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SPATIAL DATA INFRASTRUCTURES AND GEOGRAPHY LEARNING

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Abstract

Geography, as a science and in the educational sense, is benefiting from improvements in the usability of geoportals and viewers connecting Spatial Data Infrastructures (SDI) which link to high quality geographic information. It is very useful for Geolocation services. This is due to the fact that the amount of open data has been increasing and most of the data have a spatial reference and hence called geodata. It improves employment possibilities and facilitates becoming an e-citizen using e-government information.Time and space are very important for data analysis. Therefore, it is possible to learn geography from SDI geodata, especially if it is integrated into a learning environment. Some examples will be analysed. Geodata provides us with open data and a holistic approach that lead us to come to our conclusions which in turn improve learning quality leading to the acquisition of spatial and digital competencies.

Keywords: *Spatial Data Infratructures, Learning, Interactive Web Maps, WebGIS.*

1. INTRODUCTION

Spatial Data Infrastructures (SDI) is currently the basic element used for geographic information in a global context. Its importance is undeniable. So, the use of geographic information on new interfaces results from the integration of open geodata from the SDI created in the European Union under the INSPIRE (INfrastructure for SPatial InfoRmation in Europe) Directive.

SDI is organized in linking geoportals to services which allow one to share, interchange, combine, analyse and gain access to geographical data using interoperability and standardization. These last elements are essential and should go together. The format of geographic information (GI) is changing (Carbonell *et al* 2012) and SDI made GI available to everyone. Quite a lot of cartography resources are available online free of open data, mostly using geodata from SDI.

The Open Geospatial Consortium (OGC) services comprise standardized and interoperable SDI services. Currently, the most extended services are the Web Map Services (WMS). The services are also offered using tiles. They allow images to be loaded into a manageable rectangular set of pixels used to process the whole image without consuming a vast quantity of computer memory. The computer process is not visible. Tiling is the quickest way for image visualization today, as a set of rectangular pixel limits are imperceptible. There is no difference in visualization. They are called the Web Map Tile Services (WMTS). Both are basic visualization services which allow one to see geodata, but one cannot make any changes, although in some cases you can add or remove a layer.

Other OGC standard services exist, such as Web Feature Services (WFS), but they are not available for all connections. It depends on the app. WFS make it possible to access the attributes tables of vectorial geodata, download it to the local hard drive and make any necessary changes. For raster datasets, the Web Coverages Service (WCS) exists. Web Catalogue Services (WCS) and Web Process Services (WPS) are also relevant, among many other standardised interoperable services (González and Lázaro 2011). They allow one to visit a catalogue of services and to process information on the cloud (cloud computing).

As a result, geographical data or georeferenced data, called geodata, is the “raw material” served by SDI through the OGC services. Geodata is open georeferencing data available on the internet and freely accessible to download and re-use (copy, analyse, re-process) for limitless purposes.

Official bodies or organizations are responsible for each piece of geodata updated and any metadata added. So geodata is characterized by quality and reliability. Metadata describes precise data geographic information or geodata such as origin, extent, quality, spatial and temporal scope, content, spatial reference and datum, identification, author and responsible body among other properties of digital geographic data following the ISO 19115 rules. Few people are aware of all these issues in spite of the fact that they are continuously using geographical information on geoservices on their smartphones. Therefore, some literacy on all these aspects is necessary. Accordingly, lectures and lessons can be completely turned around due to technological advances and transformations.

The Spanish National Geographical Institute integrates geodata from public administrations on the Spanish SDI. The utility has come about as a result of the holistic geodata approach. Necessary standardization for interoperability comes from the ISO 19100 standard and the Open Geospatial Consortium (OGC) specifications (Bernabé-Poveda and López Vázquez 2012:44, Iniesto and Nuñez 2014). INSPIRE is applied in Spain under LISIGE Law (Ley sobre las infraestructuras y los servicios de información geográfica en España) which guarantees free viewing services of a broad range of open data not, only related to the environment.

Currently, the Spanish Spatial Infrastructure Data (IDEE) Observatory that assists in the growth of IDEE, was launched in 2006 (Del Campo *et al* 2012:247). Teachers can also become aware of the advantages of using SDI (González, 2012) as an available, quality and reliable source of geodata, although it is very useful for geography and other territorial sciences in lessons. Thus, in terms of educational aims, IDEE is relatively unknown and few people know how to take full advantage of it.

The evolution of new possibilities of SDI and technologies on the Internet evolution is based on the growth of information in general and the specific increased interaction of geoinformation access, but also on the number of learning environments (Figure 1).

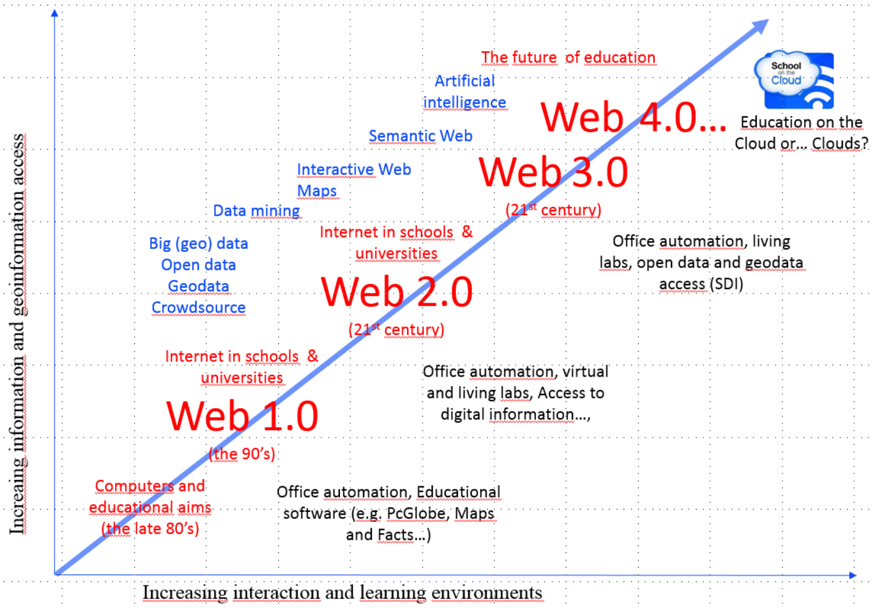

Figure 1. The future of geography education own draft

As a consequence, the two main competencies in geography learning: spatial thinking (Zwartjes, Lázaro *et al* 2016) and digital competencies (Lázaro, Izquierdo and González 2016) can be developed making sense of geodata served by SDI. Pokémon GO! is an example of increasing spatial competencies in a fun way using augmented reality linking cities and towns with online Pokémon maps.

The main objective of this article is to make people and geographical educators aware of the utility of SDI for learning aims specially focused on Geography using the enquiry processes (Favier and Van der Schee 2012, Kerski 2011, De Miguel and Buzo 2015). Learning lines (Zwartjes, 2012, 2014) and spatial thinking will benefit from using SDI.

The first part of this article will explain the background of spatial thinking using geographic information from SDI. The literature review will show some learning and teaching initiatives by means of their analysing. Finally, we encourage teachers to try learning a bit more about SDI geodata in order to use quality data to achieve learning results when it comes to spatial and digital competencies.

2. BACKGROUND ON LEARNING PROCESS AND SPATIAL THINKING

Spatial thinking is the ability to deal with a mental model of the Earth and the ability to operate using this model. Spatial thinking integrates orientation, rotation, shapes, lines, space and relationships between spatial entities. Cognitive skills will be enhanced by spatial thinking ability. Essential elements for achieving this ability are software, hardware, geodata -from many sources, although SDI geodata can be very convenient for the reasons explained above- and people, who can share the workflow. Thus, a new paradigm is appearing around the transdisciplinary approach which enhances collaborative and critical learning.

Educational policy analysis derived from the conclusions of the *School on the Cloud* project (Lázaro, De Miguel y Buzo, 2017) explains three ways of learning based on the nature of teaching: instruction, constructivism and integration (Figure 2). It should go further than the critical nature of teaching. There needs to be transdisciplinary learning based on a collaborative and participative learning-centered network, and it should help to link the Cloud and the Earth as a necessary learning ability and result of practicing education. And this result is a very important aim for citizens.

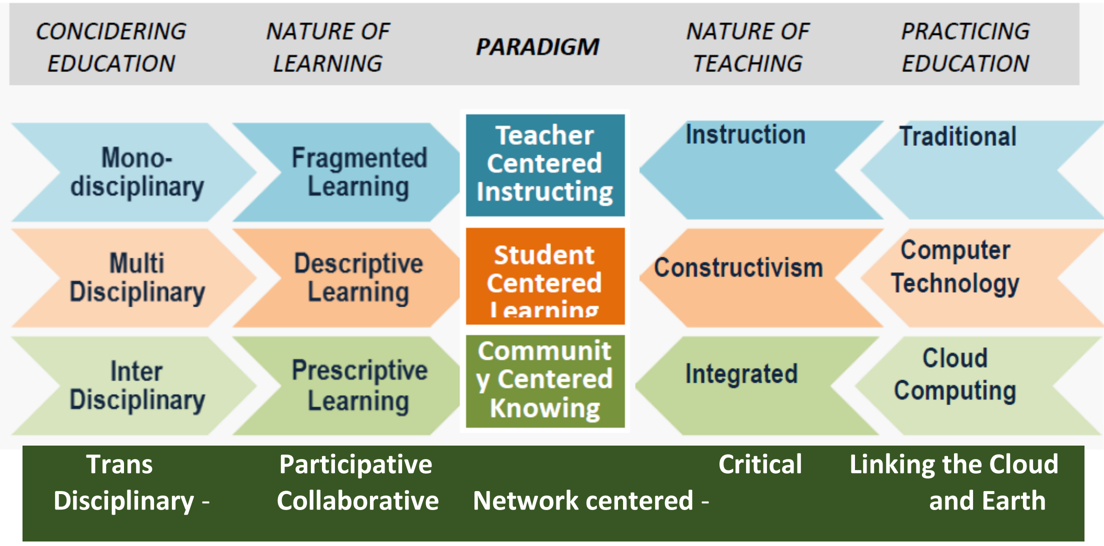

Figure 2. Based on Koutsopoulos and Papoutsis, 2016: 34.

Tools and media for the learning process have integrated new and emerging technologies in recent years. Thus, those of the 21st century are different than those of previous centuries. Then, as for territorial aims, there are many useful geotools, geomedia and new interfaces that allow students to build upon new knowledge in a different way linking the Cloud and Earth in a transdisciplinary frame. Digital and geospatial literacy enhance learning (Baker *et al* 2015) and this is possible to acquire by using geodata from SDI. But... how can we achieve this learning scope?

We can stress some steps, following enquiry processes and learning lines (Buzo 2016, De Miguel in Muñiz, Solem and Boehm 2016 and Zwartjes, Lázaro *et al* 2016) for a new approach to geography, in four different and clear actions:

- Observing (territory): Perceiving landscape and coming up with geographical questions
- Using: acquiring, exploring, organizing, analyzing and interpreting outdoor and other GI access such as SDI. Analyzing layered organization to understand the complexity of the elements involved in the organization of territory (physical, social, economic, political and cultural) resulting from their interaction.
- Structuring: making sense of geographical information. Structuring spatial relations such as identification, comparison, measurement, connections, directions or hierarchy, among others.
- Applying: acting on the correct and wise use of geographical knowledge (e.g. building new interactive maps with student's own data and obtaining new research conclusions).

This helps make it possible to acquire spatial thinking dimensions that the National Research Council (NRC 2006) explained as: spatial concepts, spatial representation and spatial reasoning.

3. SOME TEACHING INITIATIVES USING SDI FOR LEARNING AIMS

The aim of linking the Cloud and Earth has been an important task for many teachers who have been working with spatial apps and viewers given the possibility to integrate geodata from SDI and their own data from outdoor learning. Moreover, this aim facilitates required fieldwork to be updated and controlled feedback on geodata. Geodata can be compared. Laws allow dissemination, usability and reusability of geodata. Fieldwork means great educational opportunities in outdoor learning (Lázaro, De Miguel and Buzo, 2016) which proves very popular among teachers.

Main visualization initiatives, useful for learning about GISciences and linking the Cloud and Earth integrating SDI as a source of geodata are virtual globes. The most popular is Google Earth. It has quite a lot of hardware requirements and not all teachers are aware of the possibilities of connecting to SDI services and earth, sea or sky visualization.

Some WebGIS are very useful for geodata SDI integration with other geographical information sources (e.g. one's own data or ArcGIS Online platform data), creating interactive maps online, for example, ArcGIS Online (AGOL) TM, Esri® platform, CartoDB or MapBOX.

The Spanish National Geographical Institute (IGN) has created and maintained some viewers which integrate geodata from public administrations available for users (e.g. Iberpix, Cartociudad or SignA). The natural node of Spanish SDI is SignA, created so that the Spanish SDI data can be visualized on a GIS. IGN is also collaborating on very useful GPS applications for mobile devices for outdoor learning, such as Mapas de España, that works entirely with the Spanish SDI and its usability allows students to use it.

Google has updated cartography and added very detailed images. Thus, they don't use geodata from different SDI. This is the information available on MyTracks or MyMaps apps and can also be used as GPS.

Thus, we see that it is technically possible to integrate SDI geodata in different visualization apps or viewers for lectures. Using connected SDI platforms is very useful to solve the problem of fragmented geoinformation. Visualizations and simulations are possible on the platforms/viewer apps, thus linking the Cloud and the Earth should be easy and demands are continuously increasing. But only a few teachers are aware of the visualization possibilities for learning aims.

We have been collecting some of these different initiatives on table 1 using SDI for learning aims. The clear advantages of geodata coming from SDI as free and open data uses have not been discovered yet by teachers, then, there is not a frequent use of geodata from SDI as there would be in GISciences lessons. Meanwhile, GIS has indeed been trying to introduce geodata at least in Secondary Schools in many countries for a long time. Some difficulties have been encountered, already shown by Milson, Demirci and Kerski (2012). Perhaps the problem has nothing to do with the availability of tools and geodata on the cloud, but it is related to dealing with the users, teachers and students which must have a usable and accessible tool for an effective and enjoyable learning experience. The possibility of making maps on demand and interacting with them in order to learn geography is essential for our learning aim, but although it is somewhat achievable today, users feedback needs to be updated.

Table 1. Summary of Geography lessons using different viewers as learning environments SDI connected

Year	Application name, type of application, owner and URL	Study case information
2004	SignA (Natural SDI Node, Spanish National Geographical Institute, IGN) (http://signa.ign.es/signa/)	- IGN. (2015). "Navegación en SignA", vídeo disponible en: https://youtu.be/ts2fvahFHFI - Lázaro, M.L. de, Álvarez, J. and González, M.J. (2015). "Aprender geografía de España empleando SignA" en Investigar para innovar en la enseñanza de la Geografía. Universidad de Alicante, pp.25-39.
2005	Google Earth (Virtual Globe, Google) (https://www.google.com/earth)	- Patterson, T.D. (2007). "Google Earth as a (Not Just) Geography Education Tool", Journal of Geography, 106:4, 145-152, DOI: 10.1080/00221340701678032 - De la Calle, M. (2009). "Aplicación de Google Earth en la formación del profesorado de educación infantil para el conocimiento geográfico". In A Inteligência Geográfica na Educação do Século XXI. Lisboa: Associaçao de Professores de Geografia; Instituto de Geografía e Ordenamento do Territorio da Universidade de Lisboa; Grupo de Didáctica de la Geografía de la Asociación de Geógrafos Españoles. - MOOC de Didáctica de la geografía a través de Google Earth (Universidades de Burgos y Alicante). Coordinado por Isabel María Gómez Trigueros, with the collaboration of Juan Ramón Moreno Vera y Delfín Ortega Sánchez.
2007 / 2009	MyMaps, for finding places MyTracks, for building tracks (Google cartography, an app for mobile Android devices)	- Gil, N., Calabuig, S. y Medir, R.M. (2014). "El webmapping como herramienta didáctica para el análisis del paisaje Núria". In Martínez Medina, Ramón y Tonda Monllor, Emilia María (eds). (2014). Nuevas perspectivas conceptuales y metodológicas para la educación geográfica. Grupo de Didáctica de la Geografía (A.G.E.) - Universidad de Córdoba. pp. 205-218.
2007	Internet Applications: Neogreography and Volunteered GIS (Wikimapia, OpenStreetMap, e-Government sites)	- Scull, P., Burnett, A., Dolfi, E., Goldfarb, A. & Baum, P- (2016). "Privacy and Ethics in Undergraduate GIS Curricula". Journal of Geography, 115:1, 24-34, DOI:10.1080/00221341.2015.1017517 (Fundamental changes on the nature of spatial data and maps)
2013	PaikkaOppi (Finnish Web based learning environment using SDI) (http://www.paikkatietoikkuna.fi/web/en)	- Houtsonen, L., Mäki, S., Riihelä, J., Toivonen, T. and Tulivuori, J. (2014). "PaikkaOppi: A Web based learning environment for Finnish Schools". In De Miguel, R. and Donert, K. Innovative Geography Learning in Europe: New Challenges for the 21st Century, pp. 89–100. Newcastle upon Tyne: Cambridge Scholars Publishing. - Riihelä, J. and Makki, S. (2015). "Designing and Implementing an Online GIS Tool for Schools: The Finnish Case of the PaikkaOppi Project". Journal of Geography, 114:1, 15-25.
2014	Iberpix (Spanish IGN viewer) (http://www.ign.es/iberpix2/visor/)	- Delgado Peña, J.J. (2014). "Using the Iberpix geobrowser for teaching geography: perspectives from active learning methodologies". In De Miguel, R. and Donert K. Europe: New Challenges for the 21st Century, pp. 213–228. Newcastle upon Tyne: Cambridge Scholars Publishing.
2015	Mapas de España (Spanish SDI data from the IGN, an app for Android mobile devices)	- Available on Google Play. In the future it will be available for IOS and other operative systems (Windows 10). Used to find a treasure in the Science Week by GEODIDAC research group. - Lázaro, M.L.; De Miguel, R. y Buzo, I. (2016). "Outdoor Learning and Geography on the Cloud: A Challenge for the European "School on the Cloud" Network". The International Journal of Technologies in Learning, 23 (3) pp.1-13. DOI: 10.18848/2327-0144/CGP. © Common Ground Publishing.

Year	Application name, type of application, owner and URL	Study case information
2014	ArcGIS Online Platform (ESRI) (https://www.arcgis.com/)	- Lázaro, M.L.; Izquierdo, S. and González, M.J. (2016). "Geodatos y paisaje: De la nube al aula universitaria" (Geodata and Landscape: From the Cloud to Lectures). Boletín de la Asociación de Geógrafos Españoles, 70, pp. 371-391. DOI: 10.21138/bage.2175. English versión: http://www.age-geografia.es/ojs/index.php/bage/article/viewFile/2245/2132 - Buzo, I. (coord.) (2016). "Las SIGWebs en la Geografía de Secundaria para la mejora del pensamiento espacial". Memoria presentada para la obtención del XXXI Premio "Francisco Giner de los Ríos". Área de Humanidades y Ciencias Sociales otorgado a esta metodología de trabajo (BOE 17 mayo 2016).
2015	Atlas Digital Escolar (WebMap on ArcGIS Online, ESRI) (www.atlasdigitalescolar.es/)	- De Miguel, R., Buzo, I. y Lázaro, M.L. de (2016). "Nuevos retos para la educación geográfica y la investigación docente: el Atlas Digital Escolar". (New challenges for geographical education y researching: The Digital School Atlas), Spanish Contribution to IGU Congress XXXIII (Beijing, 2016). Madrid: Comité Español de la UGI.

4. ANALYSIS

All the selected initiatives are not focused on analogic maps, which are useful for locating places (climate, cities), identify some spatial patterns (physical, human, regional), learn concepts and evaluate distributions, they are focused on digital interactive maps allowing one to acquire inquiry skills and they provide a tool for territorial analysis using the previously named steps: observing, analyzing, structuring and applying. The inquiry process allows a transdisciplinary framework based on participative, critical and collaborative learning (Buzo, 2016).

Most of the projects or examples collected in Table 1 are based on an interactive learning platform connected to SDI and having as main tasks knowledge building and interaction through the geographical information provided. Many geodata sources are integrated by WMS, WMST or WFS OGC services.

Among all attempts using SDI for learning aims selected in Table 1 perhaps one of the most important is the Finnish PaikkaOppi, a learning environment for secondary schools which integrates geographical information from SDI and outdoor learning, thus students are able to link the Cloud and the Earth. The advantage is that by using geodata from SDI it will update automatically on the online maps because the official body responsible for the geodata does so on the databases which are the main source of the application geodatas. Thus, it is possible to use more reliable geographic information.

Although any country can connect by means of their own SDI to different viewer apps, the National Institutions which serve open data are not always specifically built for learning aims focused on geographical education. As for the Spanish case, there are some possibilities not experienced by many teachers, integrating geodata from SDI using IGN viewer apps previously cited (Iberpix, Cartociudad and SignA). None of them are focused on creating teaching and learning materials for a better geospatial and global understanding, such as PaikkaOppi or Atlas Digital Escolar (De Miguel *et al*, 2016° and 2016b). Both have to learn functionalities on the platform as tools. Geoinformation is necessary and it is provided in all instances, partly creating geodata for the platform and partly by SDI.

Then, the traditional work and observation turn into layered collaborative work online using interactive web cartography on the cloud (Figure 3).

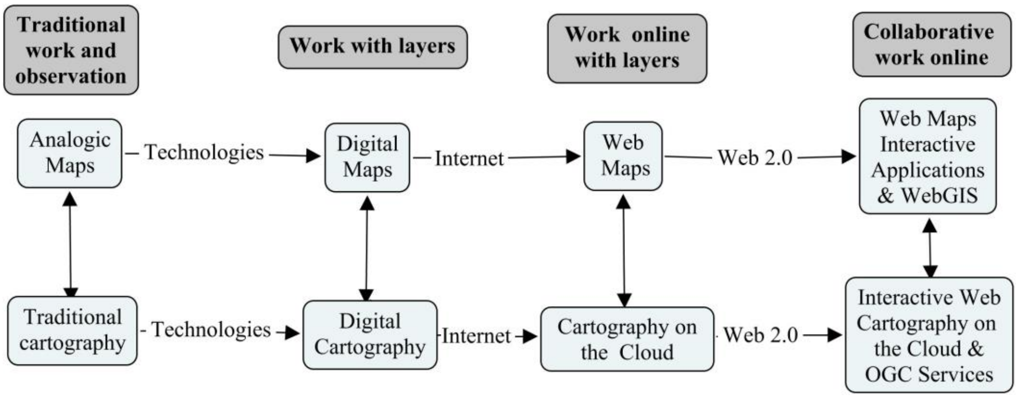

Figure 3. Drawn by M.L.de Lázaro

More experimentation on learning results using SDI on different viewers and learning environments are necessary. But a previous aim is to create the necessary pedagogic steps to use geodata for geographic learning achievement. The PaikkaOppi learning platform is a good example, as it is continuously updating not only new outdoor learning possibilities, but also new learning material (Riihelä and Makki 2015).

It is not easy to enumerate clear learning results as more research on the topic is necessary, but we can point out some of the desirable learning results of using a platform connected to SDI for geographical education aims:

- Encouraging critical geospatial thinking based on SDI geodata and a tool for territorial analysis.
- Understanding geographical concepts from reflecting on map content.
- Leveraging open and quality geodata from SDI portals, maintained by the official bodies of every country.
- Achieving a way of working usefully for lifelong learning anyplace, anytime and anyway.
- Using devices for learning aims, some authors call this smart learning (Lee and Son, 2013)
- Improving inquiry methodology and problem solving learning for a better territorial knowledge.
- Responding to social demand and the labour market as regards geospatial skills.
- Acquiring a basic vocabulary of a 21st century basic scientific paradigm such as digital geohumanities, geostatistic, big geodata, Spatial Data Infrastructure, Global Satellite Navigation System, WebGIS, Web interactive map.

There is widespread belief that beyond conventional tests where the learned memory contents are written, there are new interactive map tools based on SDI geodata and available to anyone with an internet connection that are more useful for acquiring spatial and digital competences. Currently, nearly 95 % of all under 15 year olds in Spain is connected to the Internet according to Spanish Statisticas Institute figures.

5. CONCLUSIONS

The SDI provides accessibility to a wealth of quality information as well as interoperability. Technological progress, which facilitates interoperability and access to more open data, should promote a steady improvement in data quality, especially now that the current legislation promotes dissemination, usability and reusability of geographical data. They are also useful for citizens and e-government aims.

SDI will help to provide the necessary and useful geoinformation for the process and final linking of the Cloud and Earth. But it is also necessary to go even further. Geospatial technologies have come to schools using open data and SDI connections serving what we call geodata. They are georeferenced open data. They improve learning quality leading to the acquisition of spatial and digital competencies. This is a clear opportunity to begin the renewal of teaching methods in geography.

The PaikkaOppi or the Digital Spanish Atlas way of learning is very innovative for curriculum objectives. They allow great interaction among students as well as a process development of spatial learning by discovery using the inquiry method (De Miguel et al, 2016a and 2016b).

There are few researching the learning results resulting from this new way of learning. We can conclude that more research on geographical education using interactive web cartography in the cloud is necessary together with a transdisciplinary learning approach based on collaborative and critical learning.

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