The need of geographic information systems in education research

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Resumen:
The aim of this paper is focused on raising awareness of the possibilities in data discovery, trend and pattern spotting, decision-making support, and management that Geographic Information Systems (GIS) bring to the table of education and, particularly, higher education (HE) research. The large volume of data brought by the big data, and big geodata, requires approaches that offer solutions to its complexity and facilitate understanding and communicating research outcomes. GIS has been used successfully in many fields, especially due to its spatiotemporal capacity, but the social sciences in general, and education in particular, are not taking advantage of its capabilities. On this paper GIS is presented including significant education research employing GIS.

Palabras clave: Education research, GIS, Big Data

1. Introduction:

Education is an important factor for a society's economic and social development (Rumbley, Stanfield, & De Gayardon, 2014). The European Union's (EU) focus on achieving economic and social goals in a knowledge-based society (European Commission, 2011) through an expansion of Higher Education Institutions' (HEI) involvement in society employing the Horizon2020 strategy (European Commission, 2014) is a significant example of the increased importance of understanding, managing, planning, and supporting decision-making in education effectively. However, the accelerated pace of data creation in many fields, including education, makes the task of extracting added value a complex process (Turi, Christoph, & Grigsby-Toussaint, 2013) requiring the aid other disciplines, such as educational data mining (EDM), can provide (Romero & Ventura, 2010).

This paper is organized as follows: a short introduction of big data and data mining is offered followed by a brief presentation of Geographic Information Systems (GIS) and a concise exploration of GIS' research, including recent research of GIS in the education field. This paper ends with a discussion regarding GIS' increasing relevance and concludes that the importance of the geospatial factor in education research is only at the tip of the iceberg and will only expand as it has been happening in other fields over the last decades.

2. Big Data and Visualization:

The recent trend of gathering heterogeneous data in vast volume has been referred as big data. Big data has brought the need of using data mining techniques in order to extract added value information from data (Romero & Ventura, 2010). Among the EDM techniques, the analysis and data visualization are the most used (Romero & Ventura, 2010). This is not a surprise because the human eye is wired for trend and pattern spotting as well as identifying outliers (Heer, Bostock, & Ogievetsky, 2010). Furthermore, making data visually appealing and representing it graphically is more engaging than non-visual communication vehicles such as text (Heer et al., 2010).

At this point, it is relevant to consider that the geospatial data within big data is becoming so important that it is turning into big data by itself (Sui, 2014). The relevance of location in the data calls for a methodological research approach that takes advantage of it while keeping the non-geospatial data within the same system offering visualization and analysis capabilities. It is also necessary to consider that spatial critical thinking improves the evaluation of data reliability, the spatial reasoning, and assessing problem solving (Kim & Bednarz, 2013). It is in this context of educational big data, and big geodata, that GIS is presented.

3. What is GIS?:

Defining GIS is a complex task due to the complexity of GIS itself. A complete definition is the one offered by Lo and Young (2007), who define GIS as a combination of an information system and geography, where the word "geographic" in GIS refers not only to "Earth", implying Earth's features and resources both natural and human, but also referring to "geographic" as the "geographic space" where phenomena occurs, be it natural or human phenomena. For "information system" they understand it as the functional side aiming at collecting, storing, analyzing, and presenting information systematically. This side is, in fact, very similar to the definition of GIS offered by the U.S. Geological Survey (2007). The latter notes, however, that there is a structural side to an information system that is focused on the interrelations of its components, including a combination of data and technical human resources.

In other words, because GIS is, at its core, a relational database with the geospatial factor at its center, and the study of different phenomena is its aim; GIS could be described as the technology at the crossroads between traditional geography and information and communications technologies. It is, however, very challenging intellectually due, precisely, to this central position between technology, and the humanities and social sciences. As a result of its position GIS offers many advantages to experts in a wide range of fields, including education, which can benefit from its

different perspective and its multidisciplinary nature. The main benefits are the ability to provide effective decision-making support, better management, which in turn results as financial and resource efficiency, improved communication through geovisualization (ESRI, n.d.), and facilitating trend and pattern spotting. In short, GIS has a unique ability to deal with complexity, analyze changes over space and time, and provide visualization to better explain relationships to the scientist and the non-scientist alike (Baum & Mitchell, 2010). The opportunities are immense.
It is very significant to note the lack of research investment on spatial critical thinking through GIS in the humanities. Jessop (2008) and Rumsey (2009) both agree that most humanities disciplines have not prioritized the spatial critical thinking. Goodchild & Janelle (2009) argue that when the implicit sources of spatial information will be made legible to geospatial technologies new information will arise. They also see the geospatial technologies as the essential and integrative element of multidisciplinary research. It is also true, as Boonstra (2009) notes, that GIS needs to adapt to the concerns of humanities in order to take full advantage of the crucial location information in the humanities research.

4. GIS research

Traditionally, GIS has been used in the environmental and defense domains. Nowadays, the need of GIS in environmental research is widely accepted and perceived positively. A few examples are GIS for environmental planning and resource management (Mellino, Buonocore, & Ulgiati, 2015), modelling and mapping soil texture (Akumu, Johnson, Etheridge, Uhlig, Woods, Pitt, & McMurray, 2015) or studying the evolution of a rural territory (Fujiki, Mietton, Andriamasinoro, & Andriamasinoro, 2015) just to mention a few. Another traditional field is urban planning, including many urban studies such as comparative studies (Wu, Zhao, Zhu, & Jiang, 2015), understanding the urban social changes (Lee & Rinner, 2015) or finding patterns of available construction land (Dang, Xu, & Tang, 2015). Transportation issues are also very common among GIS researchers. For example, for locating inefficient links in a large transportation network (Sun, Liu, Xu, Jie, Wei, & Wang, 2015).

There are many other, less obvious, fields where GIS is also becoming a determinant influence in the research methodologies such as health studies. Two compelling examples are the studies aiming at finding geospatial trends in male factor infertility (Odisho, Nangia, Katz, & Smith, 2014), and at understanding the spatial distribution of underweight, overweight and obesity (Turi, Christoph, & Grigbsby-Toussaint, 2013). The Stanford University Library website offers a few noteworthy examples of GIS research applied to different fields, including education.

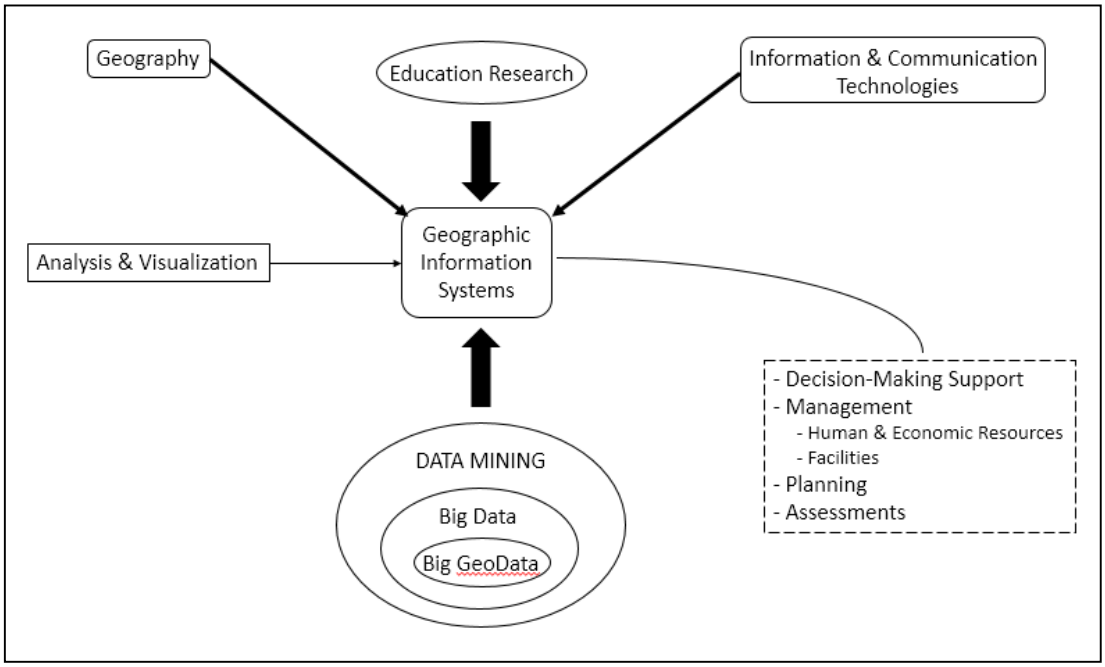
Geospatial data is a central part of all of these studies where non-spatial data was integrated within GIS for richer analyses. This, is precisely what Goodchild & Janelle (2009) mean by considering GIS the cornerstone of multidisciplinary research. Education, for that matter, also includes a large volume of data including geospatial data, as mentioned above. Therefore, GIS is able to offer a different perspective to new education studies while aiding at improving the existing studies.

GIS in Education Research

There are many studies in education but only a limited number of them take advantage of understanding the geospatial factor. Wang et al. (2009) implemented a GIS-based decision-making support system at the Peking University aiming at helping researchers, educational decision-makers and the wide public to analyze, synthesize, and display the huge data concerning the management for educational development. Similarly, the Oregon State Board of Education Decision-Support Pilot Project (OSBEDSPP) was implemented focusing on demonstrating to policy-makers that GIS is able to provide and advantageous approach for assisting better informed decision-making processes, in this specific case, for developing workforce and funding colleges (Wang et al., 2009; Oregon State Board of Education, 2004). Similarly, the National Office for Research on Measurement and Evaluation Systems, in USA, employed GIS for the exploration of the educational performance, and for visualizing the performance in relation to the current policies named Geographic Academic Policy Series (Wang et al., 2009).

Other cases of GIS in Education focus on studying the layout and structure of Higher Education (HE) at the regional level in order to rationalize the planning and distribution of HE resources while providing decision-making support scientifically (Liu, & Wen 2013). Student retention patterns have also been studied with GIS to decide where to start aid programs (Hanewicz, 2009). Considering the relevance of the European student mobility program Erasmus it is relevant to mention that student mobility issues were analyzed from a GIS perspective by Perkins & Neumayer (2014) to discern the students' mobility motivations. A specific case of GIS in educational resource management is the University of Calgary, in Canada, where GIS is applied resulting in saving thousands of dollars (ESRI, 2011)

A simplified conceptual model that summarizes the argumentation of this paper is included (Figure 1), affirming that due to the educational big data, and big geodata, data mining techniques are needed. Among them, data analysis and visualization are the most popular techniques among researchers. Considering both the implicit and explicit geospatial factor in a number of educational research issues, we introduce GIS as the most integrative and advantageous technology for understanding and communicating effectively the effects of the aforementioned factor on such issues.



5. Discussion

The significance of GIS methodology is derived from its contributions in terms of decision-making support, planning, and management improvements among others. A clear example, is the growing employment of GIS across disciplines. The recently published article on the Spanish newspaper "El País" introducing to the wide public the significance of a spatial perspective, and GIS as the vehicle to approach research issues efficiently in different disciplines (El País, 2011 & 2014) is a proof of its growing relevance. Furthermore, ESRI, the most important GIS software manufacturer, proposed the Spatial University (Sui, 2014). Its main characteristics are the spatial thinking across the curriculum, geospatial workforce development, geo-enabled research, and GIS for smart campuses. Although ESRI would be one of the main beneficiaries, independent studies have been performed agreeing with ERIS's perspectives on the benefits of such a university (Kim & Bednarz, 2013; Hanewicz, 2009; Wang et al., 2009; Perkins & Neumayer, 2014). In short, ESRI is proposing a specific application to Goodchild & Janaelle's (2010) idea of GIS as the cornerstone of multidisciplinary research, and Kim & Bednarz's study (2013) proving that those learning critical spatial thinking are better at problem-solving.

In order to promote employing geospatial data the European Commission's INSPIRE directive (2007) enforced the emergence of geospatial data readily available, facilitating the integration of datasets towards geospatially focused research.

6. Contribuciones y significación científica de este trabajo:

On this paper, Educational Data Mining has been introduced for approaching educational big data, and big geodata has been presented. Among the data mining techniques data analysis and visualization are the most employed techniques (Romero & Ventura, 2010). Contemplating educational research issues together with both the implicit and explicit geospatial factor, GIS has been introduced as the most effective approach for obtaining enhanced results in educational research.

It is important to note that GIS is more than a tool although it is often perceived as such. There are a vast number of principles and specific issues that must be approached expertly for attaining valuable and usable results. GIS experts are used to collaborating with others due to its multidisciplinary nature. However, learning to be in a crossroads is not always an easy task. It implies understanding both sides the technical, and the phenomena's from a geospatial perspective, increasing the difficulty of GIS' already complex approach.

Finally, considering the few available studies in GIS and Education, and the examples presented on this paper, it is reasonable to conclude that more of such studies are needed and, at the very least, the research possibilities should be explored for the potential of benefiting from this multidisciplinary approach and the possibilities of new discoveries are enormous.

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