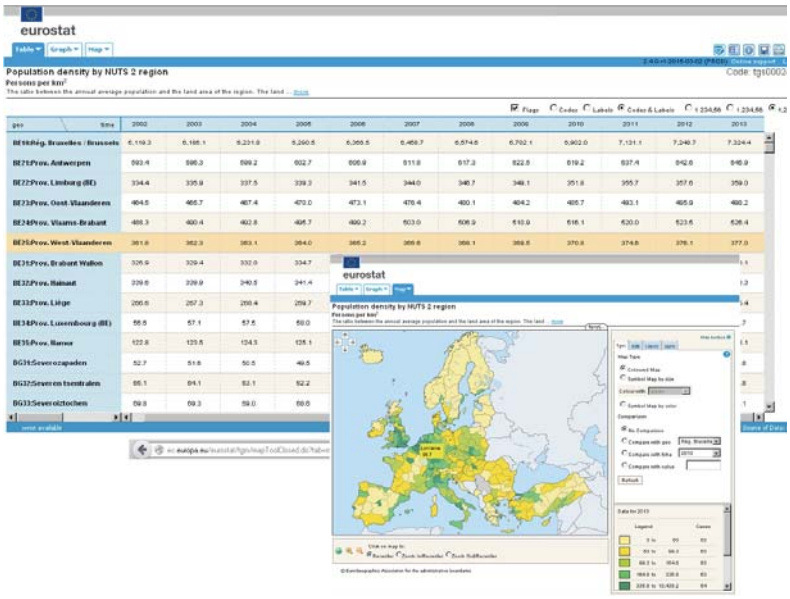

Figure 2. On-line thematic map directly associated with the database (Source: EUROSTAT portal).

The use of the EUROSTAT portal as the basic on-line provider of real and updated spatial thematic data, which are already represented on existing maps (used thus in the teaching process as examples of good or bad cartographic practice, if it is the case) or suitable to be represented in a new TC project carried out by the students, satisfies in a multipurpose ways the teaching strategy and work in the class, helping the in-situ concentration of the students' interest and self-acting but also the group work in testing and

discussing alternatives. More, the students are encouraged to think different approaches for the treatment and representation of the available data and to learn to criticise constructively the solutions adopted by the EUROSTAT staff by elaborating and depicting the relevant data and the associated spatial distribution in their own alternative way, enriching this way their knowledge and training impact.

2.3. The cartographic implementation

The next step in the student work and the interaction with the tutor is the use and proper implementation of the rules of TC for the preparation of own thematic maps using the available basic software applications.

Thanks to the plan and the integrated approach, students are trained in the use of a range of software application for the mathematical and graphical management of spatially related information. The applications are used in a combined mode, following the combined use and learning procedure in order to prepare thematic maps properly representing point, linear, surface and volumetric data. Applications like Jasc PaintShop Pro, MicroSoft Office Excel, ColorBrewer, GoldenSoftware Surfer and other less known supportive software are used in a chain-wise flow for a "best" thematic mapping of data downloaded from the EUROSTAT portal in the EU regional spatial level according to the EU countries administrative division *(Figures 3 – 6)*.

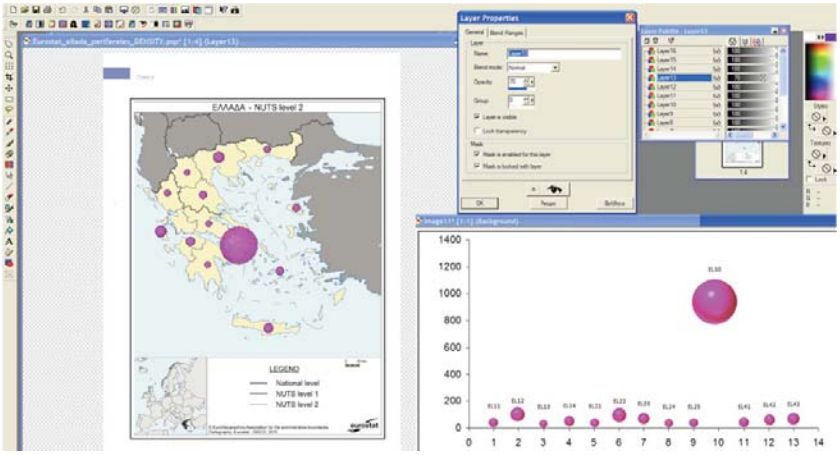

Figure 3. Preparing a thematic map with proportional point symbol using MS Office Excel and Corel PaintShop Pro.

Following this logic, the students are not stream-users of just one dedicated software application for the construction of a thematic map constrained

upon a predefined typology from those taken among the very few existing for this purpose or as those in GIS applications.

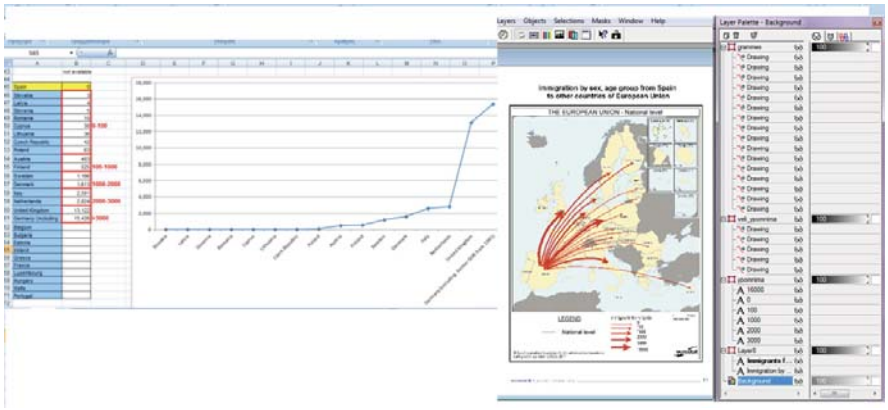

Figure 4. Preparing a thematic map with linear data depiction. The choice of optimal breaks classification using MS Office Excel and Corel PaintShop Pro.

On the contrary the students learn how to be unconstrained to just one possibility and constructive in combining a number of relevant software applications (usually easily available) becoming thus flexible *smart-users* having understood first the procedures and the rules for the best possible solution, according to the problem and the effective ways to its implementation.

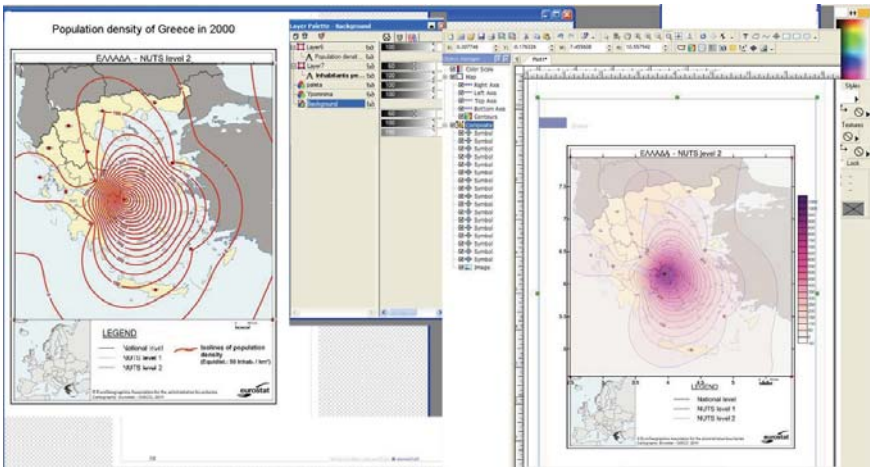

Figure 5. Compiling an isarithmic thematic map using MS Office Excel, Corel PaintShop Pro and GoldenSoftware Surfer.

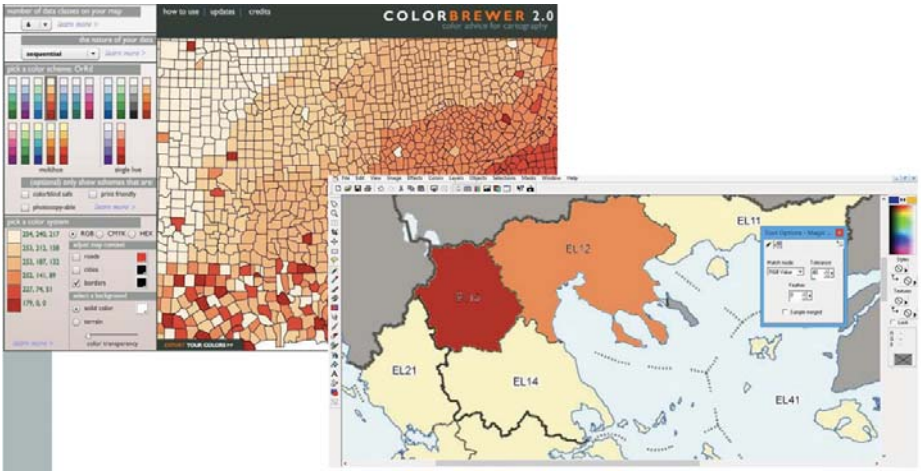

Figure 6. The production of a thematic choropleth map using the ColorBrewer utility.

2.4. The final project

The project on thematic mapping followed in the AUTH-SRSE TC class is using free online software, namely Indiemapper (2010), one of the few available for free, fuelled by data downloaded (equally for free) from the EUROSTAT portal *(Figure 7)*. After the experience gained with the use of a number of supportive software applications, the students are using an online available main application to construct a series of thematic maps. Having now the gained experience they can judge and face any gaps and imperfections to fill in the automation of such complex and multifaceted process, as it is the preparation of a thematic map, in order to satisfy the preset objectives i.e. the effective visualization and transmission of geospatial information, concerning especially issues like a properly designed title, legend, scale bar etc. which complete and enable the reading of the map. Almost always the map is further elaborated in other image processing or graphics editor software such as Paintshop Pro mentioned before, Adobe Illustrator or Adobe Photoshop.

The concept of this practical work is to make the students thinking and acting in preparing a thematic map, not only as simple users having got a surface contact on what TC is all about from the lectures-part of the course, but also as “first step cartographers”. This means that the students should be capable enough to decide, e.g. on the choice of the adequate map projection system, the selection and implementation of classification (optimal breaks, quantiles, equal intervals, manual classification etc) as well as on the design of a complete and functional legend. Considering in addition, that the students are in an engineering curriculum, they should be able to conceive,

plan, organise, install and apply integrated processes for the production of a specific product output, in this case a thematic mapping project.

Figure 7. On line thematic mapping using the free software Indiemapper.

This approach concerns especially the engineering perspective since, by definition, the students are dealing with multitasking thematic data dealing with a variety of geo-related issues such as the environment, the transportation, and infrastructures, the cadastre and land registry, the geo-positioning of natural resources and other affine themes from the worlds of physical and human activities and interactions.

Some examples *(Figures 8 – 10)* of student-exercises, following the chain flow presented in this paper, illustrate the result of the process and the work done in the AUTH-SRSE TC class. The maps prepared using the on-line free software and finalised using additional image and graphics processing software.

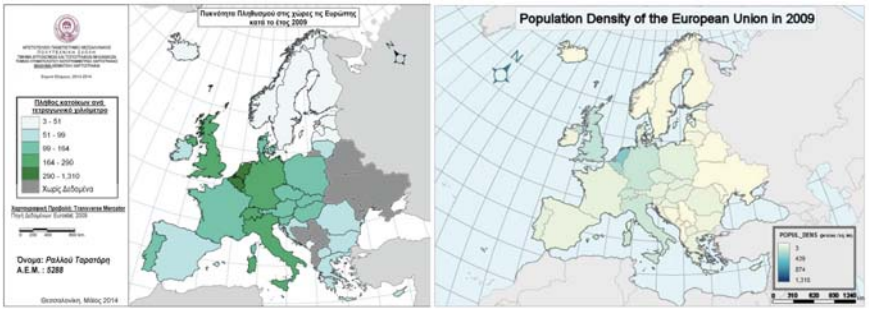

Figure 8. Student exercise: two graphic approaches to European population density

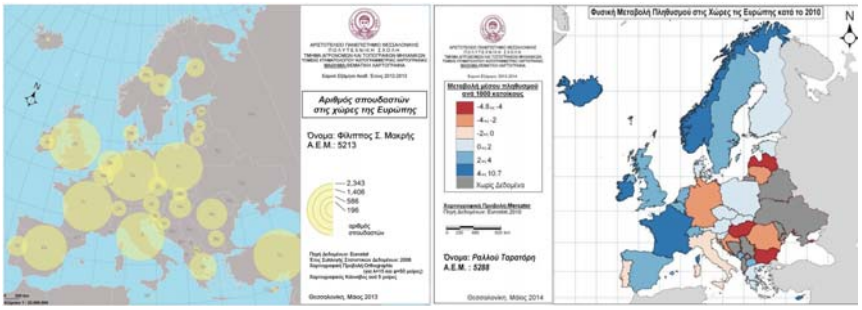

Figure 9. Student exercise: student population (left); population variation (right)

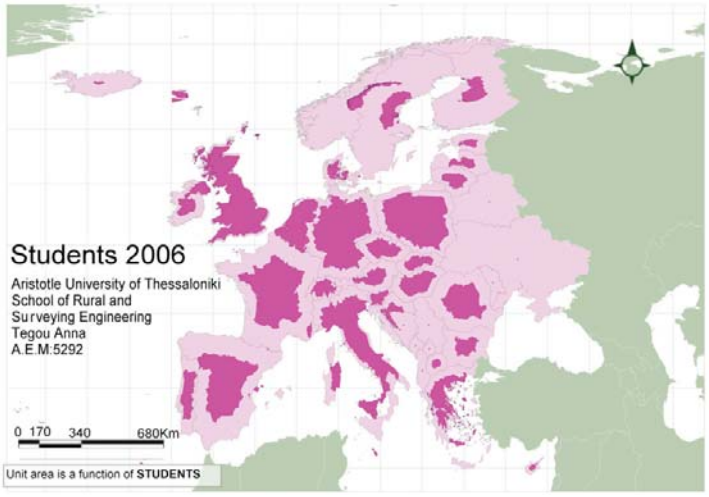

Figure 10. Student exercise: European countries according to student population; a "cartogram" onto a map.

2.5. Evaluation

The new revised teaching strategy in teaching TC in the AUTH-SRSE is developing since the academic year 2012-2013. The results are spectacular for an engineering class of a hundred students, all attending the course in-situ, each with a laptop or serviced by the SRSE desktop computer facilities, all in a wi-fi environment, for developing their own project.

Other benefits for the students were the rapid familiarization with all software available (the tendency to learn many software applications is popular among engineering students, especially when this is done in an real-life application environment, as it is the TC project), the consolidation and digest of the theoretical teaching given almost simultaneously with the preparation and guidance of any new step of the practical work, the understanding of TC as a key issue in a variety of many other study courses in all the three SRSE Departments and last but not least students look to appreciate to get direct free access to the numerical, textual, pictorial and map data base of a major European institution, as it is the EUROSTAT, portraying all data referred to the real social, political, economic and cultural life of the EU members states.

Figure 8. AUTH-SRSE students, mainly following the TC course, participated in the ICA 10th International Conference on *Digital Approaches to Cartographic Heritage* Corfu 27-29 May 2015. Here the students in educational visit in the Historical Archives of Corfu

It is especially visible the active interest and involvement of all students concerning both the class labour and the homework. In this field of students raised interest for cartography with TC as the vehicle, some other results have been observed in students behaviour towards Cartography, in

general *(Figure 8)*: their dense participation in recent cartographic Conferences held in Greece, the 13th National Cartographic Conference Patras 22-24 October 2014, organised by the Hellenic Cartographic Society and the even denser participation in the 10th International Conference on Digital Approaches to Cartographic Heritage, Corfu 27-29 May 2015 organised by the ICA Commission on Digital Technologies in Cartographic Heritage.

3. Conclusion

Having implemented the re-designed TC course for four academic years now, it seems that the originally planned modifications and improvements to it, as described above, have so far been justified. This is manifested first of all in the results of the students' projects, compared to previous ones. Furthermore, the students themselves seem to appreciate the fact that they are provided with a multitude of tools in order to carry out their exercises, despite some inevitable initial complaints, they seem to quickly realise that the variety of tools they have to use for their exercises reflects a real-world situation and they rapidly appreciate and master the different software packages they are faced with.

Additionally, some feedback from students of the first academic year that the new TC course was implemented (and who are now almost at the end of their studies) seems to enhance this point; not only they appreciate in retrospect, but they also seem to develop an increased interest for cartographic and geographic topics, as compared to previous years. This is manifested not only in the dense and enthusiastic participation to national and international Cartography Conferences mentioned previously, but also in the increasing (compared to previous years) number of students who in the last two years follow the SRSE-DCPC elective courses, from the seven semester onwards. Hopefully this will set a trend for the future; in this context the TC course already is an example of good practice.

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