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Introducing 3D Visualization of Statistical Data in Education Using the i-Use Platform: Examples from Greece

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Abstract

In the 21st century, the age of information and technology, there is an increasing importance to statistical literacy for everyday life. In addition, education innovation and globalisation in the past decade in Europe has resulted in a new perceived complexity of reality that affected the curriculum and statistics education, with a shift from content knowledge to competences. Moreover, the amount of data that can today be accessed on the Internet suggests that students can choose nearly any topic of interest to them for their work on, which can increase their motivation. Furthermore, new location - based technologies actively promote the power of digital spatial representation and geo - communication opportunities. So, the aim of this paper is to present an application of 3D visualization of statistical data in conjunction with regional spatial data from Greece, using the www services and applications in real time. This has been accomplished by modifying the code of an open source of educational software: the online platform i-Use, in particular. Nowadays, there has been a clear shift towards Free Software/Open Source Software (FOSS) from users worldwide. FOSS has begun to play an important and decisive role in Greek education, as well. The examples which are taken from Greece are related to statistical data from various sectors of modern life. The spatial background used is the 13 Administrative regions of Greece. All functions and modifications implemented were made with FOSS.

Keywords

Statistical Literacy, 3D Visualization, FOSS, Web, Spatial Data, Geo literacy

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In a rapidly changing modern world decision-making is based on data which are available in real-time, deriving from a vast amount of information, constantly hammer us on a daily basis. Therefore, we shouldbe able to organize, classify and evaluate these data in order to a) make serious decisions on our next move(s) or/and b) form an opinion on what happens all around us. Mismanagement or misconception may lead to a wrong assumptions and decisions, thus producing disastrous results. Statistics provide the right toolset for data collection, classification, management and processing.

Nowadays, teaching Statistics and, consequently, training is a non-ending research field (Biehler et al 2013, März & Kelchtermans 2013, Gryl et al 2010). During the last few years efforts have been made both at an international and at a national level to change and reform the goals and aims of the official Curricula for all educational levels, thus introducing students, or even kindergarten pupils, to the worldof Statistics – throughsimple, basic ideas (Nikiforidou & Pagge 2012). Batanero & Díaz (2010) confirmed teachers' statistical knowledge plays a significant role in the quality of their teaching. Modern studies have shown that children even at very premature age are able to handle such ideas. In countries such as the U.S.A. (Sheaffer & Jacobbe 2014, National Council of Teachers of Mathematics 1989, 2000), the U.K. (Department for Education and Skills 2001) and New Zealand (Forbes 2014, Ministry of Education 2008) –among others- teaching material for all compulsory education levels has already been created and built around Statistics.

The central pillar for every educational system in modern, multicultural societies around the world is school. At school, the teacher/trainer focuses on each student's needs and special traits, typically based on post-industrial educational models. Cooperative and experiential learning form the core of innovative and groundbreaking teaching approaches. From teachers' perspective there is a positive attitude in using computers as an innovative tool that will support the entire educational process and acquiringskills related to digital technology (Gattuso & Ottaviani 2011, Goufas 2007, Hermans et al 2008, Tzimogiannis & Komis 2004). On the one hand, the teacher should design and implement activities based on the aforementioned models, while he/she should also exploit the possibilities that digital technology offers - along with the use of appropriate educational software that should be, continuously revised to the needs of the day – and integrate them in his/her teaching.

On the other hand, students should not only know Mathematics and Statistics but also aquire additional abilities, such as statistical reasoning and expand their statistical knowledge. Moreover, new, advanced technologies, upon which Free Software or Open Source Software is based, may be of great assistance in creating educational software appropriate for classes (Lee et al 2010). The teacher will be able -after being properly trained, of course - to create his/her own software to support the given activities, provided that all initial specifications and limitations are satisfied (Batanero et al 2011).

The combination of Cartography and Geographical Information Systems (GIS) leads to a faster creation of new, digital, dynamic and interactive maps, while making it alsoeasier to revise the older versions. It is conspicuous that the need for cartographic background in the visualising information that is available to students and teachers in several courses (history, geography, environmental education, etc.) grows continuously (Lambrinos 2009, Klonari 2014). In such a way, maps become tools that can be used in decision-making. Consequently, Geography teaching supports cross-curricular teaching methods. It implements cooperative and productive learning principles, while at the same time it allows students to acquire values and abilities that will help them become cognitively aware and develop their psychomotor competences or activities.

Visual representation of statistical data can be effectively implemented within the educational process not only as an independent and unaltered discipline but also as a supportive means to many other subjects. The use of maps can help students and teachers to visualise the available statistical data and combine them effectively with specific places or countries. They are able to study the individual characteristics of each country, its development indicators, etc. Students observe, compare and contrast old and recent data, comprehend the information at hand and aquire and develop new skills, such as statistical and critical reasoning (Pfannkuch & Ben-Zvi 2011).

The web-based platform i-Use, fully created with the aid of Free Open Software, combines tools which help the statistical data analysis of and the cross-curricular Statistic approach to other subjects by using statistical data concerning Europe and the World. Data concerning individual countries are represented with the aid of two- and three-dimensional cartographic backgrounds.

In Greece and more specificaly in the field of Education, there is no such application– i.e. one entirely created with Free Open Software which can fully serve the management, analysis, interpretation and visualization of statistical data, operating on cartographic backgrounds. Motivated by the need to cover such a gap, we implemented a set of examples concerning statistical data to Greek administrative regions. Their processing and visualization on cartographic backgrounds on the end-user's web explorer program is possible by modifying the code of the Web-based platform i-Use with the help of GIS.

The goals of our application are twofold. Firstly, we aim to provide a tool that is easy to use for both teachers and students. They will be able to adopt ICT and statistical data to instruct and learn geography and quantitative analyisis respectively. To meet this goal, we implemented a few examples of teaching scenarios with actual data from Greece. Secondly, we wanted to demonstrate that through the adoption of ICT, teachers can easily customize an open source code to serve their needs during a classroom session.

i-Use Platform

Introduction and Goals

The European Comenius Multilateral Project i-Use was implemented within the framework of the 'Comenius Act' and the support of the EU 'Lifelong Learning Programme'. i-Use is a groundbreaking program whose aim is to spread the use of Statistics in Secondary Education Curriculum of the EU members that participate in it (Donert 2015, Zwartjes & Donert 2013, Zwartjes et al 2014, etc).

Its main goals are to help both teachers and pupils to:

- handle the plethora of information flooding them
- learn how to use and work with Statistics
- collaborate, exchanging views and ideas
- be better prepared to use the tools available to them for the analysis and process of statistical data – tools based on new, advanced technologies and cutting edge services provided by the WWW, and to
- use the interdisciplinary approach as a pedagogical practice to combine Statistics with other learning subjects

It is imperative that the teachers who are called to support the propagation and use of Statistics be well trained themselves in the new educational methods and practices whose aim is to present information in intuitive ways, employing various forms of media.

The i-Use project, as a whole, deals with data, statistical and pedagogical approaches and how these can be applied to various subjects, to serve the aims and the objectives of the Secondary Education Curriculum. The most important component of the project is undoubtedly the implementation of a website where both students and teachers will be able to find statistical data and have direct access to online databases, such as Eurostat and World Bank.

Upon its completion and evaluation, this web platform, created within the framework of this project, will incorporate advanced and innovative tools that will support the educational process in the use of statistical data. These tools will be structured and completely embedded into the web page to cater fully students and teachers' needs in a working environment which will not demand a bewildering amount of familiarization on the user's end. Special emphasis will be given to the functions pertaining to interactive maps and comparisons made among available time series. Additionally, it will prove itself to be a useful tool for the overall evaluation of the educational and learning process.

i-Use Features & Functions

As a brief introduction to it, the web platform i-Useoffers currently the following services; see Figure 1.

Ready-made. In this section one can find information already compiled from various areas of activities in either EU countries (based on statistical data drawn from the EUROSTAT pool) or the rest of the world (drawn from The World Bank Database, similarly). One can download and save the data sheet in many formats (.xls, .csv, .html, etc.), process them and, ultimately, print or visualize them with the tools available in situ, such as Graph, Map, 3D Map, etc.

Databases. Here one may find information about the most popular and valuable databases in the world. Additionally, the tools to manipulate and visualise these data are available here too, with the difference that the user is directed to the database's respective website, i.e. leaving the i-Use platform.

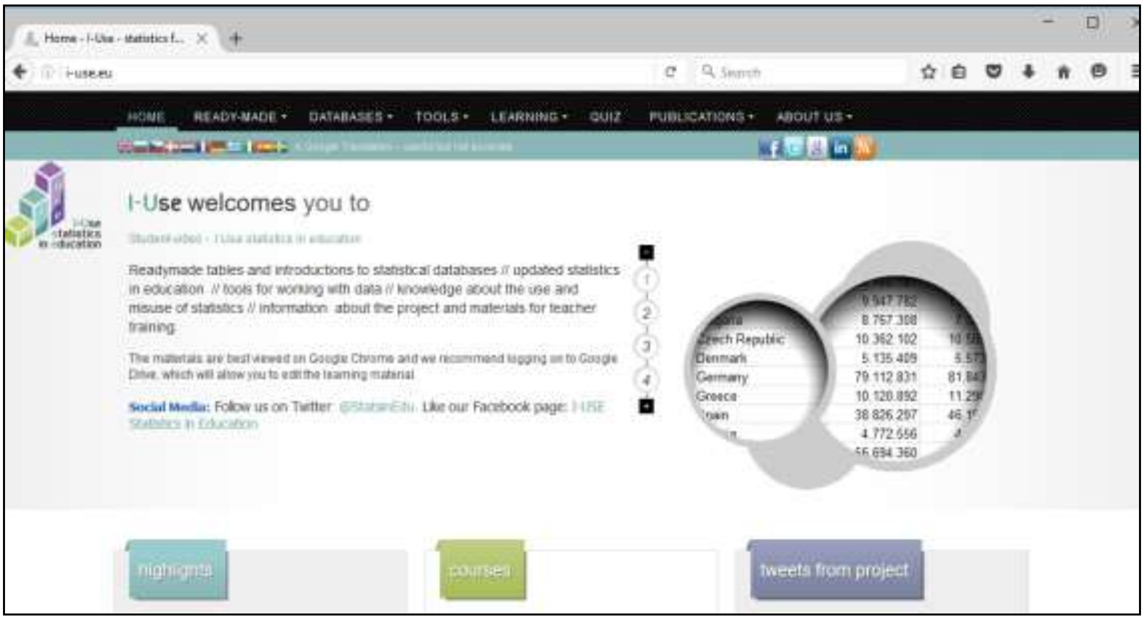


Figure 1.i-Use Home Page

Tools. Under this menu the user may find the tools required to process and manipulate their statistical data, for various platforms. For example, there are tools enabling one to compile one's own statistical measurements (e.g. surveys), or to visualise one's data in many forms (e.g. maps or graphs), or even to simply organize, measure and present one's data through spreadsheets. Finally, there are applications to help one collect data and analyze patterns and trends, implemented to run on smartphones – iOS and Android devices in particular.

Chart your input. The most important tool in one's disposal, however, is no other than 'Chart your input'. It offers a flexible and fast way of visualizing one's data, through graphs or maps of various types and shapes.

Chart your file. This tool works in a similar fashion, the only difference being the way our data are entered. In particular, instead of copy-pasting (or typing) them in the text box, here one can directly load them in the tool. Then, one can customize the visualization options.

Learning. This is the place where teachers will refer to, when searching for material used in Statistics in Education. All the resources that can be found here have been developed and compiled within the framework of i-Use project and are divided in Units and Spreadsheets.

Quiz. Under this menu, one may find a series of quizes created with the freeware Quizlet. They are divided in three categories, ranging in difficulty (easy, medium, hard) and can be used freely to test one's knowledge and grasp of Statistics.

Publications. Within the scope of the i-Use project an ever increasing number of papers have been published (Donert 2015, Zwartjes & Donert 2013, Zwartjes et al 2014, etc). Their aim is to approach the topic "Statistics in Education" from every possible aspect: pedagogical, technology assistance, need of application to Curricula. The teaching model of Technological Pedagogical Content Knowledge (TCPK) is a framework to understand and describe the kinds of knowledge required by a teacher for effective pedagogical practice in a technology enhanced learning environment.The higher goal, however, is still the creation of an online toolbox that will allow its users to take advantage of the statistical data in a range of flexible ways. The material found here ranges from dissemination papers to presentations and reports.

Building the Application

For the purposes of this project, the code of the i-Use pilot platform was made available to us. It is programmed in Javascript and synergizes with PHP and Google Docs. The modifications we executed in the code aimed to incorporate the geographical data of the thirteen (13) Administrative regions of Greece.

The validation check of our changes was performed at each step with thw aid of the 'Chart your Input' webpage/tool of the i-Use platform. The statistical data we used were in every case open public data, freely accessible to everyone. As far as the visualization of the output of the aforementioned test page is concerned, our emphasis was primarily given to the 3D presentation through the Google Earth application.

Last but not least to be mentioned, the examples we implemented about Greece have been constructed in such a manner that they are highly comprehensible by students and teachers alike, without requiring any specialized knowledge of or familiarization with any kind of tool and/or application. Additionally, only FS/FOS applications were used. This is justified by the fact that on the one hand, they are free to use–something particularly important for our low-budget education system- and on the other hand they are continuously evolving and enhanced.

Applications used

The following applications were used in the implementation of our project:

- Google Earth – "a virtual globe, map and geographical information program" which features a multitude of functions
- GPS Visualizer – a web-based online application which enables its users to

create maps or profiles from the geographical data at their disposal

- Google Sheets – online worksheet application, “part of the free, web-based software office suite offered by Google which allows users to create and edit documents online while collaboration with other users in real time”
- Notepad++ - advanced text editor, aiming primarily to edit source code;and
- FileZilla – FTP application, supporting many transfer protocols and cross-platform operation, as well as directory synchronizing. The ‘client’ version has been used for our purposes.

Implementation process

We began by downloading the geographical boundaries of the 13 Prefectures of Greece, in .kml format, from the Greek ‘Public, Open Data’ portal, (http://geodata.gov.gr/geodata/). These data are openly available through a ‘Creative Commons Source Reference’ license (CC by v.3.0).

This .kml file contains thousands of coordinates for each Prefecture, due to the lacy outline of the Greek landscape. However, for our purposes –as well as for the efficiency of our program’s execution - we decided to significantly reduce their numbers. This was performed with the aid of Google Earth:

1. First step was to load the downloaded kml file in the Google Earth application and set it as a background image.
2. Then, using the tools provided by Google Earth, we set out to define a new, more ‘rough’ outline for each Prefecture, aiming to significantly reducethe used coordinates.

This process resulted in creating of 13 kml files, one for each Administrative region. The next step was to ‘extract’ the coordinates (magnitude, latitude) from these kml files; this was accomplished through the ‘Convert to plain text’ function of the FOSS online tool, GPS Visualizer.

Each kml file was loaded separately and, upon clicking on said button, we ended up with a txt file containing the coordinates in a tab-oriented format; see Figure2.

[<type> <latitude> <longitude>]

(<type> value is indifferent for our purposes).

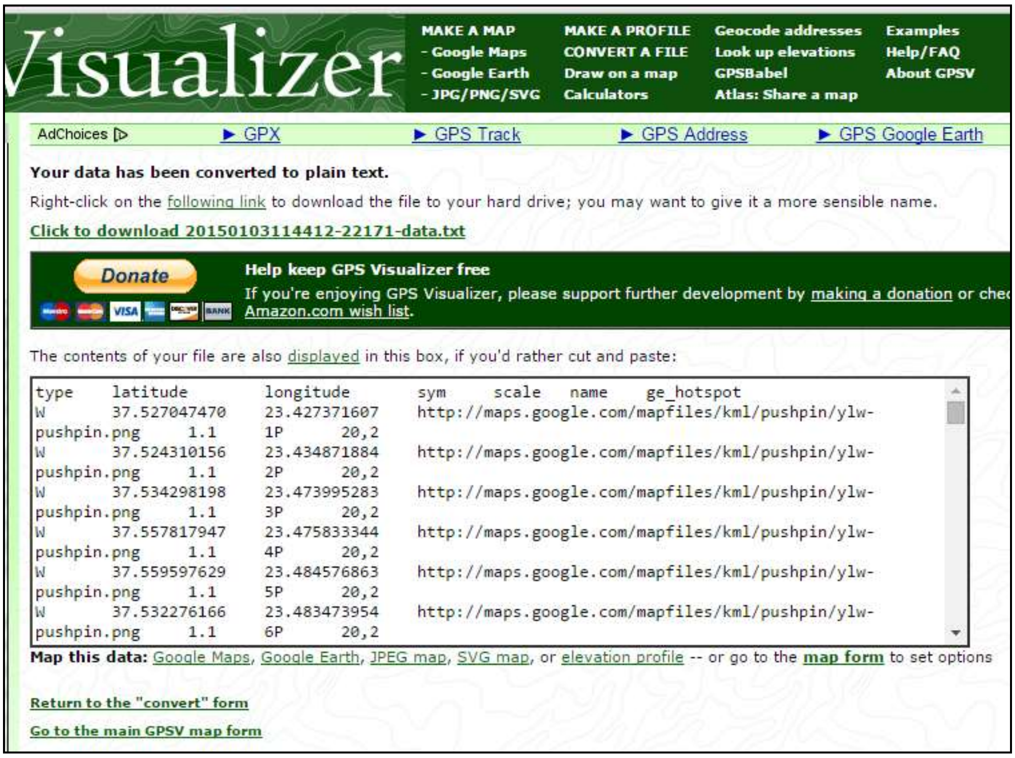


Figure 2. GPS Visualizer output window

However, i-Use expects the coordinates in the format:

[<longitude>, <latitude>, <altitude>]

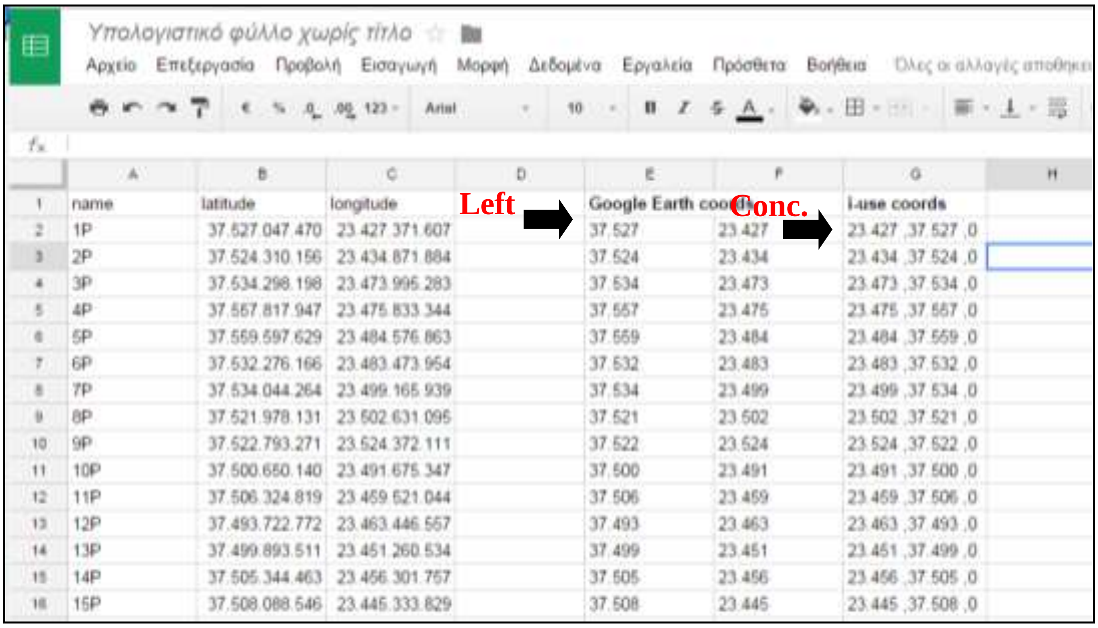
This means that we should have converted the extracted values in the latter format. This was done via the Google online office suite – Google Sheets in particular. Each tab-oriented text file was loaded on its own tab, where its data appeared in columns A (‘type’), B (‘latitude), C (‘longitude’) etc. We only needed those contained in columns B, C and F (‘coordinate name’) hence everything else was erased.

By using two built-in formulae we converted the coordinate values into the desired format:

LEFT(X;6): returns the 6 left-most characters from string ‘X’ (including the decimal separator); and

CONCATENATE(X;Y;…;N): join strings ‘X’, ‘Y’, etc into one string – in other words, it creates an expression

Ultimately, this is what we ended up with as an example output; see Figure3.



	A	B	C	D	E	F	G	H
1	name	latitude	longitude		Google Earth coo		i-use coords	
2	1P	37.527 047 470	23.427 371 607		37.527	23.427	23.427 ,37.527 ,0	
3	2P	37.524 310 156	23.434 871 884		37.524	23.434	23.434 ,37.524 ,0	
4	3P	37.534 298 198	23.473 995 283		37.534	23.473	23.473 ,37.534 ,0	
5	4P	37.557 817 947	23.475 833 344		37.557	23.475	23.475 ,37.557 ,0	
6	5P	37.559 597 629	23.484 576 863		37.559	23.484	23.484 ,37.559 ,0	
7	6P	37.532 276 166	23.483 473 954		37.532	23.483	23.483 ,37.532 ,0	
8	7P	37.534 044 264	23.499 165 939		37.534	23.499	23.499 ,37.534 ,0	
9	8P	37.521 978 131	23.502 631 095		37.521	23.502	23.502 ,37.521 ,0	
10	9P	37.522 793 271	23.524 372 111		37.522	23.524	23.524 ,37.522 ,0	
11	10P	37.500 650 140	23.491 675 347		37.500	23.491	23.491 ,37.500 ,0	
12	11P	37.506 324 819	23.459 521 044		37.506	23.459	23.459 ,37.506 ,0	
13	12P	37.493 722 772	23.463 446 557		37.493	23.463	23.463 ,37.493 ,0	
14	13P	37.499 893 511	23.451 260 534		37.499	23.451	23.451 ,37.499 ,0	
15	14P	37.505 344 463	23.456 301 757		37.505	23.456	23.456 ,37.505 ,0	
16	15P	37.508 088 546	23.445 333 829		37.508	23.445	23.445 ,37.508 ,0	

Figure 3. Coordinates format conversion with Google Sheets

Eventually, function CONCATENATE was employed again to compile the syntax of the Prefecture's outline 'border' to be entered in i-Use; see Figure4.

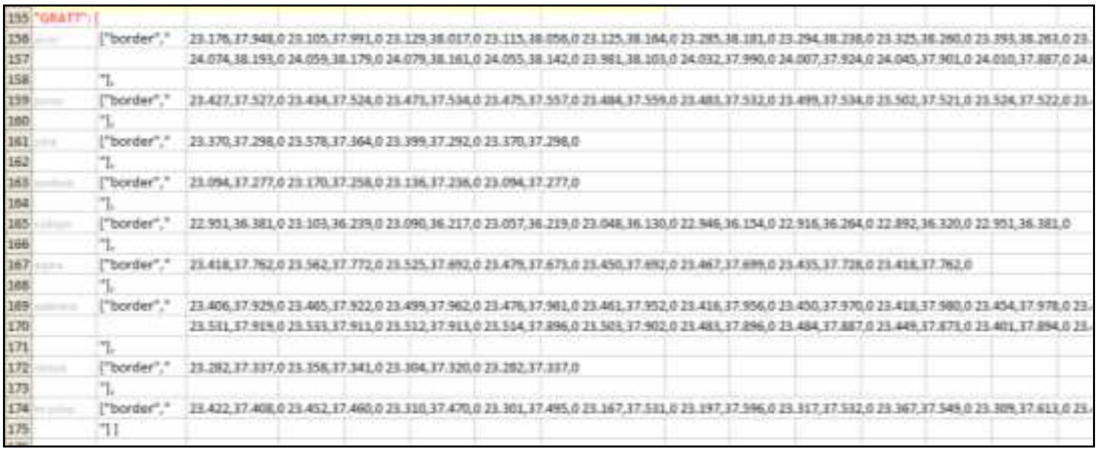


Figure 4. (Final) Boundaries data set for an example Prefecture

Code editing was done with the aid of Notepadd++ and involved 3 modifications:

a) countries.js

This file was created from scratch to contain the definition of borderlines of all Greek Administrative regions. It replaced the existing one in the original source code, which contained the definitions for European regions and countries.

b) iso_countries.php

To the end of this file we appended the definitions of the Prefecture names (‘key_value’) to be used in countries.js. By defining multiple ‘keys’ with the same ‘value’ (i.e. country) we can avoid typos when entering data, at least to a certain degree, e.g.

```
"Greece":"GR",
"Greece":"GR",
```

c) displaygraph.php

By editing lines 111-114 in this file we moved the center of our graph(s) to be over Greece, instead of the –approximate- center of Europe. These lines are read by Google Earth each time it draws a graph based on the given coordinate values.

```
111  var lookAt =
     KML.ge.getView().copyAsLookAt(KML.ge.ALTITUDE_RELATIVE_TO_GROUND);
112  lookAt.setLatitude(44);
113  lookAt.setLongitude(20);
114  lookAt.setRange(3000000);
115  KML.ge.getView().setAbstractView(lookAt);
```

After all code alterations were done, we uploaded the 3 aforementioned files unto the server via FileZilla. A test space had been assigned to us for our test purposes, accessible through the URL: http://knowto.org/i-use/

When everything was in place, we commenced with our tests and, eventually, the visualization of the statistical data we had accumulated.

Running the Application – Examples from Greece

The statistical data we collected involved many fields such as Tourism, Building Activity (private and public buildings) e.t.c. These data sets were saved in plain text (.txt) format so they can be readily entered in the ‘Chart your input’ text field.

To demonstrate the use of the application we will use an example through the step-by-step instructions, to showthe statistical data we extracted (i.e. downloaded) from Domestic Gross for five regions (Eastern Macedonia & Thrace, Crete, Epirus, Attica, and Northern Aegean) for the years 2007-2011. There are many ways one can work on these; deciding whicht the best visualization method is solely depends on the purpose of /the Statistics lesson and how the teacher prefers to present it to his/herstudents.

After inserting (i.e. copy-pasting) all the downloaded data in the designated text field on the i-Use’s test page, we click on ‘Submit’; see Figure5. We are then taken to the page where we decide and customize the way we wish our data to be visualized: 2D/3D map, graph, etc. Typically one will either opt for a chart or for a 3D map here.

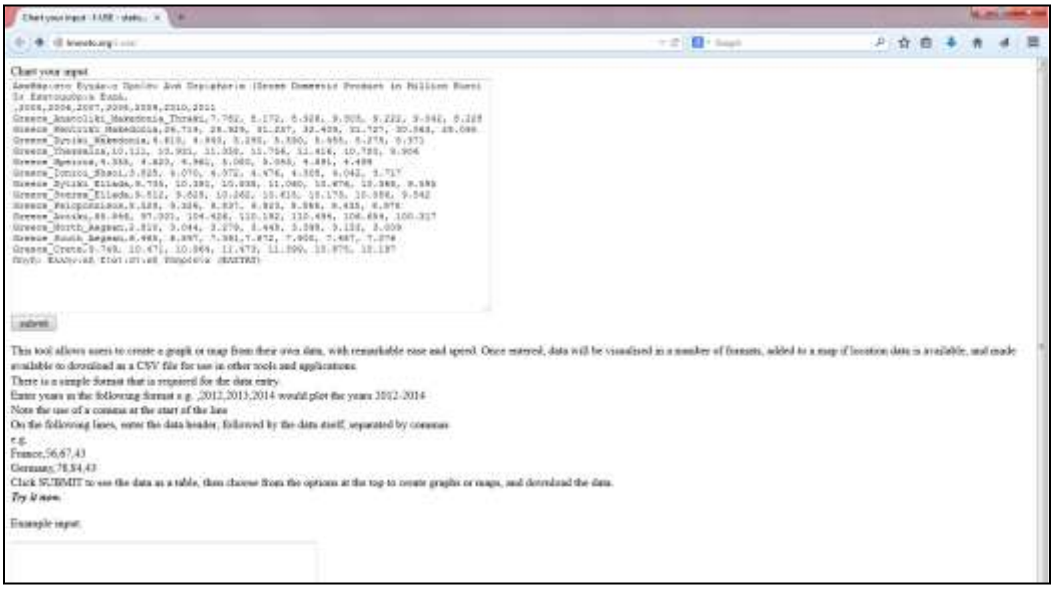


Figure 5. Data input in i-Use's 'Chart your input' webpage (form)

Scenario #1

Overall presentation of the indicators across the selected time span for all the Prefectures.

'Graph' options include 5 different formats: BarChart; see Figure6, ColumnChart; see Figure7, AreaChart, TreeMap & LineChart while some of these offer the choice of timeline sorting. In any case, we can always print our graph once we're satisfied with it and we should like or need to.

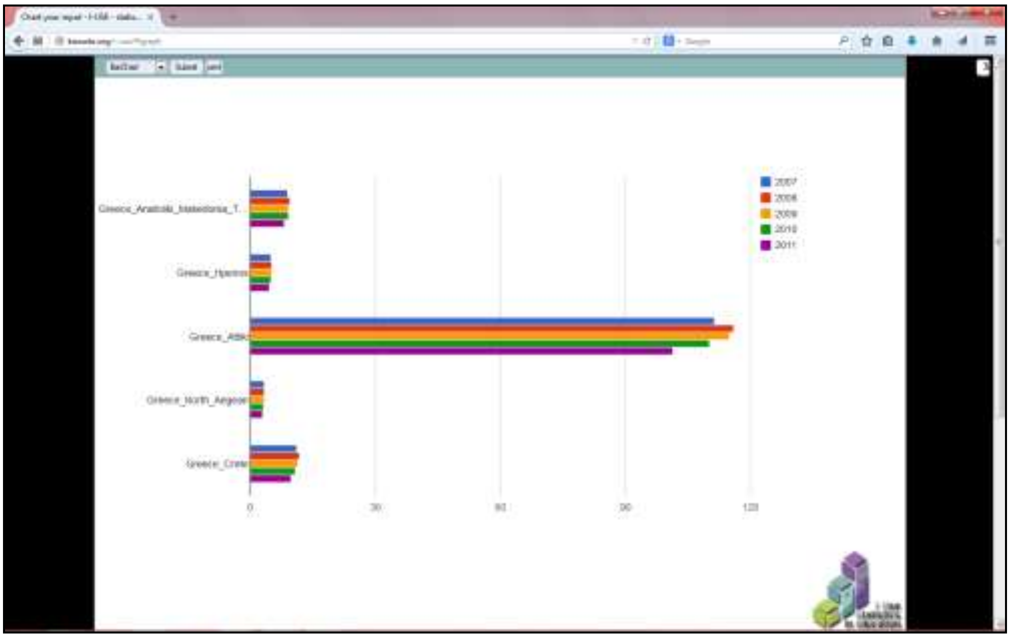


Figure 6. Scenario#1 – BarChart visualization (i-Use)

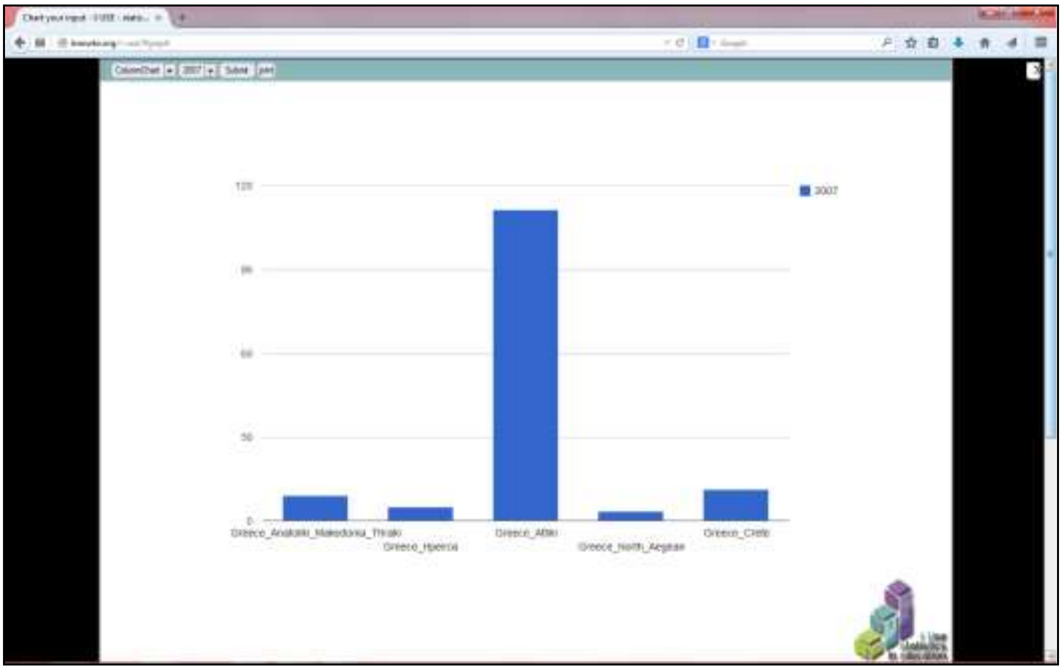


Figure 7. Scenario#1 – ColumnChart visualization (i-Use)

For '3D Map' visualization, our choices include the desired time span and the colors of the minimum and maximum values: see Figure 8.

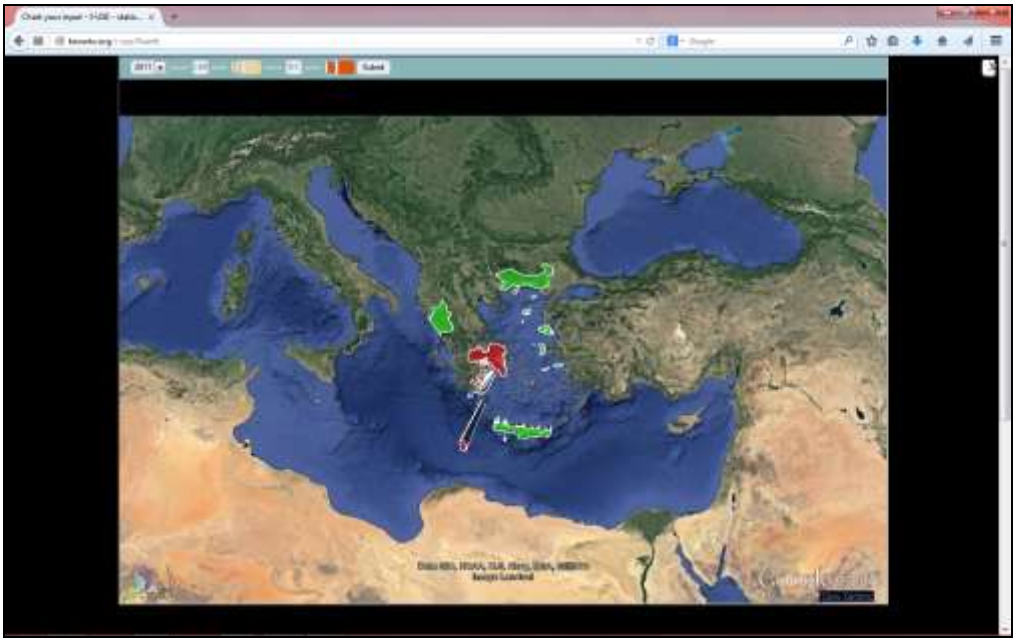


Figure 8. Scenario#1 – 3D Map visualization (i-Use)

Scenario #2

Comparison of Domestic Gross for two Prefectures (Crete and Epirus) for a specific year (2006)

Repeating the process we described above out of the whole data set we only select those we need and the choice ‘ColumnChart’ as the best approach here. On the top left of the window we select the chart type and the desired year; see Figure9.

Figure 9. Scenario#2 – ColumnChart visualization (i-Use)

The values of GDP for these two Prefectures provide a measure of economic and social development for these regions, for that specific year. We can get the same information with the aid of 3D visualization, naturally; see Figure 10.

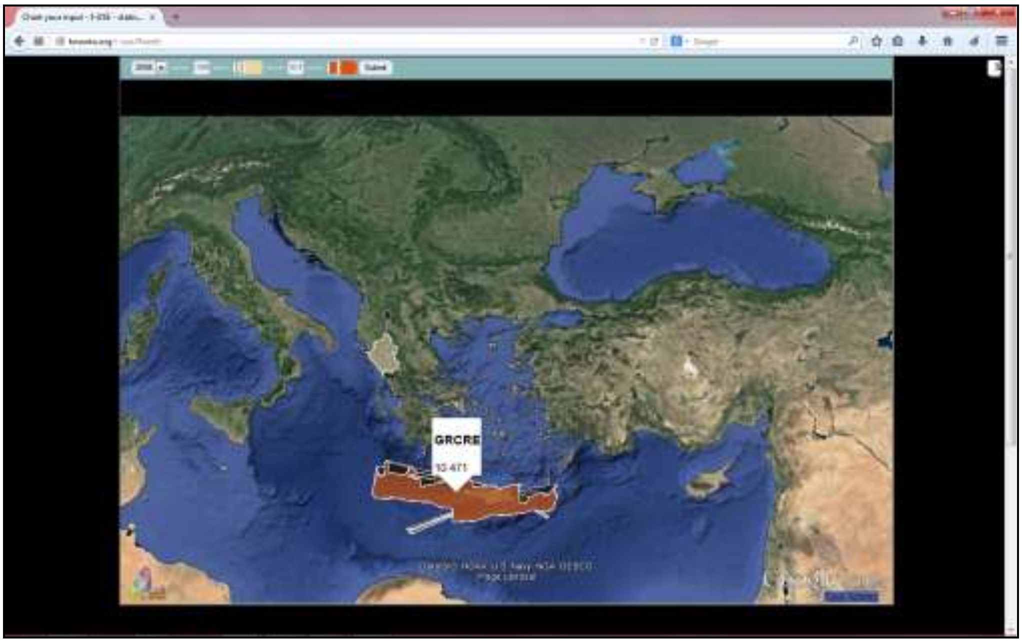


Figure 10. Scenario#2 – 3D Map visualization (i-Use)

Scenario #3

Observation of changes in the Gross Domestic Product (GDP) for a specific Prefecture (Attiki) during a specified time span (2005-2011)

For this case we only need to insert the data pertaining to ‘Attiki’ (one line only) in the test page’s text box. Once again we press ‘Submit’ and select the chart type we prefer – in our example this was 'BarChart'; see Figure 11.

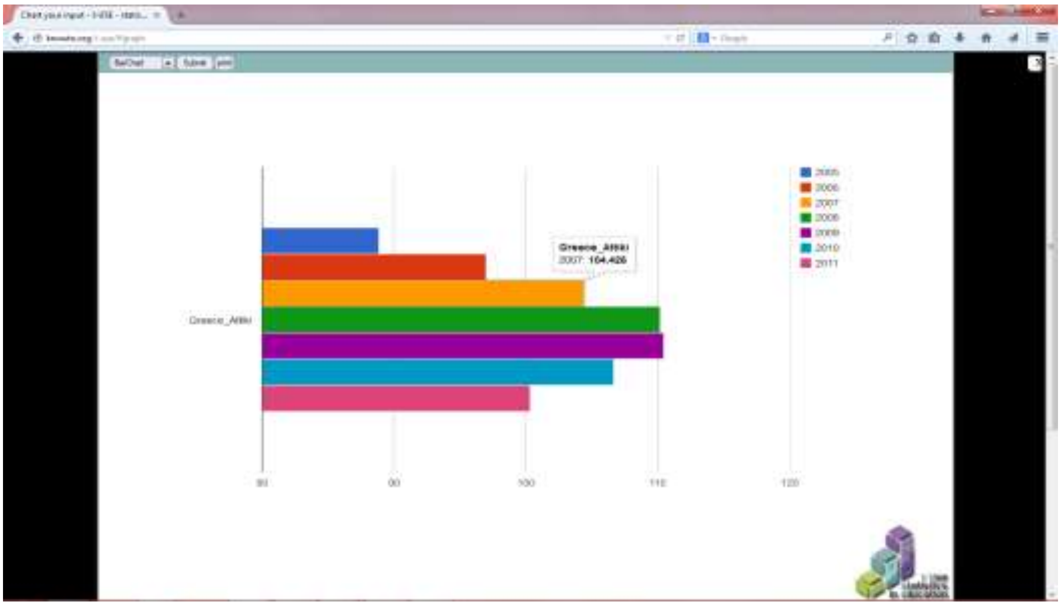


Figure 11. Scenario#3 – BarChart visualization (i-Use)

Discussion

During the implementation we faced some problems that we will mention briefly. The application code is free of charge, free to use. It can be locally installed on a user's personal computer which, with the proper software, may function as either a server and/or as client. For that reason we had initially used the Free Open Software WampServer, which is a working platform for the creation of web-based applications, incorporating Apache 2, PHP and MySQL. Malfunctions appeared during and even after installation, as well as a collision between the software and the hardware, thus we were forced to abandon the WampServer option.

As an alternative, we chose to turn to FileZilla which enabled us to access the test server remotely. Its operation was trouble-free and very easy. The user had to be especially neither accustomed nor trained to it.

The implementation of the cartographic background for the 3D-representation of the 13 Administrative regions was done by manipulating open geographical data. We had to create new sets of geographical coordinates with the help of Google Earth, because using the original data sets was far from code efficient on one hand and had no practical value for the final result on the other hand, as the desideratum was not the accurate depiction of the Regions.

The two-dimensional statistical data representation 'Map' comes from Google Docs. It concerns Google Charts and more specifically the representation with Geomaps. Within the framework of this present study though, it was not possible to use aforementioned function, because it is designed for countries' representations rather than Regions or even Perfectures.

While inserting the statistical data in the test page “Chart your Input”, we realized that we cannot insert data with decimal numbers in the form “12,45”, because the application interpretes them as two different values separated by a comma rather than a single one. Should we want to insert data in decimal numbers we have to use the form “12.45” or “1358.48”, should the latterconcerns thousands.

Finally, in case there are multiple lines with zeroes in the statistical data, their representation on the chart that appears after “Submit” on the test page “Chart your Input” is not possible. In order to avoid such a malfunction the inserted statistical data should always be other than zero.

Users who want to try i-Use do not have to be particularly familiarized with ICT or have any special skills.They can explore and get themselves familiarized with its use and functions in a very short time. This, in effect, enables them to employ it as a tutoring aid in teaching Statistics very soon. In addition, they will also be able to use Statistics itself as an interdisciplinary approach to teaching other subjects. With but a little effort on their part, this might be beneficialfor the beginning of the creation of dynamic and interactive disciplines.

As a result, we would like to emphasize that the implemented applicationcan be used by the teacher as both an instructive and a monitoring tool. Based on the teamwork model, this proposed approach offers a good degree of freedom to the teacher on one hand, while still focusing on the use of real-life data on the student’s part, on the other hand. This application with the adoption of real data can also be used in subjects such as history, geography, mathematics, to enrich teaching contents.

For instance, the teacher may create a scenario about the GDP of the 13 Administrative regions of Greece in different years and introduce students to basic Statistics terms with the aid of actual data indexes. They will be asked to observe and evaluate the information they collect from sources with statistical data for a given year or over a time period. In the History lesson, a scenario can be designedto refer to the collection and processing of information about the state (e.g. population) in past years.Students will learn to study graphs or 2D/3D visualizations over maps, make comparisons and draw conclusions

Since the application is open source software, one can modify it to meet one’s needs and create a ‘final product’ which will best fit one’s own didactic purposes. As a result, this project offers useful and powerful tools for teachers to teach efficiently and systematically. It can be a valuable aid in teaching concepts of Statistics, insofar as teachers themselves know how to help their students acquire and develop statistical literacy skills. Moreover, teachers and students could use it as a research tool to explore how far it can be helpful to teaching and education in general.

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