

GEOGRAPHICAL INFORMATION SYSTEMS IN PORTUGUESE GEOGRAPHY EDUCATION

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Abstract

The use of Geographical Information Systems (GIS) in Geography education is very important in terms of geographical skills development such as spatial literacy, the ability to recognize patterns and relations between geographical phenomena and to explore real-world problems. This paper analyses how Portuguese Geography Education (both in basic and higher education) addresses this important matter and also presents some projects that have been developed in order to enhance the use of GIS in the classroom. Being recognized as an important tool in Geography education the fact remains that a minority of Geography teachers refers using it in their classes for reasons related to lack of training or the need to develop a content centred syllabus in a limited schedule. If learning Geography is about understanding our world, GIS has an important role to play that should be present in Geography Education.

Keywords: geography education, basic education, higher education, GIS, thinking spatially

1. INTRODUCTION

The use of geographical information systems as an educational tool in school geography is quite recent in the Portuguese educational system. In fact, only in the late 90s it was possible to identify projects related to the use of GIS. It is important to refer that the Technological Educational Plan that intended to modernize, to make internet access available in all Portuguese schools, dates back to 2007. This plan was a first step in terms of providing internet access and equipment to schools in order to democratize students' use of computers and internet.

In this paper it will be analysed how GIS use is being introduced both in basic schools and higher education. The curricular reorganization from 2001, allowed an interesting reorganization of Geography syllabus that gained a new guidance: teaching and learning centred in the development of geographical skills. Still, GIS use was not a part of this process (at least explicitly). The use of GIS in Geography education was being developed through the implementation of teacher training projects where students had the opportunity to develop

these skills. The number of teacher training courses related to the use of GIS also had a great demand in the first decade of the twenty first century. But, the organization of the educational system didn't allow teachers the possibility to implement and develop an effective use of GIS in classrooms.

In higher education, the introduction of GIS subject in the degrees offered in Geography also dates from the 90s. In fact, the universities were the first to respond to new paradigms in education that claimed that students should be prepared to live in a society in constant change. So, university degrees focus should be on science and not only in technology. This means that students should develop spatial awareness and also criticism skills. In response to this challenge some GIS related subjects were introduced in Geography degrees.

Recently several projects developed by the Institute of Geography and Spatial Management have been trying to continue supporting Geography teachers who want to use GIS in their subject. Two of them will be presented as regards the activities that are being developed. Both are mainly devoted to basic and secondary schools involving teachers and students. "We Propose!" is a project that intends to involve geography students in local planning while GEORED is an online platform oriented to teachers' support regarding the sharing of GIS activities that can be implemented in classroom. A brief analysis of how these projects are working as a means to disseminate the use of GIS in Geography education will also be presented.

2. GEOGRAPHY EDUCATION AND GEOGRAPHICAL INFORMATION SYSTEMS

2.1 GIS in Portuguese School Geography

The introduction of GIS in the Portuguese educational system (basic education) goes back to the 90s and relates to two different initiatives: the introduction of internet access in Portuguese schools developed by the Ministry of Education and the creation of the Project "Ciência Viva" by the Portuguese National Agency of Scientific and Technological Culture that intended to introduce geographical information technology. Some goals of this project were: to develop spatial analysis skills among students, develop critical sense about spatial planning and make students aware of the importance of geographic information in daily life.

Moreover, this project was financed by the Ministry of Education and had the participation of two Geography Associations – the Association of Portuguese Geographers and the Association of Geography Teachers. The participation of these two associations involved some teacher training courses in order to develop the use of GIS technologies in Geography classrooms.

In 2001, the curricular reorganization of the Portuguese educational system included a restructuring of some subjects and Geography was one of them. Geography curriculum for basic school introduced the notion of the "geographically competent student" as the student who would master spatial skills and show his or her capacity to spatially visualize facts. The "geographically competent student" should be able to develop important skills such as using maps of a wide range of scales, understanding spatial patterns and locate himself or herself on the surface of the Earth. In order to attain these educational goals teachers were recommended to build in classroom learning activities where students would be able to develop geographical skills (Ministério da Educação, 2002).

This was a skilled based curriculum that changed entirely the way Portuguese Geography Teachers worked in classrooms. According to Esteves (2012) so as to contribute to the development of this geographically competent student, the geography teachers should be able

to contribute to the formation of a geographically informed citizen, which involved a set of teaching and learning experiences that all students should go through. In spite of this new concept of “geographical competent student” the fact is that the acronym GIS never appears in the new syllabus of 2002.

In fact, the development of GIS in geography classrooms was initially based on projects that intended to support teachers interested in the subject. One of them was ConTIG introduced in 2004. According to Mota (2012) the ConTIG project aimed at showing the potential of geographical information technology to better organize and manage the curricula, in accordance with the guiding principles of Portuguese national curricula. The ConTIG team established sporadically contacts with teachers who were interested in using GIS in their classrooms, but they never got feedback or published on the subject except during teachers’ training.

Another important contribution was given by the Association of Geography Teachers that was responsible for continuous teacher training courses during the last decade. Several projects have appeared and disappeared related to teacher training organized by training school clusters or even by private companies such as Esri Portugal. And of course, the universities also played an important role in the process of training school teachers in GIS.

In the school year of 2011/2012 there was a revision of the Geography curriculum for basic school and some changes were introduced (Ministério da Educação e Ciência, 2013). The “Learning Attainments” in Geography were published demonstrating a new direction in terms of what school geography should teach – and centred the syllabus on what students should learn revealed a shift from a skilled based curriculum to a content based curriculum. However, for the first time there is an explicit reference to the importance of enabling geography students to develop “spatial analyses” skills through the manipulation of maps, texts, images in order to present and analyse geographical information using new technologies of information and communication.

The importance of this document is the recognition that the technologies of geographical information (geographical information systems, remote detection systems and global positioning systems) have an important role in terms of enhancing geographical learning. By including these tools in the classroom the geography teacher will be helping students to “think spatially” and develop important skills: the use of satellite images allows the access to updated maps of different scales and their manipulation to deal with specific contents.

The research that has been done in the last decade about the use of GIS in basic schools (Gomes, 2006; David, 2007; Santos, 2010) has concluded the following: in spite of the boom of ICT training courses for students and teachers that started in the late 90’s little has happened in what concerns introducing GIS in Geography classes. One of the reasons pointed out is the lack of time to learn, the reduced time in contact with students (some geography teachers only meet each class once a week for 90 minutes) and the pressure to create learning experiences related to the development of contents that will be assessed in exams.

Other researches having been adding information from the point of view of Geography teachers and students (Esteves, 2009; Soares, 2013): students enjoy participating in classrooms where GIS is used as these classes become more interesting, active and learning based; Teachers recognize that school books are already making references to the importance of using GIS in Geography education but they don’t have the training to do it in a regular basis (among other problems related to internet access, having computers available, timetables and the need to prepare students for exams, as mentioned before).

It is important to refer that the recognition by the Ministry of Education of the importance of GIS in terms of developing students “spatial literacy” is a good indication for geography teachers. Still, a lot remains to be done in terms of teacher training and finding the way to

work with this software in classrooms. The number of master and PhD researches about the use of GIS in school geography has been growing in the last years and they have been a way of introducing GIS in many Portuguese schools that have participated in the researches done.

2.2 GIS in Geography Higher Education

The use of Geographic information systems (GIS) in higher education provides an integrated solution to support teachers and students within educational objectives. As mentioned before this training only exists formally at university level (figure 1). GIS places the information in a geographical context and can be applied across various sectors to improve learning and teaching. GIS can give students the necessary skills in several areas such as health, marketing, environmental studies, engineering, natural resource management and, of course, geography.

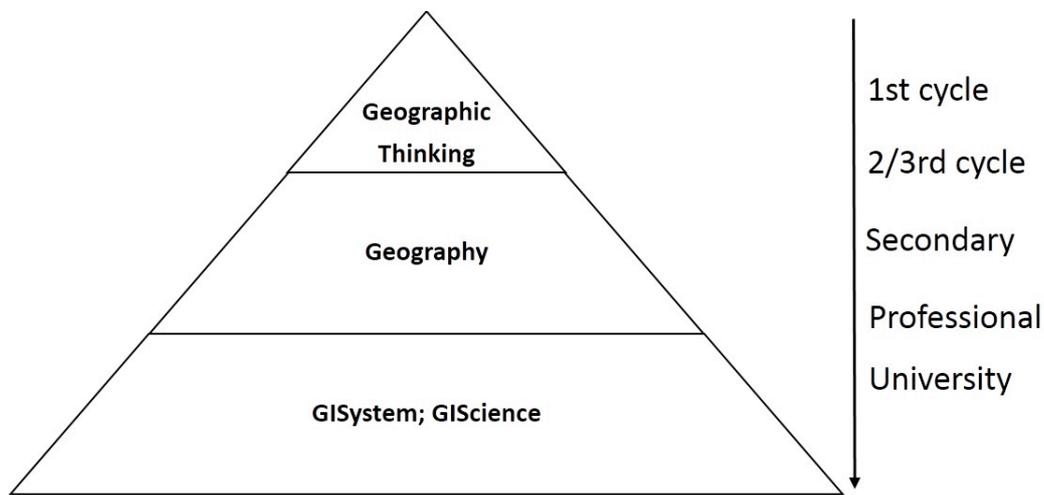


Figure 1. GIS and Geography Education in Portugal

It is important to point out that there was a certain resistance in higher education courses to take on this area as a field worthy of scientific research. In spite of this, it was very common to find this designation (GIS) in many scientific areas (and teaching) and it was abusively used in proposals for project funding (table 1).

Table 1. GIS in several universities and Geography graduations

Portuguese Universities	Degree	MSc	PhD	Research Line
University of Lisbon	YES	YES	YES	NO
New University of Lisbon	YES	YES	YES	NO
University of Porto	YES	YES	NO	NO
University of Minho	YES	NO	NO	NO
University of Évora	YES	NO	NO	NO

As it is presented in the table above, presently all public universities that offer Geography degrees have subjects related to GIS in their degrees' syllabuses. The situation changes in post-graduation courses – only three universities offer masters in GIS and only two offer PhD programmes in this area. It is also possible to realize that there are no research lines at the university level in GIS.

After some debate, Wright, Goodchild, and Proctor (1997) refer that the importance of the GIS (viewed as geographic information science) is increasingly accepted as a research field. The "multi-disciplinary work required by the GIS is risky in the academic context, primarily for researchers early in their career, because they are more valued in terms of progression, which develops at the borders of traditional disciplines" (Goodchild et al., 1999, pp: 738).

The introduction of GIS related subjects in Higher education geography is a coordinated response to a set of questions that were partially being addressed by several subjects that contributed to the study of geographic information. It should be noted the amount of subjects related to GIS: cartography, cognitive science, computer science, topography and various engineering, environmental sciences, Geodesy, geography, landscape architecture, politics and law, remote sensing and Photogrammetry and, finally, mathematics (in particular statistics, geometry, topology and operational research). The profusion of subjects is difficult to overcome as it can be seen as a loss of prominence by the academic staff that resist to the introduction of new subjects which can be considered a threat to the establishment.

The effectiveness of the teaching-learning process in geography, both in physical and human geography, has undeniably increased with the use of geographic information science. The world of new technologies is characterized by various aspects of change. One of them is speed and as Passarelli (2003) argues, the most difficult period in History to understand is the present one, in which the speed of changes suggests a revolution led by communication. Thus, the new paradigms in education claims that students should be prepared to live in a constantly evolving society. So, at the university level the focus should be in science and not in the technology itself. As a consequence, students should develop spatial awareness and critical skills.

The process of technological innovation, present in many ways in education, has resulted in successful and unsuccessful experiences. One of the difficulties in this kind of processes is the identification of the new, i.e. not just applying what was learned in a repetitive way (Almeida & Fonseca Jr., 2000). In the area of geography, the teacher should create procedures that would lead the students to realize that there can be multiple hypotheses in real problem solving. Therefore, the identification processes and learning of spatial-temporal transformation would be facilitated, which is fundamental to the understanding of geographical phenomena. In this context students' skills should not be neglected because if it is true that generally they are well familiarized with the use of internet and social networks, at the same time there are still some that don't know how to unzip a file or create a folder. So it is necessary to establish a connection between the programmatic contents which allow the understanding of geographical space and the methods of awareness of that space through the available technology.

Paradoxically, since the implementation of the Bologna process the offer of GIS in higher education has known a drawback (table 2). On one side the number of GIS classes for undergraduate students has been decreasing as they have been moved to master programs or simple were eliminated from the curriculum. On the other side, as master courses in GIS are intended for a wider public some subjects are an overlay with subjects already taught in Geography degrees. This can be a demotivating factor for graduate students who want to continue their studies in the GIS field of expertise.

Table 2. GIS subjects before and after the implementation of the Bologna process

Previous to Bologna process	After Bologna process
Methods in Geography	Data Analysis
Data Analysis I	Multivariate Data Analysis
Data Analysis II	Thematic Cartography
Cartography I	GIS
Cartography II	GIS & Remote Sensing
Introduction to GIS	Spatial Modelling
Automatic Cartography	Spatial Analysis and GIS
Thematic Cartography	GIS Seminar
History of Cartography	
GIS I	
GIS II	
Remote Sensing	
Spatial Modelling	
Spatial Analysis and GIS	
GIS Seminar	

A final reference to the relation of Geography initial teacher training (Master in Geography Teaching) and GIS formation must be made. In fact, this master that corresponds to the initial training of future Geography teachers doesn't have a compulsory subject related to GIS. It only offers an optional subject (among seven possible options) in the third semester where students can get in touch with the subject of Applied Remote Sensing and GIS.

3. GIS PROJECTS FOR TEACHERS AND STUDENTS IN PORTUGAL

3.1. We propose!

This project was created in 2011 by Prof. Claudino from the Institute of Geography and Spatial Management of the University of Lisbon (IGOT – UL). In the first year it involved 11 secondary schools who got together to identify local problems, create solutions and present these at the University of Lisbon and later to local authorities. In the last school year the number of schools involved increased to 35 from different Portuguese regions (including the autonomous region of Azores). This information is available in the project webpage at <http://nospropomosigotul.wix.com/nospropomos-igot-ul>.

The project involves not only schools (and Geography teachers and their classrooms) but also the IGOT –UL that organizes teacher and students training in the use of GIS through the collaboration of Esri Portugal. The local municipal authorities are also involved in the project providing information about local plans and land use. The project is developed in secondary schools, at the eleventh grade, where students have a subject of Geography (Geography of Portugal) and should develop a case study during the school year. Teachers interested in participating in the project are invited to enrol in the beginning of the school year in the project page and then are visited by representatives of IGOT and ESRI Portugal in order to receive further information.

The concept is quite simple: students research local problems (within the Geography syllabus), contact local authorities to learn about more about the problems and what is happening in terms of planning at a local scale, get GIS training with ESRI software that should be present used in the proposed solutions and present research based proposals to solve the identified problems. The work is developed during the school year and the project

presentation is done in a National Seminar at the University of Lisbon where all schools get together and where teachers and students share their researches.

The main outputs of this project are: involving students in active citizenship (an important skill acquired in Geography Education), developing GIS skills (through ESRI participation and training), working in real life problems (some basic concepts about how to conduct field work are given as well as how to develop a structured research) and presenting the research carried out to local authorities. In terms of enhancing the social relevance of school Geography (that is sometimes devalued by educational policy makers) the project gives high visibility to Geography at a national level. Bringing together about 1300 geography students and teachers to the University of Lisbon is an important event portrayed in the media (mainly the written and online press). In terms of the project assessment the number of schools involved attests its increasing success within the community of geography school teachers.

In what concerns learning about GIS and their use in Geography projects the assessment is made through the evaluation of the presented proposals. This year the best project was awarded a week visit to the European Parliament with the sponsorship of the Communist Party. Furthermore, the municipal authorities will implement the students' research project in the city (the winning project originated from the city of Guarda). The internationalisation of the project is also underway – next school year it will be implemented in the Brazilian state of Tocantins due to the initiative of Prof. Bazzolli from the Federal University of Tocantins. As a postdoc student at the IGOT he had the opportunity to collaborate in the Portuguese event and will now implement it at his university involving 19 schools.

3.2. GEORED

GEORED (Digital Educational Resources in Geography Teaching) is an initiative involving the Portuguese Association of Geography Teachers, the University of Lisbon (IGOT), the Ministry of Education and the Portuguese Geographic Institute (IGP). It was launched in 2008 with several teacher training courses related to the theme “Digital maps and spatial planning – the use of interactive tools in the development of geographical skills”. These courses involved approximately 80 geography teachers from all the country.

The main result of these training courses was the production of materials based in the educational use of websites with geographical information and WebGIS. These initial materials were the starting point of the later creation of a website of educational resources to geography teaching. GEORED (<http://geored.dgicd.min-edu.pt>) includes an important number of resources, many of them tested in school classrooms, built initially by a group of teacher that attended these initial courses. Nowadays, any teacher can upload or download educational resources related to the use of GIS in various themes of school geography.

Recently there has been a growing interest in the use of Open Educational Resources (OER), not only in the sense of free resources with no copyright, but also in the sense of being used several times in specific contexts and fostering the habit of open practices. In the specific case of geographic information authors like Crampton (2010) stress the importance of the movement Free and Open Source Software (FOSS) in the expansion of new services. A key concept of the free software movement is that it can create and share information more easily than a closed source, as traditional GIS.

The option GEORED intended to share information, focusing on open source desktop GIS or free WebGIS, as well as other mapping tools on the web (Ferreira et al., 2010). One of the basic ideas of designing the website, and perhaps the most original one is the articulation between 4 areas: geographic information, software, teaching guides (resources) and

bibliography. These four areas, although may be considered separately, constitute a network of interconnected links.

Geographic information is a kind of raw material for the preparation of resources. The software is then understood as a tool to treat it. The bibliography, in turn, should be a permanent horizon looking for innovation, new educational directions and sharing research and knowledge. Last but not least, the pedagogical approach in the resource guides expresses the importance of educational strategies and is intended to promote the effective learning of geographical contents.

4. CONCLUSIONS

As it was possible to understand there is a lot to be done in terms of implementing GIS in classrooms. Even at university level the basic formation in GIS that exists in Geography degrees omits those who could implement it in schools. The importance of GIS in Geography education seems to be undeniable in order to foster significant learning with tools that are also available in the world outside classrooms and that are being used by students in their daily life.

If initially the debate was between "learning with GIS" and "GIS learning" nowadays it is clear that both dimensions are important. In a context of professional learning it makes sense to learn GIS. But in a Geography education context as a way of understanding spatial phenomena the importance of learning with GIS seems very clear. Having this in mind there is still the need to develop an effective model that combines curricula with competence standards (Schubert & Uphues, 2009).

Regarding the use of geo information and GIS in the classroom there are four important steps that should guide teachers' practices at different levels of schooling geography learning:

- i. Teaching about GIS (teacher-centred). The teacher can present explanations of what is a GIS, and how it is used (from the 5th grade);
- ii. Teaching with GIS (teacher-centred). Teacher-centred lessons where GIS is used as a tool to discuss a geographic content (from 6th /7th grade);
- iii. Learning with GIS (student-centred). GIS can be used by students to explore a geographic content with the help of the teacher, using sets of pre-defined data (from 8th/9th grade);
- iv. Research with GIS (student-centred). Students create their own sets of data and work with them (from 10th/11th grade).

It is essential that students learn to use technology and to think spatially so as to be prepared to understand and address economic, political and environmental issues at local, national and global scales (Schubert & Uphues, 2009). More recent research has proven that GIS experiences in different school years are very important in order to develop spatial thinking skills. Lambrinos (2014) has demonstrated that the use of GIS technology with primary school children had an important role in enhancing critical thinking and spatial thinking.

But that cannot be done without a suitable teacher training. It must be added that in 2007 a new directive was issued by the Ministry of Education in order to regulate continuous teacher training where it was stated that for career progression only courses related to the scientific and didactic area would be valid. GIS courses are many times classified as "New technologies of information and communication" which meant a decrease in the search for teacher training courses in GIS.

The projects presented intend to fill this gap concerning the use of GIS in geography education. As demonstrated both the universities and the associations of teachers' training are facing problems in terms of the development of GIS in Geography education in an

opposite movement to other European countries. In higher education it will be difficult to change the situation at the undergraduate level. But at the graduate level, namely the Master in Geography Teaching, it will be important to ensure that future teachers will have a contact with GIS during their scientific and pedagogical training.

In what concerns “We Propose!” the project is facing a good acceptance by schools and next school year will include 50 which means an increasing dissemination of the use of GIS in Geography. Still, an objective evaluation of the impact of the project in the introduction of GIS in classrooms after the participation in the project remains to be done. If learning Geography is about understanding the world we live in, GIS has an important role to play in the development of spatial analyses skills that should be present in an proficient Geography Education.

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