

GI Learner

Creating a learning line on spatial thinking

THE NEED FOR GEOSPATIAL THINKING IN EDUCATION



A manual for implementing geospatial thinking competencies in the curriculum

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1 Why (geo)spatial thinking?

Geo-ICT is part of the digital economy identified by the European Commission as being vital for innovation, growth, jobs and European competitiveness. As a rapidly growing business sector, there is a clear and growing demand for Geo-ICT know-how.

The use of GI tools to support spatial thinking has become integral to everyday life. Through media agencies that use online interactive mapping and near ubiquitously available tools like GPS and car navigation systems, the general public has started to become aware of some of the potential of spatial data.



Space and location make spatial thinking a distinct, basic and essential skill that can and should be learned in school education, alongside other skills like language, mathematics and science.



Its importance is also acknowledged in the "European Reference Framework, Key Competences for Lifelong Learning" document.¹



2 Competence Model for GI Learning

2.1 Spatial thinking

Spatial thinking is a learning outcome mainly based on ways of thinking and reasoning related to pattern recognition, spatial description, visualization, spatial concept use and the spatial use of tools. It concerns the critical application of spatial information to deal with real-world problems.



Michel, E. & Hof, A., 2013, Promoting Spatial Thinking and Learning with Mobile Field Trips and eGeo-Riddles, Jekel, T., Car, A., Strobl, J., Griesebner, G. (eds.), GI_Forum 2013: Creating the GlSociety, 378-387. Berlin, Wichmann Verlag

¹ Document available via via <u>https://publications.europa.eu/en/publication-detail/-/publication/5719a044-b659-46de-b58b-606bc5b084c1/language-en/format-PDF/source-71624064</u> updated version via <u>https://ec.europa.eu/education/initiatives/key-competences-framework-review-2017 en.</u>

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Spatial thinking is traditionally linked to spatial visualization, orientation, spatial perception and mental rotation.



FIGURE 2.1 Spatial visualization items. Left, embedded figures: respondents are asked to find the simple shape shown on the top in the complex shape shown on the bottom. Right, paper folding: respondents are asked to indicate how the paper would look when folded. SOURCE: Linn and Petersen, 1985. Reprinted with permission of the Society for Research in Child Development.

National Research Council, 2006, Learning to think spatially: GIS as a Support System in the K-12 Curriculum, Washington DC, National Academy Press

2.2 Geospatial thinking is even more:

It is not simply about visualization and relationships², it implies <u>manipulation, interpretation</u> and <u>explanation</u> of information³ ... at different <u>geographic scales</u>.

It is not a single ability but comprises of a <u>collection of different</u> <u>skills</u>⁴, it is the ability to study the characteristics and the <u>interconnected processes</u> of <u>nature and human impact</u> in time and at appropriate scale⁵.

The geographic skills provide **necessary tools and techniques to think spatially,** they enable <u>patterns, associations, and spatial order</u> to be observed⁶ and provide students with skills to respond to **crucial scientific and social questions** of the 21st century⁷.



² Wang, H.S., Chen, Y.T. and Lin, C.H., 2014. The learning benefits of using eye trackers to enhance the geospatial abilities of elementary school students. British Journal of Educational Technology, 45(2), pp.340-355.

³ Baker, T.R., Battersby, S., Bednarz, S.W., Bodzin, A.M., Kolvoord, B., Moore, S., Sinton, D. and Uttal, D., 2015. A research agenda for geospatial technologies and learning. Journal of Geography, 114(3), pp.118-130.

⁴ Bednarz, R.S. and Lee, J., 2011. The components of spatial thinking: empirical evidence. Procedia-Social and Behavioral Sciences, 21, pp.103-107.

⁵ Kerski, J.J., 2008. The role of GIS in Digital Earth education. International Journal of Digital Earth, 1(4), pp.326-346.

⁶ Geography Education Standards Project, 2012, Geography for Life – National Geography Standards, Second edition, National Geographic Society, Washington D.C., 272 p.

⁷ Tsou, M.H. and Yanow, K., 2010. Enhancing general education with geographic information science and spatial literacy. URISA Journal, 22(2), 45-54

3 What are learning lines?

A learning line is an educational term for progression in the construction of knowledge and skills throughout the whole curriculum. Learning lines have an increasing level of complexity, starting from easy, more basic skills and knowledge, and developing into difficult, more challenging knowledge and skills.⁸An example:

Level	Learning line
Level 1	Perception – knowledge of facts
Level 2	Analysis – selection of relevant information
Level 3	Structure – look for complex connections
	and relationships
Level 4	Application – thinking problem solving



4 The GI Science Learning lines

Out of the literature review⁹ 10 competencies have emerged. **All ten competencies are required to develop geospatial thinking in GI Science.** For curriculum development purposes, the ten competences have been further developed into a learning line using three levels A, B and C of complexity. Each has been illustrated with an example. The numbering of these 10 competencies does not reflect their level of difficulty nor their level of importance.

In order to create a learning line, the GI Learner competence levels (A, B and C) have been summarized across the K7-K12 curriculum, a model that has been developed through feedback from a number of events across Europe.

1	Critically read, interpret cartographic and other visualisations in different media	interpretation
	A: Be able to read maps and other visualisations	Example: use legend, symbology
	B: Be able to interpret maps and other visualisations	Example: use scale, orientation; understand meaning, spatial pattern and context of a map
	C: Be critically aware of sources of information and their reliability	Example: critically evaluate maps identifying attributes, representations (e.g. inappropriate use of symbology, or stereotyping) and metadata of the maps
2	Be aware of geographic information and its representation through GI and GIS.	learning about
	A: Recognize geographical (location-based) and non-geographical information	Example: describe GPS, GIS, Internet interfaces; be able to identify geo- referenced information
	B: Demonstrate that geographical information can be represented in some ways	Example: employ some different representations of information (maps, charts, tables, satellite images)
	C: Be critically aware that geographic information can be represented in many different ways	Example: be able to evaluate and apply a variety of GI data representations
3	Visually communicate geographic information	produce
	A: Transmit basic geographic information	Example: produce a mental map, be aware of your own position
	B: Communicate with geographic information in suitable forms	Example: basic map production for a target audience - using old and new media, Share results with target group
	C: Be able to use GI to exchange in dialogue with others	Example: discuss outcomes like survey results/maps online or in class, referring to a problem in own environment
4	Describe and use examples of GI applications in daily life and in society	applying
	A: Be aware of GI applications	Example: know about GPS-related/locational (social networking) applications including Google Earth; produce a listing of known GI applications or find them on the internet/cloud
	B: Use some examples of (daily life) GI applications	Example: problem-solving oriented with GI application like navigating; use an app to read the weather, environmental quality, travel planner
	C: Evaluate how and why GI applications are useful for society	Example: assess the functionality and use for society of a GI application (emergency services, police, precision agriculture, environmental planning, civil engineering, transport, research) and present the results

⁸ Zwartjes, L., 2014. The need for a learning line for spatial thinking using GIS in education. Innovative Learning Geography in Europe: New Challenge for the 21st Century, pp.39-62

⁹ The literature review can be downloaded from the website <u>www.gilearner.eu</u> \rightarrow Publications.



5	Use (freely available) GI interfaces	use
	A: Perform simple geographical tasks with the help of a GI interface	Example: Find your house in a digital earth browser; finding a certain location; measuring the distance between two points by different means; use applications for mobile phones (ex. GPS) to locate a place
	B: Use more than one GI interface and its features	Example: collect data and compare to set the best route from school to home and back; get a topographical map for a walk
	C: Effectively solve problems using a wide variety of GI interfaces	Example: Find and use data from various data portals (SDI) to look for the best facilities of a specific region, or for the 'best' place to live using parameters like infrastructure, noise, open spaces,
6	Carry out own (primary) data capture	produce / gathering
	A: Collect simple data	Example: gather data during fieldwork (coordinates, pictures, comments) e.g. sound data to analyse impacts of traffic; map attractive places for children in your city
	B: Compare different qualitative and quantitative data and select an appropriate data gathering approach, tool etc.	Example: when investigating environmental factors choose what data is needed
	C: Solve issues concerning data gathering and select the most suitable alternative approaches to data capture	Example: design a methodology which explains the data collection for land use change, like how to collect data from different sources and classify them appropriately
7	Be able to identify and evaluate (secondary) data	use / evaluate
	A: Locate and obtain data from source maps (different visualisations)	Example: Find and download data on migration and be able to use it
	B: Acknowledge that there is different quality in data, not everything is useful	Example: Identify multiple data sources for example of population or pollution and be able to assess their level (scale), detail, frequency, accuracy and other considerations; analyse different sources and decide which is the most useful
	C: Fully assess value / usefulness / quality of data	Example: Use data on climate change from ESA, IPCC compared to Facebook graphs
8	Examine interrelationships	analyse
	A: Recognise that items may, or may not, be related (connected) in different ways to one another	Example: recognize simple relationships between things, e.g. heat and sunshine, or city size and traffic jams // inverse relationships // some things are not related
	B: Demonstrate interrelationships between a variety of factors	Example: changes in environment, influence, connections and hierarchy of ecosystems
	C: Valuate different relationships and judge causes and effects	Example: Evolution of ecosystems over time is complex and is related to many variables; problem-oriented exploration of interrelationships like: where do my jeans or my mobile phone come from
9	Extract new insight from analysis	produce
	A: Read what the analysis says	Example: understand there are different types of climate
	B: Combine elements from the analysis to make sense of the outcomes	Example: realise that climate is changing
	C: Assess the analysis in depth, create new meaning and make links to the bigger picture	Example: responding and suggest solutions on climate change
10	Reflect and act with knowledge	action: decision making / applying in real world
	A: Recognise the decisions that had to be made	Example: Use geodata to assess which new road system should the local authority build
	B: Judge implications for individuals and society	Example: conclude there will be winners and losers for each road proposal
•	C: Design future actions to stakeholders - including themselves	Example: develop a campaign to persuade decision makers concerning traffic planning; make a blog or a website with collected and visualized data; write a documented article in a magazine using GI information

Level of learning across the secondary school curriculum K7-K12



For each year different exercises have been made - linked to the curriculum and mapped to the competencies and level of difficulty for that each group. All these materials can be found on the website <u>www.gilearner.eu</u> \rightarrow Course.

A teacher can replace an existing lesson topic with one of the lessons provided. If this is done for each year (with at least 2 lessons) the implementation of the learning line will be fruitful.

5 Impact of the approach / student comments¹⁰

5.1 Analysing the tests

The project involved students from five different European countries. There were initially 223 students (2016), and it was fully completed by 120 of them (2018). The project began with more male students, but by the end and for the school exchange there were more females from all countries. There are many reasons that haven't allowed us to have the exact same students from the beginning to the end of the project. Some of those students are no longer at their original school, as the school roll fluid, and there are pupils who transfer in and out.





The assessment of progress from the beginning to the end of the project (summative evaluation) has been carried out through self-evaluation tests, carried out at the beginning and end of the project, which have made it possible to verify what pupils have learned. The students self-evaluated using the Likert scale, which has been used for its simplicity. The tests of self-evaluation seem to have offered a good measure of progression. They have helped to make students become more responsible on tasks. It has been impossible to achieve a perfect synchronization between each of the schools because of the pattern of the school calendars. Agreement has, however, been possible on all the main project areas, and also on other project issues because of the excellent working relationship between all partners involved.

The project has considered three test models, according to the level of difficulty of the learning line involved:

A. For K7, which could be also used in the medium term for K8 students.

- B. For K9, a final test, which will be the same as the initial K10 test. Some questions are the same but with different figures increasing the difficulty.
- C. For K12, the final test of the project was used. Some extra questions were added for specific competencies which would not have appeared at K7

 10 The complete report can be downloaded from the website <u>www.gilearner.eu</u> \rightarrow Publications.

The test consists of several parts, related to the selected learning outcomes /competencies which were developed for use in the project. The tests were completed at the start of the project (0-value) and at the end of every year and based on the comments and opinions of the pupils involved.

In general, improvement has been shown in using geographical information from different sources. The selfevaluation tests show an improvement in the learning of students from all the countries involved in the project (graph below). The use of common questions on the self-evaluation test has also allowed us to compare the improvement shown by students in several tasks which were developed as part of the project.



Regarding reading and interpreting maps and images (Q1) there is a clear improvement from K7 to K 12. K10 has better self-assessment than K12, a result of more cautiousness in the self-evaluation. The learning of the students helps them to know better the limits of their own knowledge.

The next two questions (Q2 & 3) have shown an undoubtedly improvement. Students have learned that geographic information shows not only where things are located, but why, perhaps this is the reason of the slow down on improvement in the question about geographical information.

Regarding gathering, communicating and using quality geographical information (GI), there are two clear levels, the K7-K9 and the K10-K12, with an imperceptible improvement in the task (Q4). Most students feel able to use an app, maps and images and show the results to other people, for example, indicating their way to school or the institute. However, when we add some nuance about the quality of these data, self-assessment is reduced, as in the answers to Q5 (K9 toK12). Students have seen the complexity of the world and the huge quantity of available data (Big geodata), as in the current world, the raw material begins to be the data.

Regarding Q6 there were low scores. In general, students are more confident in the use of the closest data than in the use of data far from their living place. But in Q7 their scores increased. This question is perhaps the most important of all, since it requires all the skills and competences of the designed learning line. The



students provide year by year a greater appreciation of nuances, in relation to the contamination by plastics in the ocean, which was the proposed theme for application, being a major contemporary issue.

To recap: there has been an improvement in general terms, not only by all quantitative data collect during the self-assessment tests, but also, because students were happy following the project.



5.2 Student feedback

Other evaluations were done via feedback on the exercises the pupils made during the project and carried out during the final meeting in Madrid in 2018.

As the students were also the 'guinea pigs' of the project materials they were asked after executing an exercise to give us feedback¹¹ on the exercise: was it clear, did everything work fine, ideas to adjust... but also feedback on what they thought of the methodology and materials used. This is an excerpt of what they wrote:

I think the material we are learning here are very interesting and they can be useful. The methods are great because it is a new form of learning this type of subjects.

I think it was good. The questions were clear, and the subject was also interesting and topical. It's also good that we were given links to the different sites where we could get information from.

It was really interesting to fulfil the different tasks. My English is not the best, but it was really simple to understand.

I think this is a new form of learning about the tsunamis and the risks we have in our planet

I have found the duties very interesting and, besides, have learnt a lot. Positive I found the website with the map, because one could read from this extremely a lot and learn

 $^{11}\,\mathrm{AII}$ feedback documents can be found on

https://drive.google.com/open?id=1qC3PbxUzGZPYGG9Av2boUGL3CMyMaAdE

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The tools themselves as well as the methods were new. I guess I improved my skills according to computer tasks. What was also new is that globalisation has many different categories in which it can be evaluated.

working with the learning materials I have learnt to work with new materials for me, to orientate myself better on a map and to learn more about GIS technology.

It was new to me to test learning materials - a very interesting way of learning!

We díd not only discover Madrid in our final meeting, we also met people from all over Europe. This was a very important experience for me and made me more open towards other people.

The project was important for my personal development - from active learning to getting into contact with other nationalities.

I gained not only GI-skills, but also our thinking (spatial thinking!). I think it is important that other pupils have the opportunity to participate in projects like this!

Travelling to Madrid gave me both the opportunity to meet with students from other EU countries, but to explore the city in a new way using the maps and tools that we were shown.



6 Results, limitations and reflections

One of the main limitations in the GI Learner project has been the continuity of the students during the three years, the project began with more than two hundred students and finished with just over half the original cohort. The students' mobility between schools has also meant that a few of those who completed it were not always the same as those who started it in some cases, having joined part way through the learning line. Also to map the impact over the whole K7-K12 curriculum thus following the same pupil the project should have lasted 6 years.

The conclusions obtained in the whole process are not just geoinformation aspects, but are also technological and pedagogical aspects, and as result of all, the student learned to think critically, or as one student put it:

Over the years we have learned to create and analyze maps with ArcGIS online and improve our spatial thinking. We got the opportunity to learn geographical tools while we connected with other people and share our ideas. We have gained insights into different problems of the world.

Spatial thinking is a skill that is necessary in daily life and this project helped us to gain it.

7 Recommendations



7.1 Recommendations for (national) curricula

- 1. Know the importance of GI Science digital skills and jobs are a growing sector of the economy.
- 2. It should be possible to develop learning lines to integrate GI Science into other curricula.
- 3. Take actions on your own curricula on methodology (e.g. using WebGIS or Story Maps or other geomedia instead of learning a map by memory (by heart).
- 4. Provide more freedom of choice for teachers in order to be able to take advantage of project activities, or even better, project work and collaborative learning should be in the curricula as well as geomedia use (not connected to certain topics, of course), in the best case at a European/international level.
- 5. Be aware on geodata quality to be more critical on information sources.
- 6. Promote self-evaluation skills.

7.2 Recommendations for teachers

- 1. Improve teachers' skills on visualizing geographical information on maps.
- 2. Use GI Science Methodology for selected topics, e.g. as suggested in GI-Learner materials.
- 3. Find topics in your curriculum that fit to GI-Learner contents and take advantage of ready-to use materials.

7.3 Recommendations for school administrations & EU commission

- 1. Provide a suitable framework for all teachers in all European countries to be able to participate in and coordinate European projects! Some countries still do not allow EU funded research work for their teachers.
- 2. As students are less confident on tasks using different sources and have shown problems in understanding the reliability of them, we suggest resources for improving use of 'real life' data in schools should be provided, in a world in which data are the raw material for new business opportunities.

Find out more: visit the website <u>www.gilearner.eu</u>





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