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Open Data and Open Source GIS in school action towards a sustainable and livable environment

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Abstract
With the advance of technology and the wealth of information continuously generated nowadays, the Open Data concept has become essential to our societies, and so has the need to educate our students on how to demand, search for, and exploit information which should be open to citizens and entrepreneurship. A similar attitude that young generations need to be educated on regards the Free/Open Source Software. FOSS solutions can be as efficient as proprietary software, at minimal costs, with the extra added value of the ability to contribute to the community by enhancing or modifying open code. Last but not least, quality of life, livability and sustainability of our neighborhoods, cities and countries and what we -citizens, scientists, decision-makers- ought to care and do about it, is also an important axis of K12 education. The paradigm of a GIS application which can combine all the above ideas in a problem-solving setup was extensively used in action, for the very first time at this level, during a term-long project in an upper secondary general education class in Greece, as part of an ongoing Erasmus+ Programme. More specifically, the student team carried out a social field research employing Likert-type questionnaires, which regarded livability, quality of life and sustainability in their city districts. QGIS, an open source GIS, was used in processing and illustrating the research geospatial attributes and their relationships, together with various FOSS and online services, regarding questionnaire document setup, online forms, and responses processing. Groups and Blogs, a service by the Greek School Network -official Intranet Service Provider for K12 Greek Schools, was exploited to facilitate remote cooperative work and results publishing. Experiential Learning, learning by doing, inquiry-based learning methods were all exploited in a framework of social constructivism learning principles and a problem solving setup, all encapsulated in a long-term project methodology. Empirical results have been very encouraging, with students showing enthusiasm, creativity, and high levels of responsibility, together with high quality of the outcome product.

1. Introduction
Identifying the need to enhance teaching approaches and means to Geography in upper secondary education the three-year European Erasmus+ KA2 *Geo Future Excellence Programme* which kicked off in fall 2014 with peers in Heraklion, Amsterdam, Utrecht and Barcelona, aims at producing Learning Objects and didactic interventions in modern Geography (w.r.t. nature, humanities and technology), at the same time focusing and bringing awareness to quality of life issues, sustainability, smart use of technology, as well as to the relationship of citizens to civic and geographic space and their participation and collaboration in it.
Thus, secondary education brings students to confront major issues and factors of today and tomorrow: energy and natural resources, climate change, water abundance and scarcity; European citizenship, participation and globalization; sustainable cooperation between schools, companies and knowledge institutions; interdisciplinary approach to knowledge in complement to unavoidable specialization; smart exploitation of technology by creators and innovators and not lay users; thinking in terms of solutions and scenarios and not simply learning.
The Smart Cities theme, sustainability and quality of life, Public Open Data, and Open Source GIS were the four axes of the first year project work at our school. As a real life scenario, students conducted a quantitative research on the quality of life, livability and sustainability in their city neighborhoods, as perceived by its inhabitants. They looked for and exploited Open Data in order to study and illustrate the geospatial variability of their results.
To the extent of our knowledge, this has been the maiden paradigm of adopting GIS and Open Data as tools of student work in the Greek upper secondary *general* education.

2. Open Data

Open data hold the properties of universal availability, open access, open universal reuse and redistribution, thus becoming useful, usable and used. This means that such data is available as a whole in the form of sets, free or at minimal cost, preferably downloadable through the Internet, in forms that are convenient and modifiable both to humans and machines/software. It should allow reuse and redistribution as well as mix with other data sets, without any restrictions of use or discriminations on users, without even excluding the possibility of their commercialization.
"Opening" data improves their quality and nature and enhances the participation of citizens, organizations and enterprises in society. Furthermore, Open Data may generate information that is essential in decision making to the whole society; information which might have skipped the public and/or remained in the hands of a power players.

3. Geospatial data

Any data that can be illustrated on a geographical map (digital or not) is geospatial data; in other words any data that has a component determining location (e.g. coordinates). For over a decade, we are into the so-called geospatial revolution, an era which has transformed the way we navigate, how we make decisions, how we share our stories. Evolution in positioning technologies and the Internet, rapid developments in communication technology and significant software development have led to a transition from simply describing *where is what*, to being able to make decisions by answering the subsequent question; *so what and why*. This is no more the privilege of experts, but has spread to everyday Internet users and applications for computers and mobile devices, introducing the new term Neogeography [1].
The geospatial component enriches other data formats exponentially, introducing exciting new possibilities to the perception of information perception via space knowledge. Due to its geospatial component, within a click or a tap, information acquires new representation formats, new relationships, ultimately new content. At the same time, the transition from printed to digital and online maps, not only enhances usability, but transforms them to a communication medium, which can be enriched with information by the user herself, sharable information beneficial to other users, contributing to openness and a new user culture, who no more face technology as just an auxiliary means, but as a powerful tool in order to create and share solutions and new ideas [2].

4. Geographical Information Systems

An Information System designed to capture /input, store, process, analyze, manage, and illustrate /output any type of geospatial or geographical data is a Geographical Information System (GIS). The (geo)spatial data attributes are in the format of some geographic, cartographic or Cartesian coordinate system. Additional non-geospatial attributes corresponding to descriptive data are also present. Either of the relational or the object-oriented data model can be applied to encompass both information components, the spatial and the descriptive, resulting in some JOIN operations or object properties respectively.
Together with proprietary GIS, a wide variety of FOSS GIS, has evolved with strong community support around the world. Quantum GIS, or QGIS, is the Open Source paradigm we used here. Furthermore, a multitude of free online map services, like Google Maps, are essentially front-ends of GIS with huge amounts of data, allowing users to add their own data or even develop applications. This has contributed to the popularity and wide spread of GIS. A typical, however, problem in Greece has been the difficulty of tracking down Open Geospatial Data.

5. Teaching Interventions – student activities

Any GIS has practically unlimited functionality. Here we designed and applied an introduction to QGIS followed by its utilization in the visualization and comparative study of the results that occurred from a field research with Likert-type questionnaires. Along QGIS, students used Open Source and proprietary word processing and spreadsheet software in designing the questionnaire, analyzing and illustrating questionnaire responses, together with Google Docs, Forms, Spreadsheets and Maps, and the QGIScloud free service [3] to host their results.
In parallel, we utilized the Greek School Network Groups & Blogs [4] services creating a Working Group and a Blog, serving both for remote asynchronous collaboration and for publishing the project progress. Students also searched for and used Open Geospatial Data for the wider metropolitan area of Heraklion and conducted sample targeted live interviews to get the questionnaire responses. Thus

the project team had the opportunity to discuss and conquer knowledge through an interdisciplinary approach to the central problem and its individual components.

Work by the 16yr-old students was based on:

- the socio-constructivism, as prior knowledge and social environment of each student individually served within each working group, as well as within the project team as a whole, to conquer new knowledge and develop new skills, via interdisciplinary approaches,
- inquiry-based and discovery learning, with the "syllabus" concerning Open Data value, geospatial information, QGIS usage, was not presented by frontal instruction, but through shifting focus to exploratory and investigative methods, through personal student involvement in the cognitive process, with a complementary aim at how to learn by themselves, and
- the project method, by which students practiced time management, kept deadlines, shared work within the team, and learned to compose member work into team work.

5.1 Questions and objectives

The central problem-question to the working group was:
Consider the quality of life and sustainability in the Heraklion districts, comparing them with one another. Use QGIS to illustrate your results from a geospatial perspective.
This led to a series of direct sub-questions:

a. *What do we mean by quality of life and sustainability?*
b. *Which are the districts of Heraklion?*
c. *How can we carry on our study?*
d. *How can we make comparisons?*
e. *What is QGIS, what is "geospatial perspective", how do we illustrate results?*

Brainstorming, discussion and recall of experiential and prior knowledge helped answer the first question, by identifying the factors that make up the perception one has about quality of life and sustainability offered in the area in which she lives; ranging from basic infrastructure and networks, through to security feel, beauty perception and ease of commuting.
The Open Data concept developed with the discussion of the second sub-question. The subjective determination of city districts had to be replaced by some objective public authority definition. Failed Web search enabled the debate on citizen rights and the variety of paths they can by pursued through.
Determining the components of the concept of quality of life and sustainability led to discussing their evaluation, in order to assess the data in question. Evaluation can be done with objective observations and measurements, or by composing the subjective opinion of the citizens themselves. Students concluded that the latter is preferable, by asking inhabitants to evaluate each factor on a fixed scale, from total dissatisfaction to total satisfaction. Thus one also tackles the problem win non-measurable features such as the beauty of an area, while the information gathered after all is indeed the opinion of citizens.
So a questionnaire was decided, which brought up more interesting subjects, of theoretical and practical nature, such as its size, the neutral manner of wording the questions, or the means of its distribution and collection in relation to the target population sample, and so on.
In conjunction with the third one, the penultimate question highlighted a number of concerns regarding the quantification and arithmetic processing on concepts which by nature contradict it. Students had the opportunity to recall and utilize recent knowledge of descriptive statistics, and to enrich it with new material, such as weighted averages and their respective values.
Basic geospatial concepts both from the Geography and the Computer Science perspective, GIS and their usage, as well as QGIS itself, were brought into discussion by the last question. Illustration and interpretation of results was another subject in our query-driven discussion. Complementing all of the above didactic aims was the conquest of the relevant competences and skills with online and offline software tools; of great importance was engaging students into critical thinking, continuous questioning and multifaceted approach to knowledge.

5.2 Development stages

Following the initial discussion which broke up the main problem to its key concepts and component questions, students were introduced to the fundamentals of geospatial data and GIS employing Google Maps and Google Earth with short examples in order to directly and practically apply newly acquired knowledge.

Then came the debate and search for information about our city districts. Open Data were introduced, the local providers of it were eventually identified and were contacted with the team requests. Students actively realized how various processes differed from legislation to reality.
Furthermore they learned by experience what compatible formats and interoperability is all about, and realized what data cleaning is. Students were confronted with a number of decisions regarding mismatches, poor or missing information, and so on, operations for which were mostly carried out by the teacher in the background.
In parallel, the survey questionnaire [5] was discussed and compiled. Regarding a total of 19 districts, it comprised 28 Likert-type questions, on an integer 0-6 scale, divided into 3 categories: Basic Infrastructure, Security, Quality of Life. An online version of the questionnaire was put on Google Forms [6].
After an introduction to QGIS basics, students learned how to transfer questionnaire responses to spreadsheet. 626 returned questionnaires from 16 districts were processed, with the 3 categories equally weighted. Time limitations allowed only for the mean value to be considered, making it clear that by itself it may produce false or inaccurate information. Eventually students had the opportunity to apply their QGIS skills in order to illustrate the geospatial results of their survey.
An interesting final question that emerged was how the 16 district individual indexes can be combined to generate information for the entire metropolitan area of Heraklion. The importance of weighting individual components, i.e. the 16 districts w.r.t. their population, was stressed again, bringing yet another challenge for Open Data to pursue. 2011 Census data from the Hellenic Statistical Authority came to our rescue, not without having to tackle inconsistencies with the rest of the data; the latter eventually led to complementary QGIS acquired competences.
Publishing geospatial results on the Web concluded the 2014-15 school year project.

5.3 Issues

It took few students a longer time to show real interest, so they were limited to auxiliary roles in it. Time limitations pruned the opportunities to view and analyze the GIS as a Data Base Management System. Locating Open Data, noise in it, and serious inconsistencies although problematic, proved beneficial by adding new dimensions to the project. They were discussed and analyzed within the team, but eventually the teacher had to tackle with them in the background.

6. Overview - Future work

To conclude, students acquired knowledge, competences and skills in multiple levels, while realizing in practice the importance of geospatial information. They also confronted and were called to act upon important issues of our universal future. The experiential nature of the various methods employed proved quite efficient. During their work, students felt they carried out meaningful tasks important to their hometown.
Following in this fashion, we make the survey raw data and results available in an Open Data form. Last but not least, we will use our data to produce a form of information similar and comparable to that regarding Heraklion in a recent Eurostat survey publication [7].

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