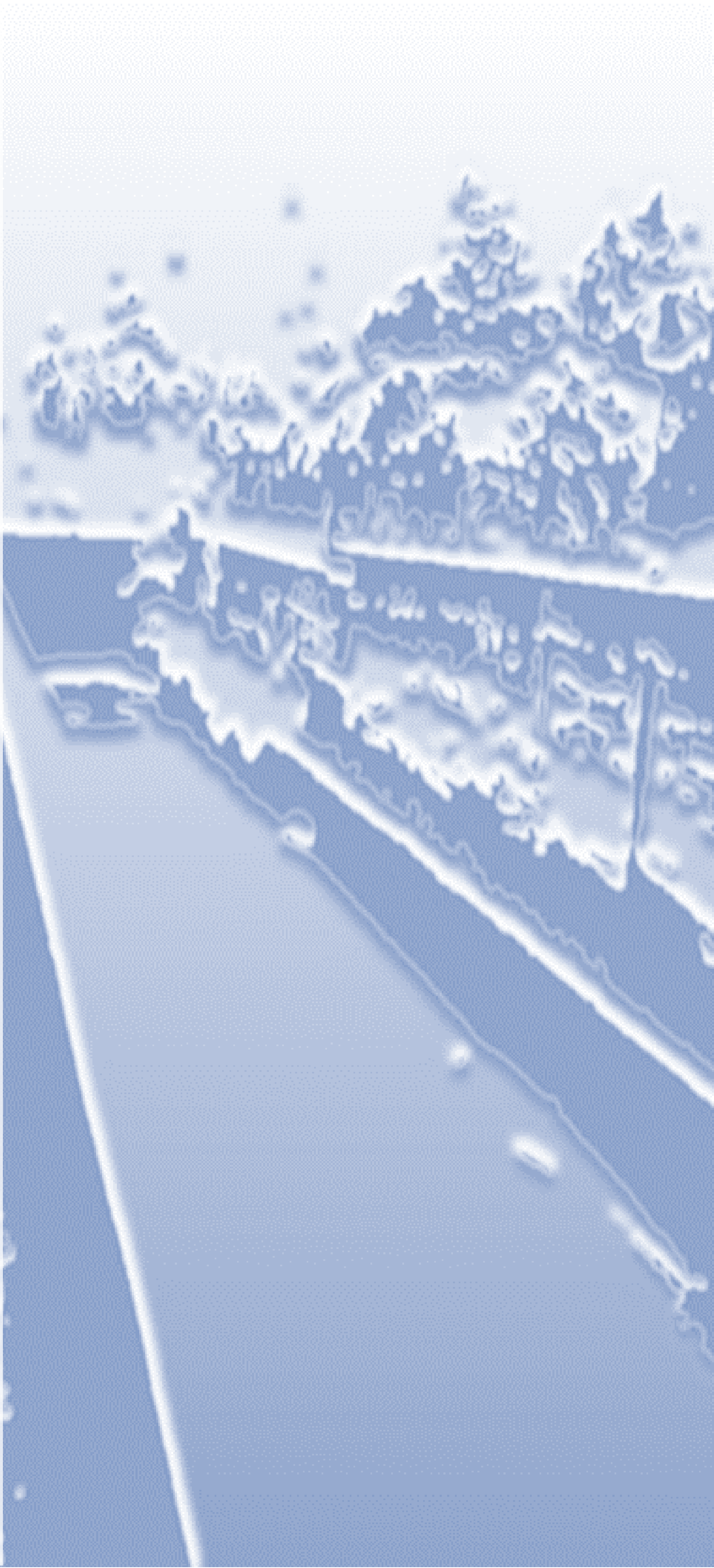
Co-funded by the
Erasmus+ Programme
of the European Union

Project 2017-1-IT02-KA201-036968 – IO2

DAYLIGHTING RIVERS
SCIENCE EDUCATION FOR CIVIC ECOLOGY

LEARNING METHODOLOGY GUIDELINES

APPLICATION OF THE PEDASTE‘S MODEL IN DAYLIGHTING RIVERS



Project partners

Authors: Ugolini Francesca, Cavas Bulent, Di Grazia Serena, Massetti Luciano, Mylonas Demetris, Ozdem Yilmaz Yasemin, Papageorgiou Fouli, Pearlmutter David, Ungaro Fabrizio, Striano Vincenzo

Acknowledgments: DAYLIGHTING RIVERS partnership: Sara Fabbricanti (WREF, Italy), Elvira D'Ambrosio, Mariella Mazza, Maria Teresa Gambino, Teresa Somma, Sabato Iuliano, Roberta Iannone, Maurizio Califano, Giuseppe Gioiella, Raffaele Annarumma, Pantaleona Marrazzo, Vincenza Somma (Sensale High School), Antonis Lazaris, Andrea Theofilou (Rafina Lyceum, Greece), Eleni Kolovou (PRISMA, Greece), Gonzalo Barbera, Carlos Garcia Izquierdo (CEBAS-CSIC, Spain), Marìa Germàn Escudero, María Pilar Parras Masa (IES Miguel Espinosa, Spain).

Editing: Pearlmutter David, Ugolini Francesca

Photo of the front and back cover: Vincenza Somma (Sensale High Schools)

ISBN: 9788895597386

2018. Published by IBIMET-CNR, Firenze, Italy.

Co-funded by the Erasmus+ Programme of the European Union

Project 2017-1-IT02-KA201-036968 – IO2

Summary

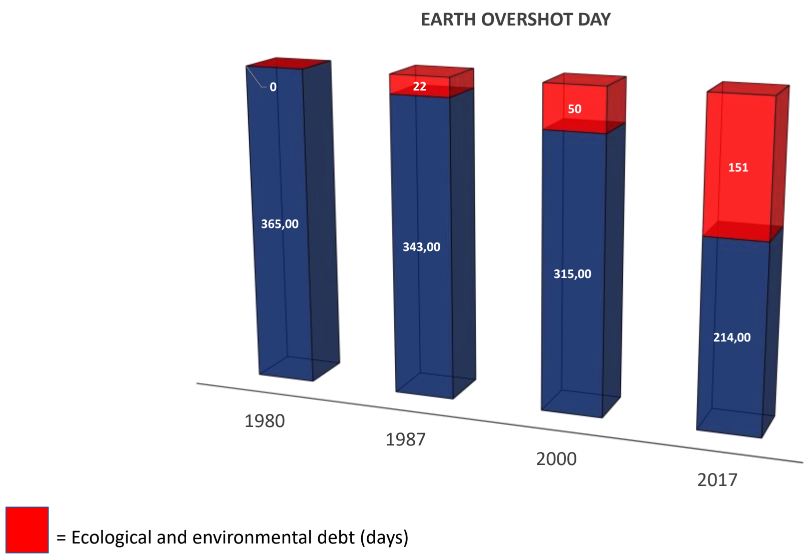
1. Ecological and environmental debt

Vincenzo Striano

In the past decades, the available natural resources have decreased exponentially. We are building up a real, massive ecological debt, which should worry us much more than public debt.

Fresh water used to be seen as an inexhaustible source but, since the mid 80's, its consumption has been faster than its natural cycle.

Each year, the Global Footprint Network determines Earth Overshoot Day: "Earth Overshoot Day marks the date when humanity's annual demand on nature exceeds what Earth can regenerate in that year. In 1987 that day was December 19th. In 2000 it was November 1st. In 2017 it was August 2nd. Humanity is currently using nature 1.7 times faster than ecosystems can regenerate. This is like using 1.7 Earths every year".



The Earth Overshoot day (red number) marks the date when humanity's annual demand on nature exceeds what Earth can regenerate in that year.

However, it is not only a matter of numbers and theory; in fact, among concrete and visible effects is the disappearance of rivers and lakes. The flow of the Nile and the Indus river has visibly decreased. The Yangtze (or "Blue River") and the Huang He (or "Yellow River"), which used to be among the six longest waterways in the world, today hardly reach the sea. The Colorado river and the Rio Grande do not even reach Mexico, ending in the USA. Not to mention thousands of small rivers and water streams dried out in the last years. The situation is not different for lakes (drastic reduction for the Aral, Chad, Owens etc.). There is a generalized tendency to waste water resources, but it's fair to point out that 11% of the world population consumes 88% of fresh water. Intensive agriculture and animal rearing are among the main causes of the disappearance of water resources, together with diets based on food produced using massive quantities of water. Water itself is essential and irreplaceable for all living forms. Farming alone uses on average 70% of the available water resources. But there is more. According to the FAO, about 1/3 of the food that is produced on our planet goes to waste, and every year, the amount of food Italians throw into the garbage would be sufficient to feed 3/4 of the country's population for an entire year. It is a paradox, but in the world the number of deaths caused by malnutrition and those caused by overeating and poor nutrition are more or less equivalent.

It's mainly the rich who waste resources, and it's mainly the poor who see their living condition worsen drastically. According to the "Lancet Countdown on Health and Climate Change" report, drafted by the Health World Organization, a billion of climate refugees are expected within 2050.

There is also a further aspect complicating the scenario. The demographic growth is encouraging a rising concentration of the population in big cities. In 2009, the number of people living in urban areas overtook the number in rural settings. Following this trend, in 2030 about 3/4 of the world population will be living in cities, making accessing water extremely difficult.

All this is not caused by the natural evolution of the planet, but it's the consequence of human behaviors. We must change our lifestyle, and this will not happen thanks to moral calls, but rather by raising public awareness and educating the citizens. Starting from the younger ones.

The path to build a culture that prioritizes the fight to ecological debt is long. Both the macrocosm of major, universal issues and the microcosm of our everyday life can be great starting points to introduce projects on the theme of environmental education, and to understand the strong impact each of us can have. The relationship between man and nature needs to be the main focus. For instance, it is very important to educate students on the anthropic cycle of water. Visiting your local industrial water treatment plant offers an opportunity to learn how complex the process of potabilization and depuration is. You also learn to drink from the tap instead of plastic bottles, taking part in the fight against CO2 pollution. The most effective way for students to learn is through active participation and practical experience. It is interesting to experiment with new teaching methods that involve not only scientific subjects but also arts and humanities. For instance, for one of our projects with schools, in collaboration with the Centre for Contemporary Art Luigi Pecci (Centro per l'Arte Contemporanea Luigi Pecci) based in Prato, we used work from "Studio Orta", a group of fashion designers and performers carrying out multimedia research, who have successfully exhibited their minimal habitats, tackling themes such as water scarcity and climate migration https://www.studio-orta.com/en/artwork/278/OrtaWater-Zille-Fluvial-Intervention-Unit

They displayed bikes or canoes decorated with plastic bottles and equipped with microsystems for mechanical potabilization. All these elements symbolize the experience of migrants who have to flee destruction and waste. Paradoxically, waste becomes an accessory and a floating support. These are complex, rigorous and disturbingly beautiful structures, which are not made to be reassuring, but to raise issues and awareness.

Water Right Foundation deals with environmental education, working with thousands of students and teachers every year. The Erasmus+ Daylighting Rivers project has been a great opportunity to tackle issues that were only addressed within local contexts and deal with them in a European dimension, so as to build international partnerships and relationship networks, and to experiment new methods to introduce young citizens to civic training.

2. Science education to trigger environmental awareness

Francesca Ugolini, David Pearlmutter

One of the greatest educational challenges in this century is to prepare young people with the scientific basis they need to understand rationally environmental issues, in the hope of initiating a societal process of environmentally responsible behaviour. This challenge is especially acute if we consider that Europe faces a shortfall in scientifically knowledgeable people at all levels of society, and a decrease in the numbers interested in pursuing science-related careers (SIS.net 2012, Bøe et al. 2011, National Academy of Sciences 2007, European Commission 2004).

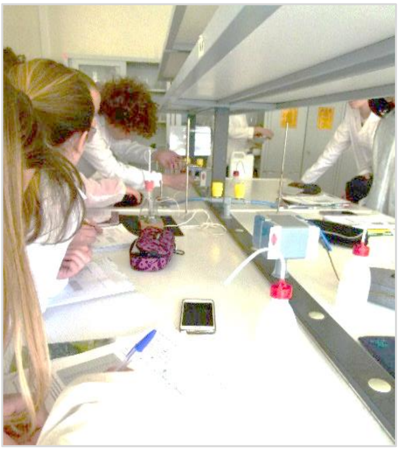
The scarcity of interest among students for science-related pursuits may be due to various sociological and personal factors, among which are the perception of scientific subjects as difficult and not connected to their lives, and the lack of stimulation in conventional approaches to teaching. Relatively few appreciate the extent to which science can enrich their lives, by helping them to understand natural phenomena and interpret changes going on around them, and to find solutions to specific issues. Young people with a basic science background are likely to be more keen about understanding how things work, and more responsible for their own behaviour, because better able to manage risks; thus they should find it easier to access job perspectives.

Moreover, innovation and technological development are constantly entering our lives, indicating how science, technology, engineering, and mathematics (STEM) will impact everyday life, not only in science based careers. The knowledge of science has not only a conceptual importance, but also a social and economic development utility (Haas 2005).

Source: Papageorgiou et al., 2015a.

Another important aspect is the responsible citizenship (SIS.net 2012) that science knowledge may foster. Decision making processes should be informed by knowledge that originates from scientific methods and evidence, and since nowadays there is an increasing attention toward the participatory processes in decision making, citizens should be more aware and confident in understanding complex scientific topics in order to participate with their personal opinion and critical thinking.

Science education starts in the schools – where students can experiment, get their first experience on scientific methods, and be inspired in investigations. Therefore, the use of engaging methods in science teaching, such as Inquiry based learning (IBL), is fundamental. IBL nurtures students to be responsible for their own learning process (Pedaste et al. 2015, Kaltman 2010), enhances their interest in science (Bruder and Prescott 2013), and makes it easier for them to envisage of a science-related future career (Di Fabio et al. 2013).



The assumption is that learning is enhanced when students are asked to build their own solutions, and when they acquire practical experience by doing. However, teachers support the students' thinking by posing questions without pre-judging their ideas or answers, with the goal of sharpening students' curiosity and reasoning skills.

In complex projects like this one, in order to be successful in the acquisition of knowledge and skills (i.e. competence acquisition), the students' interests and prior knowledge should be identified. For this reason, prior to the implementation of the project with the class, students and teachers fill in the survey (IO1) (links available in the Annex). The survey is designed to assess the respondents' basic level of knowledge on the project topics, to define their main interests, and to identify students with specific skills or interests that may play specific roles for the overall success of the project.

A guided learning process in which the teachers act as facilitators, without giving the correct answer but rather supporting the students in achieving their own findings, can produce very positive results during the practical experience (Almuntasheri et al. 2016). Some authors think that an open-inquiry thinking raises their logical thinking skills (Berg et al. 2003; Germann et al. 1996). Therefore, most challenging for teachers is posing these questions, to enahnce students' thinking and stimulate them to investigate and find solutions.

Most often, IBL activities are used for understanding basis concepts in physics, chemistry and biology, for which students can experiment with materials and variables to understand a specific concept in one lesson. In contrast, DAYLIGHTING RIVERS offers thematic modules that address the understanding of more complex systems (e.g. river ecosystem, soil properties, effects and impacts of land use, river etc.). Scientific investigations, including hands-on activities, land use studies etc., will allow students to construct their knowledge and also raise their environmental awareness. Hopefully, this will be achieved by applying structured IBL in order to allow teachers to have a better awareness of the knowledge level of the students before starting, and the cumulative effect on knowledge, skills and environmental awareness that investigations without preconceptions between genders or different ethnicities will bring.

Moreover, outdoor learning in a natural or semi-natural environment is foreseen in strict connection to areas that students know. Outdoor learning enhances not only educational achievement, but also environmental awareness, natural science skills, cooperative behaviour and social cohesion (Ofsted 2008; Natural England 2012) – and this seems especially effective for young people living in urban contexts (Thomas and Thompson 2004; England Marketing 2009). Another important aspect that DAYLIGHTING RIVERS takes into consideration is the use of technologies for studying, investigating and communicating the project results and knowledge acquired during the project.
Nowadays the use of technologies is prominent in everyday life and in work. Learning how to use software and devices is useful for acquiring knowledge and skills based on logical thinking, and for communicating independent findings in a different way. DAYLIGHTING RIVERS offers the opportunity to work with Geographic Information Systems (GIS) and to develop Location Based Games (LBG).

Besides the more engaging teaching methods, DAYLIGHTING RIVERS suggests a partnership in which teachers and students can collaborate with scientists and experts in the professional fields related to the project themes. There is evidence that the presence of scientists in the schools is beneficial not only for the students but also for teachers and scientists themselves (Teachers-Scientists Partnership report, 2010). The TSP project (2008-2010) identified the following benefits: for teachers: *i.* knowledge transfer and understanding of real-world and new scientific discoveries; *ii.* opinion exchange; *iii.* access to resources (papers, presentations, didactic materials, scientific instruments etc.); for scientists: *i.* improving methods of communication with students; *ii.* increasing motivation and enthusiasm in their job; *iii.* understanding better the community's awareness and perceptions of science, scientists and their work. Finally, students: *i.* acquired knowledge and understanding of basic research and applications for problem solving; *ii.* had opportunities to experience real science with real scientists; and *iii.* increased awareness of the types and variety of science and technological careers.

Thus, the main objectives of DAYLIGHTING RIVERS are:

- To increase the awareness, confidence and understanding of phenomena using the scientific method;
- To enhance the educational experience by making science connected to students' local territory;
- To support cross-disciplinary learning between scientific subjects, art and history;
- To develop skills in practical activities and technologies; and
- To develop soft skills like group work and communication.

3. Rivers and land as learning environment

Serena di Grazia

People are strongly tied to the landscape with emotions (Davidson et al., 2009) that increase interest and awareness for landscape studies, regardless of their age. Indeed, rivers have a strong imprint on the territory and historical importance. Understanding the dynamics of interaction between man and nature is useful for developing a critical appreciation of rivers and their many aspects the topics, and this can be accomplished through comparison between the different ways that people have responded to changes in the river system at different times (e.g. in the past and in the present).

The fluvial dynamics as well as the technological, economic and social development of civilization are linked to water courses. The study of the water courses relates to different places, since the entire river basin is regulated by river dynamics. For instance, upstream engineering interventions have an impact on the valley, and dams and hydraulic modifications on the tributaries interfere with the river behaviour. The river's reaction to man's actions offers insights for the analysis of nature and man. Studying the river makes possible new knowledge to raise, like the history of the landscape and the culture of a place.

Topics like the ones listed below deserve more attention by all generations, and at the high school level they can be approached in not only in STEM but also in humanistic subjects. Moreover, inquiry-based learning methodologies allow tackling problems through interactive methods and techniques, to reach a deeper knowledge by description, quantification and calculation of important parameters. This new knowledge, acquired also with a direct contact with the river system, is consistent with the cultural awareness that should be acquired in high schools.

Hydraulic hazard

The presence of a river in a town can cause floods and the presence of covered rivers increases the hydraulic hazard. The water inside covered rivers flows into concrete walls and does not infiltrate as groundwater. In case of a heavy rain, the water that previously flowed into a big river bed goes straight into a narrower underground channel – usually less than twenty meters wide – that is not suitable for extreme amounts and for this reason, it can cause floods in the urbanized area. Every year, floods in urban areas cause massive deaths and damages.

Source: www.noaa.gov

Moreover, with the climate changes recorded during the last decades, the amount and the distribution of rains has changed, and the size of the covered rivers built from the 19th century onwards is no longer adequate.

The perception of the danger is linked to the memory of disasters like floods and to the view of the river which grows rapidly during the rainy season, so that the different levels of risk can be assessed. However, the flooded rivers hide river dynamics – so even if citizens do not have direct perception of danger, the awareness of their presence in the territory increases the perception of danger.

Geomorphology

The territory is shaped by the water courses and the river dynamics give it specific characteristics. Hydrological studies increase awareness of the slow evolution of nature that follows the river course with a force and constancy to which man must relate and adapt.

Climate change and daily behavior

Co-funded by the Erasmus+ Programme of the European Union
Project 2017-1-IT02-KA201-036968 – IO2

The river is an element of the landscape and the changes made by both man and climate change are easily recorded (Palmer, 2008). Drought decreases the water flow and increases the concentration of chemical and bacterial pollutants in water, causes eutrophication etc. On the other hand, a different distribution of rains with extreme events causes hydrogeological disruptions and affects directly the amount of water flowing in water courses. Therefore, studies on rivers, including the water management in urban areas and hidden rivers, can be useful for the assessment of climate change impacts and to understand how the territory can be more resilient.

Management of the water course

Man's intervention on the rivers may influence the territory at river basin scale, affecting also the landscape, and at a wider scale when places in more than one country are involved. The environmental planning involves all inhabitants of a river basin, and therefore any intervention in a territory, rather than being limited to the political boundaries, needs to consider the whole river.

Moreover, urbanization has strongly affected the flow of rivers in cities: river beds in and around towns have been channeled, drained, diverted or culverted, generally to create new infrastructures such as roadways. These "hidden" rivers are part of the natural drainage system, but they are flowing underneath concrete streets.

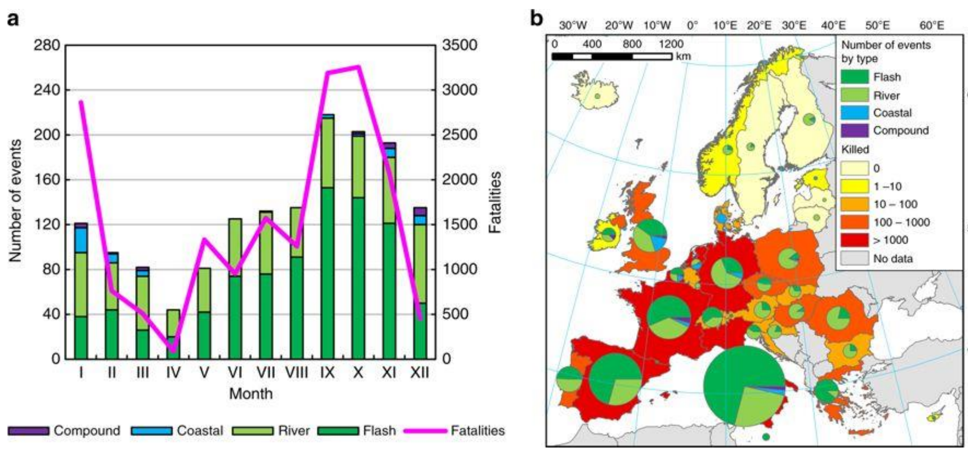
The hidden rivers in the territory

Hidden rivers can be of different types. There are streams that have been covered to build roads, there are sewage systems that collect surface water, and much more. Memory has been lost in many of the rivers. Cartographic research by students can be a way to foster the awareness of young people toward the topic and increase their knowledge of the territory.

Cephissus river view under the highway Athens-Lamia. Source: Wikipedia.

This is also important in connection to climate change, which often causes alternating periods that fluctuate from extremely dry conditions to heavy rains, which suddenly increase the river flow with consequent enormous hydraulic risks.

A recently published study (Paprotny et al. 2018) has analyzed flood events from 1870 up to 2016 in all Europe. The study indicates that there has been an increase in annually inundated area and number of persons affected since 1870, and three Mediterranean countries (Italy, Spain and France) count the highest number of flood events (especially



*Flood occurrences and fatalities. Total number of flood events and fatalities between 1870 and 2016, **a** by month and **b** by country. Source: Paprotny et al. 2018, Nature.*

flash floods) with a higher frequency between September and November – while central and western Europe countries count more river floods concentrated between June and August.

Land planning

Planning is not just about making a physical change, but also transforming people's emotional vision of the landscape (Balmori, 2014). In DAYLIGHTING RIVERS, students' planning is based on the definition of "landscape quality objectives" – that is, a detailed indication of the characteristics that students would like to see recognized in a familiar place. Everything changes in such systems, and the action of man is a dominant vector (Ghersi, 2005).

Based on these issues, DAYLIGHTING RIVERS aims to create a young community that is sensitive to the issue of rivers, and to encourage the acquisition of knowledge, capacity to design basic research studies and practical solutions for saving river ecosystems but also raising awareness of the importance of rivers over a wide range of aspects. Through Learning Units in natural and urban environments and thanks to the contribution of urban/landscape architects and scientists, DAYLIGHTING RIVERS also fosters youngsters' curiosity on the hidden rivers in their town and stimulates design solutions for their daylighting.

To address this general and long-term objective, DAYLIGHTING RIVERS aims to produce leaning modules based on Inquiry Based Learning (IBL) in contexts familiar to the students. In this way, it aims to attract students to science and at the same time, raise their awareness on urban sprawl, land use changes and issues connected to rivers.

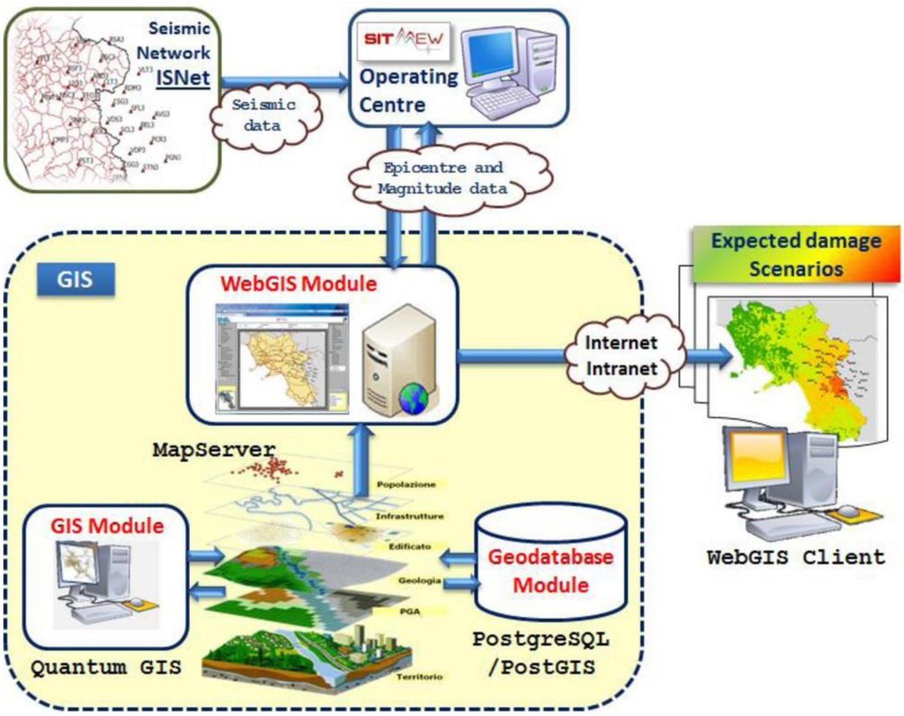
Source: Rafina Lyceum (Greece)
http://zogaris.blogspot.com/2018/10

4. Technologies for land use studies and promotion

4.1 Geographic Information Systems for secondary education

Fabrizio Ungaro

The feature that makes Geographic Information Systems (GIS) particularly interesting to educators is its ability to dynamically represent the world and its issues from a variety of spatial perspectives (Audet and Paris 1997). Fitzpatrick and Maguire (2000) describe GIS as a set of integrated software programs designed to store, retrieve, manipulate, analyze and display geographical information. Currently the availability of web-based GIS (i.e. a module allowing connection with a remote map server) has expanded the classical GIS architecture (i.e. a geodatabase module coupled with a GIS module), combining the advantages of both the Internet and GIS. Web-based GIS allows users not only to add and remove layers of data, but also to collect, process, analyze, interpret, visualize and communicate them, and to achieve client-server interaction (figure below).



Example of a Geographical Information System (GIS) logical architecture: GIS modules are represented inside the dashed box, to differentiate them from other subsystems they connect to via internet (From Pollino et al. 2012).

As a technology, GIS has the capability to expand the topics students can explore virtually to a limitless extent, promoting interdisciplinary learning and changing the way students approach and think about the geographic space and the objects it contains.

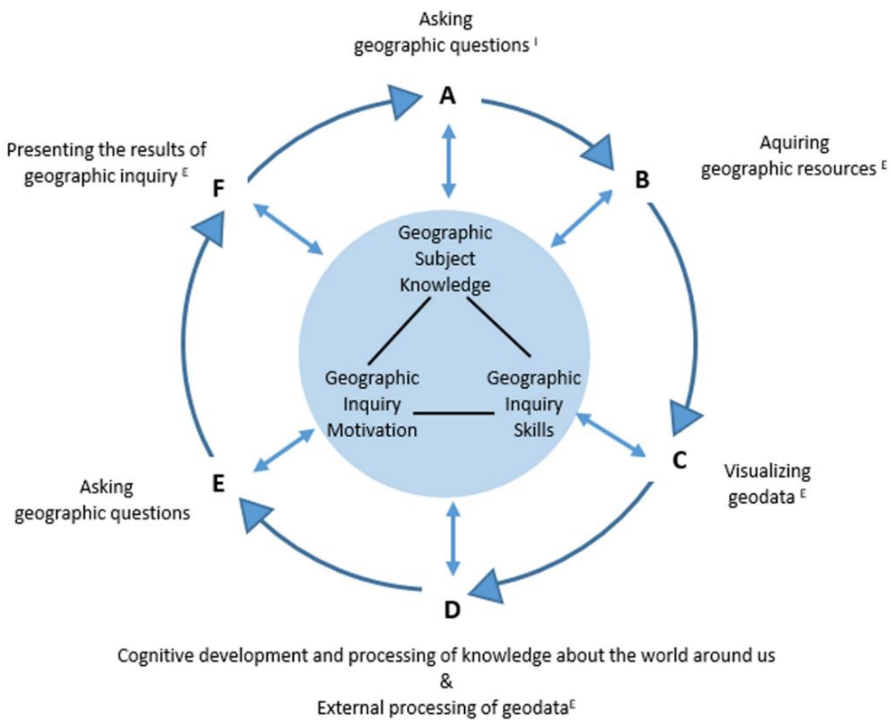
The use of GIS tools fosters the development of geospatial thinking competences, enabling the students to:

1. Develop spatial thinking skills: spatial visualization, spatial orientation, and spatial relations;
2. Critically read and interpret cartographic data and other visualizations of geospatial objects and their relationships in different media;
3. Be aware of geographic information and its representation through GIS;
4. Visually communicate spatial information, developing a language to transmit and exchange basic geographic information with others ;

5. Describe and use examples of GI application in daily life and in society, relating the features of the geographic space and their changes to the past and current dynamics in society;
6. Tackle a number of spatially based problems, address conflicts at different spatial scales from local to global, and explore space-dependent dynamics over time from a multidisciplinary perspective;
7. Use (freely available) GI interfaces and Web-based map services along with other kinds of mobile devices (smartphone, tablets).

Typically when assessing the role of GIS in secondary education, the first distinction is that between teaching and learning *about* GIS, and teaching and learning *with* GIS (Sui 1995). Teaching and learning about GIS focuses on the development of students' knowledge about the system and spatial data and the development of skills in using GIS, while teaching and learning with GIS focuses on the development of students' geographic knowledge and geographic thinking skills. According to Meyer et al. (1999) the focus should be on "using GIS to learn how to do geography", rather than on "learning how to use the technology". Today most educators believe that geography education should put more efforts on teaching and learning with GIS, rather than teaching about GIS (Lemberg & Stoltman 2001; Kerski 2003; Bednarz 2004). Neverthelss, some authors (e.g. Johansson 2006) claim that it is necessary to teach students first about GIS before they can engage in learning with GIS.

Education with GIS can then have different forms: (1) teaching about GIS; (2) teaching with GIS; (3) learning with GIS; and (4) inquiry with GIS. In teaching about GIS, teachers tell students about what GIS is and how GIS works. In teaching with GIS, teachers use GIS with a digiboard or a projector and a screen, in order to illustrate their talks about specific themes, regions, or geographic problems. Educational WebGIS software and Virtual Globes are very suitable for this kind of teacher-centered education. In learning with GIS, students work on short GIS-based lessons in the computer room. This is a more student-centered kind of education. The fourth and final form of education with GIS is inquiry with GIS. In this case, students are challenged to tackle real life problems within a specific spatial domain using GIS to find solutions via iterative cycles of designing, testing, and evaluating, together with teachers.



The processes adopted when answering geographic questions (Favier 2011). Notes: i, internal operations; E, external operations.

This iterative process allows the students to see how GIS integrates as part of the wider cycle of problem – evaluation – solution loop. This is shown very clearly in the above figure (Favier 2011), while the following table summarizes the types of question usually addressed by GIS enquiry.

Step	What to do	Type of Knowledge Construction
Ask a geographical question	Ask question about the world around you	Enquiry
Acquire geographical data	Identify data and information that you need to answer your questions	Inventory
Explore geographical data	Turn the data into maps, tables graphs and look for patterns and relationships	Spatial processing and analysis
Analyze geographical information	Test a hypothesis, carry out map, statistics, written analysis using evidence	Spatial Analysis, Modelling, Decision making

The types of question usually addressed by GIS enquiry.

Numerous studies have documented the increase of GIS tools in secondary education around the world: according to many authors, (Audet and Paris 1997; Bednarz and Ludwig 1997; Johansson 2003; Landenberger et al. 2006; Kerski 2008) GIS supports constructivist teaching and learning strategies such as problem-based and inquiry-based learning. Furthermore, the use of GIS provides opportunities for issue-based, standards-based, and student-centered education in classrooms (Kerski 2003). Nevertheless, recent studies (Kerski et al. 2013) highlight that although the current use of GIS tools in secondary education remains small, there are chances of greater increases in the number of schools, teachers and students using GIS. This is mainly due to the convergence of citizen science, emphasis on spatial thinking, the widespread use of mobile devices, the accessibility to open data and the spreading of Web-based map services (Kerski et al. 2013). According to Demirci et al. (2013) though, the use of GIS as an educational technology is hindered on the one side by technological obstacles (e.g. lack of quality data, GIS software, and internet infrastructure) and on the other by pedagogical difficulties, (e.g. teachers' limited knowledge, skills and experience about GIS). Bednarz (2004) highlighted that Teachers appears to be 'the weakest link' and a serious component limiting diffusion of GIS in secondary education.

In DAYLIGHTING RIVERS teachers are trained in the use of GIS, and GIS based activities with students will be developed during the school year. The focus of training and educational activities will be in the development of spatial thinking skills related to spatial relations, such as those reported in the following table:

Skills for spatial relations	Process used in cognitive mapping and GIS
Recognizing spatial distribution and spatial patterns	Constructing gradients and surfaces
Identifying shapes	Layering
Recalling and representing layouts	Regionalizing
Connecting locations	Decomposing
Associating and correlating spatially distributed phenomena Comprehending and using spatial hierarchies	Aggregating Correlating
Regionalizing	Evaluating regularity or randomness
Comprehending distance decay and nearest neighbor effect in distributions (buffering)	Associating

Way finding in real world frames of reference	Assessing similarity
Imagining maps from verbal descriptions	Forming hierarchies
Sketch mapping	Assessing proximity
Comparing maps	Measuring distance
Overlay and dissolving maps	Measuring directions
	Defining shapes
	Defining patterns
	Determining clusters
	Determining dispersion

Examples of spatial thinking skills.

Students will be asked to identify a problem in their area related to the environmental status of rivers and its implication at ecological, social and economic levels, and to determine a (Web)GIS project topic to help design solutions to these problems.

4.2 Location Based Games in education

Demetris Mylonas and Fouli Papageorgiou

Location based games

Hide and seek, I-Spy, police and thieves, role playing games and capture-the-flag games have all been popular real-life location-based games that have been played in different versions across the globe. These games allow the players to refer to physical objects and location(s) and use their creativity and imagination in order to interact meaningfully with others, as well as with the location(s). In recent years there has been a rise in the number of creative games, interactive narratives and playful activities that are facilitated by mobile devices in such a way that the game activity follows the players' location. A term used to describe such games is "mobile location-based games".

The advent of mobile devices, such as smartphones and tablets, and the fast evolution of game technology, provide great opportunities to develop place-based games that encourage participants to become immersed in playful and meaningful interactions, using different layers of information. These products also offer real opportunity for learning and storytelling about specific locations and routes, introducing the natural or built environment as a participant in the players' interaction and experience.

New media, such as internet-connected mobile devices, enable instant social networking, micro-blogging and video sharing, all of which are being widely used by young people. The nature of these media and the applications used, possibly more than their content, have greatly influenced the way the younger generation and society at large think.

In recent years, advanced mobile devices have made the use of location-based services very convenient. Location-based Services (LBSs) are IT services for providing information that has been created, compiled, selected, or filtered taking into consideration the current location of the users or other persons on mobile devices. With the expansion of location-based services, location-based games have also gained in popularity and become more widespread.

Many applications for modern smartphones incorporate LBSs to provide location-based information. This information can be used to give location-based advice, navigation directions, to track movement and conveniently communicate one's current location to friends, etc. However, it can be also used in the fields of entertainment and learning, to create games that make the position of the player an essential part of the gaming and learning process.

A location-based game (LBG) is defined as a form of play designed to evolve on a device in motion, directly linking the game experience with the location of the player. To create a location-based experience, usually a connection to other devices, e.g. a server or other players, is necessary. However, it is also possible to run single player games, provided that all required information is stored in the player's device. In this case, a connection to other devices is not necessary to run a LBG, as long as the game follows the changing locations of the player's device.

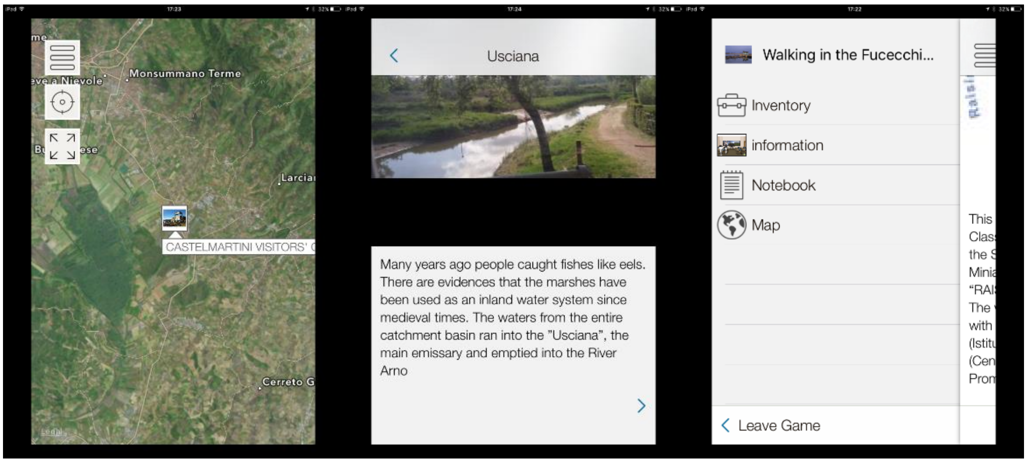
Location Based Games and Learning

Location-based gaming offers great educational possibilities, as it allows educators and facilitators of learning to create constructivist experiences rich in educational content (Papageorgiou et al. 2015a, 2015b). The proliferation of LBGs is due to the widespread use of mobile devices, like smart phones and tablets, with advanced location sensing capabilities, as for example GPS satellite positioning. LBGs can be compelling for young players as well as adults. Video games are, by their very nature, built around interaction and participation. Therefore, they provide a tool for designing curricula that offer more than mere exposure to content, aiming to enrich student experience through engagement and active participation. LBGs offer an additional level of experience: due to the fragile border between games and real world activities, and because of the resulting changes in the game experience, players become involved and associate with the LBG, thus gaining stronger emotions and satisfaction from well-designed LBGs.

Mobile games are particularly suited to creating educational experiences in informal settings. Mobile media and augmented reality can fruitfully combine the advantages of educational video games with place-based learning.

LBGs offer great opportunities to include educational content in the playful experience by using context-aware learning tactics and content generation mechanisms like augmented reality, embedded in a mobile device game or triggered by simple technologies such as QR codes and RFID.

LBGs have another important feature, which makes them valuable for education: they connect places and stories. In a LBG, it is possible to embed extra layers of information and narratives about, for example, the route of an urban river or other locations of environmental importance. By visiting real places, the story becomes a personal experience linking physical objects with learning content. This conveys to the player location-specific knowledge, which is easy to remember, exploiting the connection between the real world and the game.



Game icon on a game-map (left), example of text produced by school kids for a plaque (descriptive form) of a game stop (centre) and game items (right).

Game patterns of LBGs

A useful classification of potential game patterns in LBGs is outlined below:

A. Search-and-Find

In Search-and-Find games the player has to search for a specific geolocation in order to progress in the game. This can be made possible either by suggesting the rough location to be visited using a map in the game interface; or by giving a clue referring to the surroundings e.g. a building, a road feature or a landmark. In such games the player can choose from a range of proposed locations or move towards the single location suggested. Reaching a destination is the main objective behind Search-and Find Games. An example of this game-pattern is Geocaching in which the player moves to a specific location in order to find a hidden physical object, usually a box containing items, then takes one item out of the box and leaves back another item in replacement to the one the player removed. GPS coordinates provide the location for the next "geocache" to be discovered.

B. Follow-the-Path

A Follow-the-Path game is quite similar to a Search-and-Find game with the only difference being that a destination is not the goal, but the sequence of destinations is, and how the player reaches them. Any deviation from the defined route can result in penalties for the player i.e. missing a reward/item/clue. Treasure Hunt is one of the most popular Follow-the-Path games.

C. Chase-and-Catch

In Chase-and-Catch games the players try to find a moving virtual target and claim it: this target can refer to the actual location of another player or the changing locations of a moving virtual object that exists only in the game world. The player is informed about the location of the target via the game interface/ interactive map and the aim of the game is to approach the target quickly to "catch" it. This game-pattern promotes strategy building and physical activity while it can involve a single player or be a multiplayer gameplay. Ingress is an augmented reality territorial version of the Chase-and-Catch game type.

D. Change-of-Distance

Change-of-Distance games use the notions of proximity or remoteness between the player's location and several geolocations within the game; the location itself or the direction of the player's movement are not as important as the movement of the player. The player's goal is to either move towards a location or move further away. An example of this pattern is The Journey: in this game the actual location of the player does not influence the plot, however the movement and the journey of the player are tracked, as well as the locations already visited.

Challenges during Design and Play of LBGs

The very nature of LBGs, being placed in the physical world and using actual locations and places as their backdrop, poses several challenges to both designers and players, such as energy consumption, network coverage or GPS accuracy.

A. Energy Consumption

Using GPS on a mobile device while being connected to a wireless Internet at the same time results to high-energy consumption in most devices. Shorter game sessions and offline intervals or content introduced through QR codes can reduce the energy demands of an LBG.

B. (In)-Accuracy of Positioning Systems

Bad reception of GPS signal or inaccuracy of positioning systems can cause interferences to the player's experience. A strategy that may efficiently address this problem is to increase the range of the geolocated virtual objects so that a non-accurate location would have fewer possibilities to interfere with the gameplay.

C. Inadequate wireless internet reception

Bad signal, although limited nowadays in most EU countries, is not unusual especially in natural areas and in some urban areas as well where 3G or 4G coverage is poor. Testing the signal of different providers on-site with mobile devices before starting the game could prove useful for two reasons: firstly, to define the field of action for the game more precisely; and secondly to choose a provider that offers the best coverage. Portable hotspots can also come in handy for data sharing in such cases.

However, if the group of designers preferred to create an offline game, either because data pack plans can be expensive or because portable hotspots can be slow, an alternative would be to use QR codes. This is a feasible option if the would-be game designers wished to avoid internet coverage restrictions, being willing, at the same time, to settle for text-only game content.

Practical guidance on how to construct an educational game targeting river management

Before starting designing a game one should think about the following questions:

- What is the goal of your game?
- Is there a learning objective? How will you accomplish it?

- How many users and age groups will be involved?
- How long will the game last?
- What game mechanics will you use (points, scoreboards, escalation, narrative goals)
- Will your game require Wi-Fi /3G coverage? Will you use QR codes instead?

In order to better understand the process of game design, a set of issues that are integral to the design process are presented:

Field trips: Throughout the completion of the project you will have the opportunity to visit the river course several times. Make use of those visits and take advantage of the walking tours with experts. People like telling stories while wandering around. Also, keep in mind that this also works vice versa: Game mechanics can encourage wandering around!

Inquiry: Do not hesitate to ask experts and teachers about issues related to river management. Use their expertise in order to accurately identify the issues regarding the river of study, and inquire about past experience, best practices in your country and elsewhere, and proposals for possible intervention. One of the best practices possible is to discuss and inquire about issues in the location where they are most evident.

Choosing game genres and narrative: People sometimes feel demotivated to play alone or get easily bored when playing by themselves. A cooperative or competitive game between teams can provide a solution to this problem. For several locations it might be practical to create games for solo players that enjoy strolling around at their own pace and discover the game. Learn about game types, ways to motivate the player and storytelling by examining video-games, street games, traditional games and interactive storytelling experiences.

Game Mechanics: Simple is beautiful! Don't use too many mechanics and too much text. Try to design an interactive and emotionally moving system/game/story.

Think of all the simple but truly beautiful games you have experienced and you will understand that the fun in the game does not lie in its complexity. Think as a player when you design the game and avoid long texts and excessive information. Concentrate on the issues at hand and the message you want to get through and try to use as few game mechanics as possible. Get inspired by the issues themselves and games that you love and create a new experience for your users.

Storyboarding: *"Plan First, Play Later!"* Paper prototypes are an easy way to get feedback on multiple ideas. A script is always useful when trying to get a story through. Prepare your plot by writing a script and use paper prototypes before digitally designing your game. Share your idea with friends and classmates and check if it makes sense and keeps them interested before implementing your game.

Implementation: Use the help offered by the game-design platform you select (tutorials, forum, help desk etc.). Don't be afraid to ask your teammates and make mistakes. Remember that the platforms are free and might contain bugs. Don't lose heart! Creating a piece of software and debugging it, even in such a simple and user-friendly way, requires patience.

Playtesting: Playtesting is the most important phase of game design. This is where a game shows its potential and ideas are tested in action. Do not be afraid to fail. Fail fast and try to fix the problematic points or redesign. Run the game within its actual context on site if possible. Test out core mechanics before emulating the final game.

Environment: The game you have to design has a significant feature that you cannot ignore: it is set on the course of a river, whether it is flowing through an urban area or a rural area.

This will give you several extra parameters to take into consideration during the design process.

- Respect the features of the urban landscape and the natural landscape where the river is flowing through
- Follow rules and guidance of the riverside area
- Take safety issues into consideration
- Remember to integrate them in your game design

Technology: Such issues are always there – especially when you have to deal with territories away from city centres. You should keep in mind technology inefficiency and breakdowns. Mind potential 3G or 4G coverage issues and be prepared game mechanics interventions to favour the game flow.

Enjoy your game design process! The most important part of the game process is to remember that it is supposed to be fun.

5. The Learning methodology: application of the Pedaste Inquiry Based Learning model

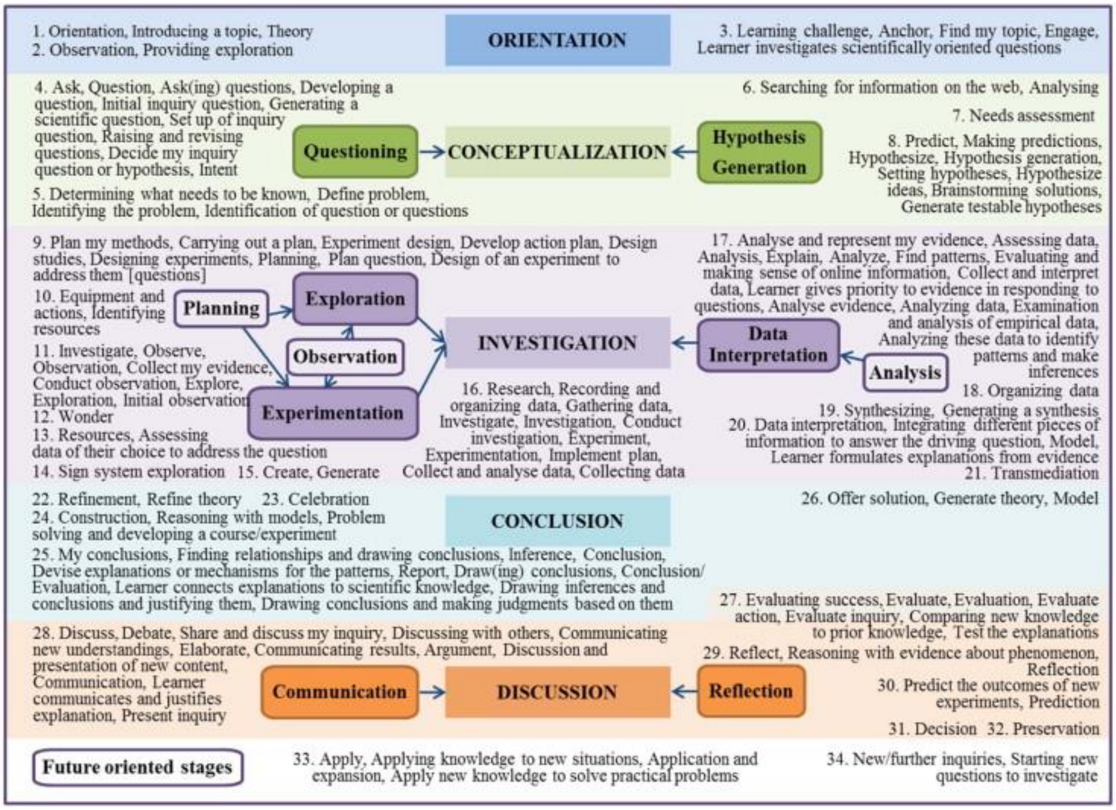
Francesca Ugolini

5.1 What is Inquiry Based Learning (IBL)

In Inquiry Based Learning (IBL) the activity is centred on the student, who should design and build the body of information, solve problems that arise and reflect on the significance of the solutions (Kaltman 2010). This approach allows students to actively acquire new knowledge rather than receiving it passively through routine teaching or standard frontal instruction, whilst the teacher facilitates the learning process. This means that the teacher should support students' engagement in inquiry and engage them in constructing meaningful understandings. The teacher encourages the students to put forward their ideas, explore and debate their point of view while using dialogic, critical and thought-provoking questions and giving students time to think and answer (Chin 2007; Maaß 2011).

IBL has a long history. Dewey in 1933 outlined several important aspects of inquiry-based learning, such as defining a problem, formulating a hypothesis, and conducting tests. Later on, interaction between phases, sequencing of phases, modifications in terminology, and more definitions were introduced. However, contemporary inquiry cycles implicitly reflect aspects of earlier frameworks. White and Frederiksen (1998) proposed an inquiry cycle of five phases: Question, Predict, Experiment, Model, and Apply; more recently, Bybee (2006) published the 5E learning cycle model in which he proposes five inquiry phases: Engagement, Exploration, Explanation, Elaboration, and Evaluation.

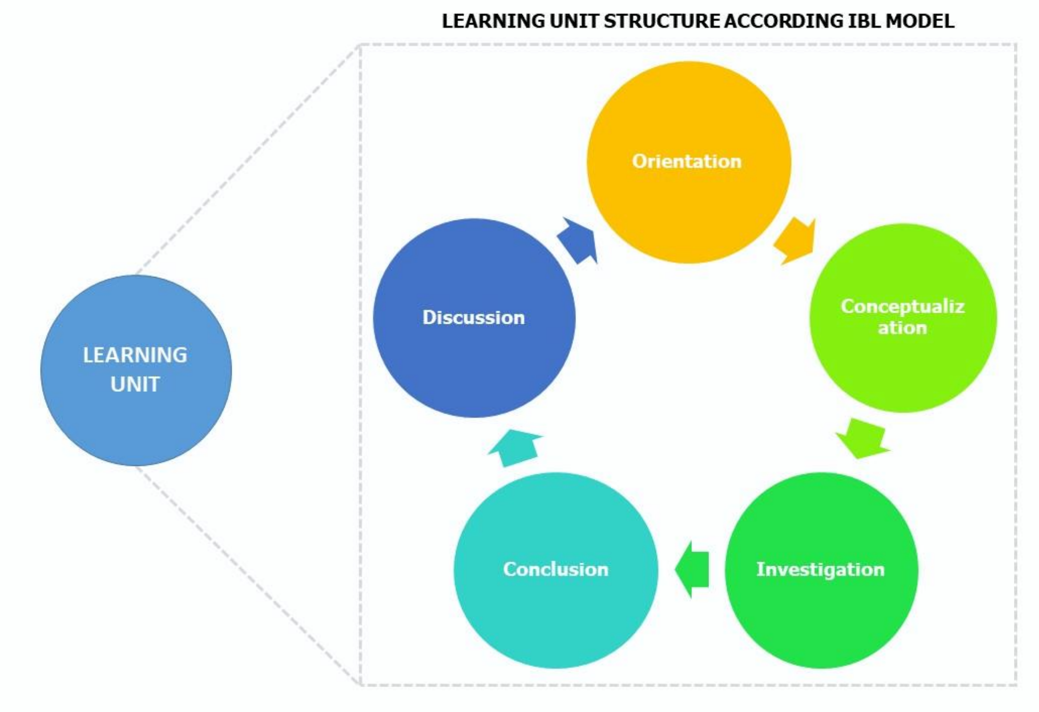
Pedaste et al. (2015) found that different descriptions of inquiry cycles in the research literature use various terminologies to label phases that are very similar. These authors summarize the Inquiry Based Learning phases from different frameworks into 5 phases: Orientation, Conceptualization, Investigation, Conclusion and Discussion (figure below).



Scheme of the five phases of the summarized model described by Pedaste et al. (2015).

5.2 The five phases of Pedaste's model in the Learning Unit

DAYLIGHTING RIVERS has developed Learning Units structured on the Pedaste model. The choice of this model has different motivations: as it is an integration of other models, it is flexible and adaptable to different kinds of Learning Units – such as simple explorative experiments in which different variables are tested, or more complex scientific research studies. Understanding how Pedaste's model works is crucial, and therefore a description of each phase (adapted from Pedaste et al. 2015), together with an example as guidance for the Learning Units, is reported here below. The following figure summarizes the model as a cycle, because it is intended to lead to further investigations.



Phases of the learning Pedastes's model within the Learning Unit.

At the beginning, the teacher introduces the DAYLIGHTING RIVERS project to the class by saying a few words about the innovative and interdisciplinary learning path regarding the local rivers, with reference to a relevant macro-theme of actual interest.

Then, a Learning Unit on a specific topic or river aspect is begun, with its activities following the model of implementation described below. Here we give a general description of each phase (objective and description) with some practical examples of questions and implementation activities.

Orientation

Orientation is the phase in which the interest and curiosity is stimulated in relation to the problem or the topic. The teacher, as facilitator of the learning process, introduces the topic to the class. In some situations or environments, the students define the topic by their curiosity (Scanlon et al. 2011). The variables connected to the topic are identified during this phase and the problem statement is the main outcome.

Objective: Presentation of the topic; identification of the problem and the variables

For instance, the teacher in the classroom shows some pictures of the selected river/area/canal.

Do you know where this picture (river) has been taken?
What are the predominant characteristics?
Why is it like that?
Are there issues connected to this river?

Depending on the answers, the next phase identifies the questions and the hypothesis to investigate. The learning units available are examples of activities that have been performed and implemented by the piloting classes.

Conceptualization

Conceptualization is a process of understanding a concept (or concepts) belonging to the stated problem. It is divided into two sub-phases, *Questioning* and *Hypothesis Generation*. These sub-phases yield similar yet distinguishable outcomes: Questioning arrives at a research question or more open questions about a domain, while Hypothesis Generation arrives at a testable hypothesis. Both of these are based on theoretical justification and contain independent and dependent variables, but have one key difference – the hypothesized direction of the relation between variables given in the hypothesis is not present in the case of a research question (Mäeots et al., 2008). In general, hypothesizing is a formulation of a statement or a set of statements (de Jong, 2006), while questioning is a formulation of investigable questions (White & Frederiksen, 1998). Thus, the outcomes of the Conceptualization phase are research questions or hypotheses to be investigated, or both if first research questions are formulated and then hypotheses are generated based on these.

Objective: Identification of the questions and the hypothesis on specific topic/issues

The students should start reasoning about the aspects that they are curious to investigate, by posing questions and formulating hypotheses.

Why does it look like that?
How does it work?
Where/when may it be different?

"Where does the (river) come from?
Where does it go?
How was it in the past, and how might it be in the future?
What is the colour of the water? Why?
How many animal and plant species live here?
What kind of sediments do we observe?
What differences may we observe compared to other locations?"

The project or the implementation of the investigation should involve more than one school subject. Interdisciplinary activities integrate different approaches, methods of investigations allowing a more comprehensive and coherent learning of complex issues. Knowledge on fauna and flora can be acquired in the biology course, the quality of water and soil can be analysed in the chemistry course, etc. Therefore, a good coordination between different teachers is expected in order to find and gather the needed data and information, as well as to attain a final synthesis that integrates the different perspectives.

Investigation

Pedaste et al. write that investigation is the phase where curiosity is turned into action in order to respond to the stated research questions or hypotheses (Scanlon et al. 2011), and they identify the sub-phases of Exploration, Experimentation, and Data Interpretation.

Objective: planning, experimenting, analysing data and interpreting the results

Let's do it!

1. *Planning the investigation: list of materials and methods*
2. *Performing the investigation (experimenting) by gathering data and making observations*
3. *Interpreting the results*

During the preliminary activity of *Planning*, the students can actually design their investigation, as this is also an important part of the work.

Planning the experimentation:

The teacher and the students plan their investigation, by deciding:

- *Where to conduct the investigation*
- *What to do and how to do it*

For instance, the preliminary work can be based on a map or an aerial photo (e.g. Google Earth), using an interactive whiteboard. Students can identify the route of the (river) digitally or on the map, observing where it starts, where it goes and how the territory is used (i.e. the land cover) along the watercourse. They can measure the length of specific features and identify the location(s) *where* they want to carry out the investigation. They also decide *What* and *How* to carry out the investigation (the school's subjects and topics are indicated in the Learning Units). For any kind of investigation (for instance, analysing the river ecosystem by noting the species of plants, fishes, reptiles, and birds that live next to a water course or taking water samples to test the water quality etc.), they will have to list the materials and methods which they will apply, with the support of teachers and experts. Involving experts from local research centres and universities can be a valuable opportunity to access up-to-date knowledge and to make use of scientific equipment.

The Learning Units developed in DAYLIGHTING RIVERS cover several specific topics dealing with water and land management. They include digital media, bibliographical references and worksheets for teachers and students. Although some of them are developed for specific locations or issues, they serve as examples for implementation in different contexts, adapted by the teacher to the local environment. The Learning Units are available on the DAYLIGHTING RIVERS website http://www.daylightingrivers.com/.

Acquired skills: photo-interpretation, map orientation, use of the scale, designing an investigation.

Performing the investigation

The investigation is the implementation of the previously devised plan, and thus follows from the previous step along the project timeline.

Students should have the possibility to go to the river of interest during a field trip for the collection of data, pictures and information by using specific materials, equipment and worksheets.

They can also work with Geographic Information Systems (GIS) to understand the land use changes, calculate the amount of land take due to urbanization and estimate the amount of rain whose infiltration is prevented.

As an alternative or in support of the investigation, students can perform explorative experiments to understand the variables that influence certain aspects. For instance, if they want to understand the variables influencing the turbidity of the water, they can run experiments testing the effects of soil texture on the deposition of sediments but also the water percolation and runoff in soils of different textures. They can test their predictions and interpret outcomes (de Jong 2006; Lim 2004; White & Frederiksen 2005).

<u>Data analysis and interpretation</u>

The collected data are analysed and interpreted. Data Interpretation should lead to the understanding of the collected data and the synthesis of new knowledge (Bruce & Casey 2012; Justice et al. 2002; Lim 2004; White & Frederiksen 1998; Wilhelm & Walters 2006). The interpretation of the data gives a better idea of the relations between the factors and variables that are involved in the investigation.

Acquired skills: data acquisition with practical work, data elaboration with basic statistics, group work.

Conclusion

The conclusion phase gathers the results and the interpretations from the investigations and experimentations made within different school subjects. The students integrate the knowledge acquired by different explorations and learning activities in order to get an inclusive picture of the findings related to the issue addressed. They can prepare a PowerPoint presentation or a report that explains all the project steps and findings.

Objective: draft conclusions from results and interpretations.

What have we learned?
Did we answer our questions and confirm our hypothesis?

These conclusions are very important for the next steps of the learning process, which will focus on the use of mobile technologies and communication. The results from the investigation are supposed to be georeferenced (located in certain areas): findings and elaborated knowledge will be the basis of a narrative that will be transferred into a platform for the creation of a Location Based Game (LBG). LBGs are versatile tools that can have educational and informative content and be played by anyone equipped with the appropriate App on a mobile device (see Chapter 3.2).

Discussion

The Discussion phase includes the sub-phases of *Reflection* and *Communication*.

Reflection is defined as the process of reflecting on anything in the learner's mind, e.g. on the success of the inquiry process or cycle, while proposing new problems for a new inquiry cycle and suggesting how the inquiry-based learning process could be improved (Lim 2004; White & Frederiksen 1998).

Communication can be seen as an external process where students present and communicate their findings and conclusions to others, receive feedback and comments (Scanlon et al. 2011), and articulate their own understandings (Bruce & Casey 2012).

Objective: reflections on the experience and communication of the findings to others

What did we miss doing in order to gain a full understanding?
How was the experience?
What do we need to investigate further?

Reflection

The conclusions obtained in the Learning Unit(s) can be firstly discussed among peers, either with or without the teacher. They are confronted with the original research questions and/ or hypothesis. The reflection is mainly viewed as an internal process (What did I do? Why did I do so? Did I do it well? What are the other options in a similar situation?).

DAYLIGHTING RIVERS has developed a set of evaluation tools to test the students' attitude – either during the implementation of the Learning Unit, in order to assess their perceived level of challenge, or at the final stage in order to assess their level of satisfaction with the completed activity. The survey tools can also be used to assess the efficacy of the Learning Unit implementation or other aspects of the learning experience (see Chapter 6).

Communication

The students present their results and conclusions to the teacher and participating experts, and may also arrange a more wider presentation for local administrators and the general public in order to reinforce their knowledge and communication skills. The findings and knowledge will also be made accessible in alternative innovative formats such as Location Based Games (LBG), which can be attractive tools for the younger generation. Within the thematic module, the students will collect all necessary information to be re-elaborated in the framework of the game through the storytelling, in an attractive and stimulating narrative that will be transferred to a LBG platform. The games produced will be free and publicly accessible.

At the same time, students will also experiment with different forms of communication in relation to the target:

- Exchange events or visits between students (even between schools from different countries)
- Public events such as open-days, science fairs (at school or in research institutes, or organized by the local municipalities etc.), conferences.
- Skype-call with researchers.
- Location Based Games as educational and tourism tools.

6. Thematic modules and Learning Units

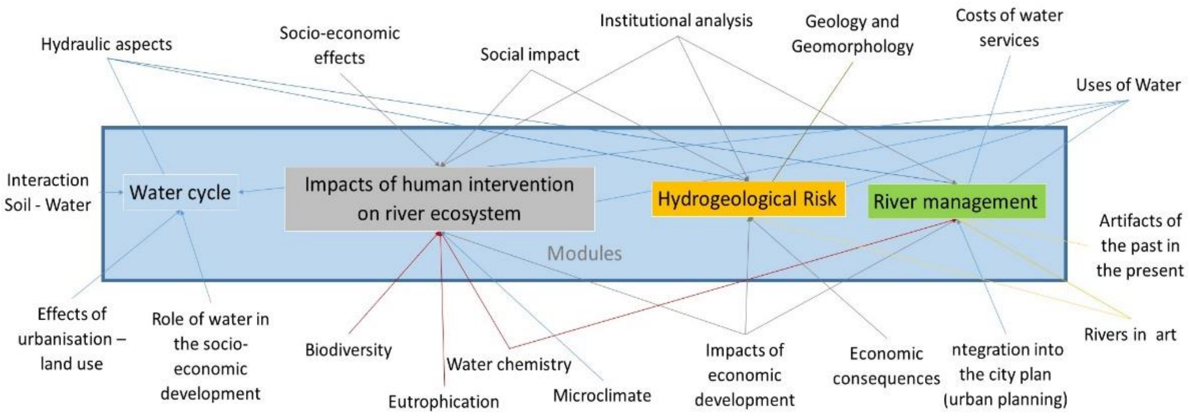
Ugolini Francesca

6.1. Implementation of the modules

DAYLIGHTING RIVERS has developed thematic modules on six environmental themes related to rivers, which are addressed by implementing the associated Learning Units. The thematic modules are as follows:

- Water cycle
- Impacts of human intervention on river ecosystem
- Hydrogeological risk
- River management

Some Learning Units are also related to theme of climate change as the greater frequency of extreme events has an impact on river related aspects.



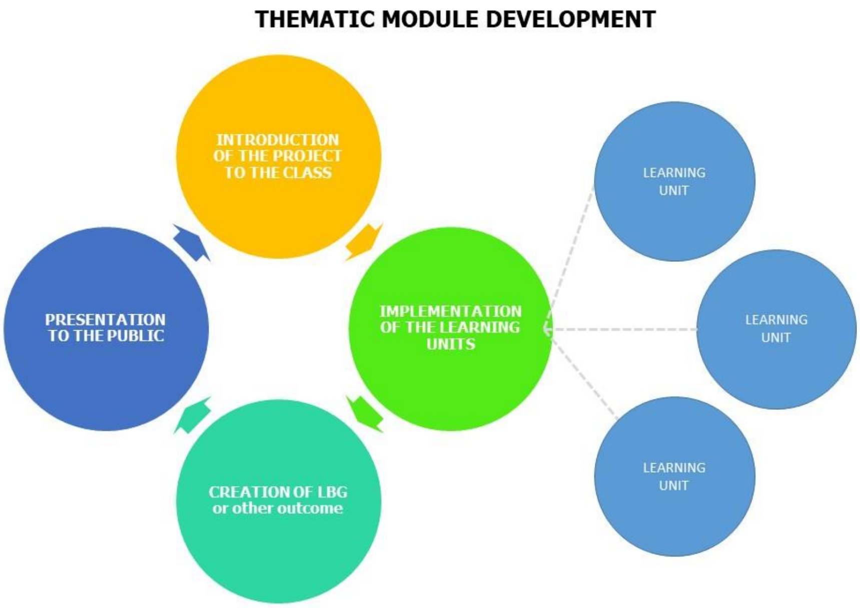
Integration of Learning Units into thematic modules.

The methodology includes two integrated levels of knowledge and competence acquisition. The students are engaged in an environmental theme and perform one or more Learning Units for a better understanding of the issues connected to that theme. Each Learning Unit investigates in scientific way some specific issue or topic related to the local river or water management, by closely following the structured Pedaste's model.

In general, DAYLIGHTING RIVERS adopts a cyclical work flow process made of four steps, that branches off into separate learning units, as summarized in the diagram below.

1) The module starts with an initial step, a brief *introduction* of the project and the selected environmental macro-theme by using multimedia material or brainstorming to raise curiosity and lead students to choose and investigate one or more specific topics. Indeed, the broad theme may include different topics that will be specifically addressed within the Learning Units.
2) Next comes the *implementation of the Learning Unit(s),* following Pedaste's model. Descriptions and worksheets of these Learning Units are available from the project website. The activities of the Learning Unit can be carried out by students in different ways:
   - Students working individually or in groups (different groups may run the same activity, or different activities);

- Activities can be carried out during one or more school subjects;
- Activities include research exercises, experiments, scientific laboratory experiences, and the use of technologies.
- Students may use low cost materials or scientific equipment depending on the availability and the choice of the Learning Unit.



Representation of the cyclical pattern used in the DAYLIGHTING RIVER project.

3) Students will summarize the main findings and will draft conclusions which will be useful for the production of outcomes, such as *design projects for daylighting rivers* or the production of *Location Based Games* (LBG). These outcomes will require the application of specific tools, software and new technologies and knowledge acquired during the implementation of the Learning Units. This means that the exchange of results and findings within the group and between the groups in an interdisciplinary way will be fostered.
4) The *presentation of outcomes* to the public (including stakeholders such as participating experts, local administrators, parents the general public) is an important opportunity for students to reflect on their experiences and find the most appropriate communication tools and methods.

Students will become active in raising environmental and civic awareness. Indeed, each thematic module aims to increase the students' broad knowledge, competence and skills in carrying out an investigation project, but also to enhance their creativity and communication skills.

DAYLIGHTING RIVERS aims to encourage responsible citizenship by working strictly in and for the local territory. For this reason, most learning units include a minimum of one field visit to the river/canal/area in order to carry out practical work and observations that are more in the form of a scientific investigation. Moreover, these units also include support from scientists and other experts – not only to allow students to use professional and scientific methodology, but also to learn more about the professional contexts of these subjects.

Performing more than one unit may take a long time, but it will give students a wider perspective, more competences and greater awareness on the addressed issues. Group work or the involvement of more than one school subject can allow students to perform different Learning Units and encourage them to integrate all their results and knowledge acquired for the final steps of the thematic module.

Some examples of Learning Units are available in Annex II, at the end of this book. This group of units covers diverse topics and approaches that can be adapted to any school context. All of them are structured and give practical guidance according to the chosen IBL model, with instructions on how to perform the activity in the class. Some Learning Units include research activities in relation to the river ecosystem and its threats, and on the effect of the river on its surrounding environment. Other Units regard the relationship between river and society from the historical, cultural and economic points of view, analyzing the evolving population's needs that over the years have influenced urban planning.

The 19 Learning Units developed within the project, can be used in different types and grades of secondary schools, and in school disciplines other than science. Although most of them include outdoors activities, in some Learning Units the activities are performed in the classroom or in laboratory and river observations and surveys can be done by the students out of the school time, in autonomy or with the help of the family. To access and download the Learning Units, visit the website www.daylightingrivers.com.

Co-funded by the Erasmus+ Programme of the European Union
Project 2017-1-IT02-KA201-036968 – IO2

6.2 New Learning Units

Teachers who want to perform class activities on aspects other than the ones developed in the framework of the project are free to develop new Learning Units. This guide gives an indication of the objectives of Pedaste's model steps and the way they should be applied with the class in outdoor or in-classroom activities.

Moreover, an evaluation tool has been developed to assess whether the Learning Unit follows the adopted structure. Below is an evaluation grid that can be used after the development of the Learning Unit.

Questions	**YES**	**NO**	Notes
1) Does the title reflect the content of the Learning Unit?			
2) Are there missing parts to be filled in? If yes, indicate which ones:			
3) Are the references/websites (supplementary material) sufficient for the teacher to implement the Unit?			
4) Is the investigation phase activity appropriate for addressing the formulated hypothesis or question?			
5) Is the conclusion phase activity appropriate for understanding the issue (and likely to lead to the proposal of solutions)?			
6) For which age range of students is the Learning Unit appropriate?			
7) Does the Learning Unit include worksheets for students?			
8) If Yes, are the questions well formulated to be easily understood by the students?			
9) Do you think that the Learning Unit stimulates interest and curiosity among the students?			
10) Is the Learning Unit practical and feasible according the time and the materials indicated?			

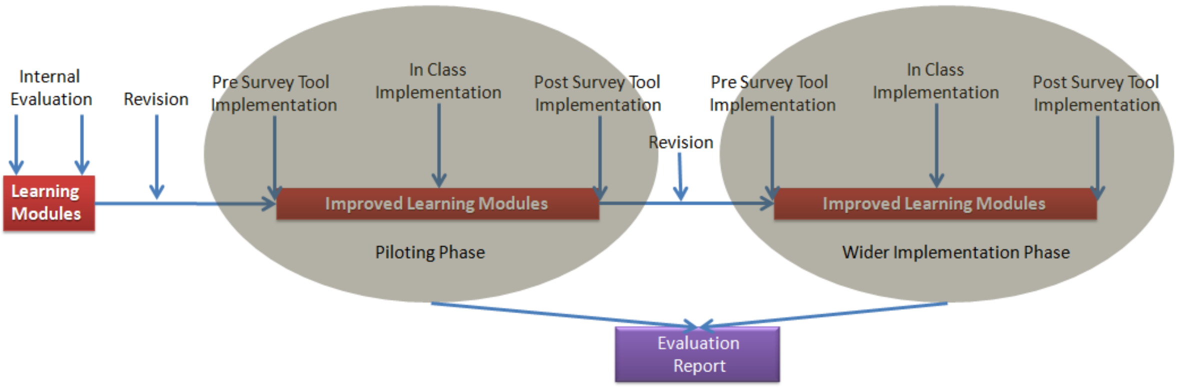
7. Evaluation of the efficacy of the modules and Learning Units

Bulent Cavas

The project includes an evaluation section which aims, by means of developed instruments, to evaluate the success and efficacy of the project, and to collect and analyse evaluation data during piloting and wider implementation phases.

In the evaluation section, detailed analysis is undertaken to check whether the pedagogical framework of the project that is designed and developed within the *Intellectual Outputs* IO2 (IBL Methodology) and IO3 (Development of the Modules) is suitable for engaging youth meaningfully in scientific investigations. A special focus aims to determine whether the appropriate competences (skills and knowledge) needed for land-use and river studies are gained.

In order to evaluate the learning process and materials developed within IO3, a questionnaire, available in English, has been designed and implemented during the project. ICASE is responsible for designing the questionnaire and analysing the collected data from partner countries.



Evaluation process of DAYLIGHTING RIVERS project

The figure above presents the evaluation component within the DAYLIGHTING RIVERS project. The thematic modules and Learning Units developed within O3 are first evaluated by participating teachers and their students (internal evaluation). This is in terms of suitability and feasibility in the school teaching and learning environment. At a more detailed level, teachers and students are asked to indicate the level of challenge for implementation; cost of implementation, level of commitment, effectiveness for transversal learning and type of competences and skills addressed. In order to collect such data from teachers and students, two different interview forms have been developed by ICASE, accessible from the internet (link available in the Annex). After receiving sufficient data from teachers and students, the compiled information is used to revise and improve the thematic modules with additional references and resources.

During the piloting phase, a survey tool (also in the format of an online questionnaire) is used both at the beginning and just after the module implementation in order to determine the impact of the modules and learning units on the:

a) increased acquisition of competences;
b) improved attitude of students towards STEM;
c) decreased career decision-making difficulties;
d) increased career decision-making self-efficacy;

e) increased teaching self-efficacy and effectiveness.

as well as, increased ability in

a) communication,
b) team-working,
c) problem-solving,
d) leadership, and
e) self-confidence.

After the Piloting phase, collected data from teachers and students are evaluated contributing to a better implementation of the project at wider level. This leads to a further revision of the thematic modules and Learning Units based on the data collected.

At the wider implementation phase, a pre-post test of the methodology application will be applied to obtain wider data from participating partner countries.

The Evaluation task of the project also applies the instruments developed within the Intellectual Output IO5 for assessing students' skills and experiences. However, here a scientifically validated approach is used in order to collect evidence that the instruments developed within IO5 really do measure that intended and can be effectively applied both within the project and beyond the scope of the project.

For the development of questionnaires, in some cases existing instruments have been used, for example: instruments for assessing learners' problem solving skills (e.g. Pedaste & Sarapuu 2009), inquiry skills (Mäeots, Pedaste & Sarapuu 2011; Pedaste & Sarapuu 2010), self-regulation (Mäeots, Pedaste & Sarapuu 2011), reflection (Leijen, Valtna, Leijen & Pedaste 2012), and level of scientific and technological literacy (Soobard & Rannikmäe 2011).

The following numbers of teachers and students from participating countries (plus Turkey) were involved to collect data for evaluation purposes:

- Liceo Sensale and Liceo Copernico in Italy: 5 Teachers, 45 Students
- 1st Lyceum and 1st Gymnasium of Rafina in Greece: 5 Teachers, 15 Students
- IES Miguel Espinosa in Spain: 5 Teachers, 50 Students

8. Synergies between the proposed IBL model and citizen-science

Luciano Massetti

The Inquiry Based Learning model proposed by the project has potential synergies with citizen science.

Citizen science is a well diffused type of initiative that aims to bring scientists and citizens together to collaborate on scientific projects, potentially leading to mutual benefits. In the Oxford English Dictionary, citizen science is defined as "Scientific work undertaken by members of the general public, often in collaboration with or under the direction of professional scientists and scientific institutions". Other definitions are available that highlight the role of volunteers and professionals: For instance the Cornell Lab of Ornithology (http://www.birds.cornell.edu/Page.aspx?pid=1478) provides the following definition: "the engagement of volunteers and professionals in collaborative research to generate new scientific knowledge" (Bonney et al. 2015). Different definitions reflect diverse citizen science approaches and the model of engagement they propose. In the figure below, a classification of citizen science projects according to the levels of engagement and participation is presented (Buckingham Shum et al., 2012).

The first level is crowdsourcing (Howe, 2006). In this level, participants can contribute mainly by collecting data and often apps for smartphones are used to facilitate the work of the volunteers. This type of project aims to maximize the number of participants to obtain a large spatial and temporal coverage, but the cognitive engagement of the participants is minimal as are as the potential benefits for them. In this model, participants learn how to collect data following a scientific protocol, or to take measurements with scientific tools and smartphones. Generally, the scope of the research project is far from the daily life issues of the participants; therefore they might not understand the utility of the project and often these projects fail to engage citizens in the long term.

Distributed intelligence is the second level. Here participants are trained to use basic scientific protocols for data collection and can carry out some basic interpretation of the collected data.

The third level, participatory science, fosters and enables more active citizen engagement. They are involved in the problem definition and in selecting data collection together with scientists and experts. They are involved in data collection but need the help of scientists in interpreting results. This level is spreading as community science, and it is especially applied by communities in local environmental issues like the construction of new facilities that have high impact on the surrounding environment. In the last one (collaborative science or extreme citizen science), volunteers and scientists work together and contribute at the same level in any activity of the project. In this way, volunteers can choose their level of engagement in any phase.

1. Crowdsourcing
Citizens act as sensors

2. Distributed intelligence
Citizens are basic interpreters

3. Participatory science
Participation in problem definition and data collection

4. Extreme citizen science
Collaborative approach: problem definition, data collection and analysis

Scheme of the four levels of participation in citizen science (Buckingham Shum et al. 2012)

Crowdsourcing or distributed intelligence approaches are the most common and they are generally implemented by stakeholders from the regional to the international level. These projects target general issues and provide information, guides and tools through a website. The volunteer can subscribe and start to register and upload observations through an app.

The "eBird" project by Cornell Lab of Ornithology (https://ebird.org/home) and "Nature's Calendar" (https://naturescalendar.woodlandtrust.org.uk/) are examples of such projects for recording the timing of plant and animal phenology.

The third and fourth levels of engagement are locally focused and most of them are community based projects in which citizens take the initiative against private interests and their actions provide results that afterwards compel the local authority or the government to take into consideration environmental issues. The famous "bucket brigade" is an example of an action started by an attorney against fumes from a petroleum refinery in California and continues in other similar initiatives like the Louisiana Bucket Brigade (http://www.labucketbrigade.org/), collecting air samples near industrial sites for assessing quality.

All these levels of engagement, but particularly the last two, can be applied or combined to science education in schools and therefore reach two goals: fostering science engagement and proactive citizenship by the students. Indeed, citizen science can be an added value for science education at school. Applying the methods of Inquiry Based Learning, students learn science by posing questions and doing their experiments and drawing conclusions, and at the same time they enter into contact with local environmental issues (like water quality or covered rivers). Moreover, they feel that they can contribute to their community and to local authorities by sharing their results, which are useful and can be merged with other similar data collected in other places.

In this way students can have the double benefit of learning science by doing, and contributing to produce new knowledge or to raise awareness in their community by spreading their results in various media formats like the storytelling and Location Based Games proposed in the project.

The topic of water and its related aspects (water quality, ecosystems, etc.) are very popular among citizen science projects. The Open Air Laboratories (OPAL) network in the UK (https://www.opalexplorenature.org/watersurvey) proposes several activities that aim to survey freshwater ecosystem composition and water quality. Most of these activities are of the first or second type, and users can retrieve a guide and toolkit for collecting data through the OPAL website.

Another example is the Catchment Based Approach (CaBA) that is a community-led approach that engages people and groups from across society to help improve water environments (https://www.catchmentbasedapproach.org/).

The Daylighting Rivers project is focused on covered rivers and any aspect of water in urbanized environments or those under human-induced pressure, and in this respect it has some common points with several citizen science projects that deal with water. Within the project, students can learn by applying the proposed learning model to the nearby river and addressing associated issues.

The students have a certain degree of freedom in choosing the question they want to answer or investigate, and afterwards they measure, collect, and analyse data and present and discuss results. Clearly, there are constraints in implementing each step depending on how the activity is integrated in the school curricula, and on the self-confidence of the teacher in managing such a process, especially the conceptualization phase. In any case this model can be seen as a form of citizen science applying the participatory science approach, and in particular cases even the extreme citizen science approach, since students learn also by producing new knowledge on issues that they feel relevant for themselves and their community. Therefore, the model can be a template for other projects in which students act as citizen scientists during their school formation, and can integrate or compare information from different regions and nations, thus creating a network of distributed knowledge about rivers.

9. Annex 1 - Evaluation tools

There are specific questionnaires for teachers and students. All of them are in English and available also from the website www.daylightingrivers.com. Contact daylightingrivers@gmail.com to receive the data of your surveys.

The questionnaires should be administrated before and after the project implementation in order to assess a change in the subject.

Questionnaire for the evaluation of competences and interests (IO1)

For students:
https://drive.google.com/open?id=1bgmb-1aO3ShGQ7GCwUnhF_zFmnDkt3hv1GDCb5I_soA
For teachers:
https://drive.google.com/open?id=11K48o8pBcVYKWSn_N4rOBcC8no_VXU1HGIiXU2MFuW8

Questionnaire for the students' evaluation of the efficacy on attitude toward STEM

https://docs.google.com/forms/d/e/1FAIpQLSdaAlJtkNCbsCvtpvRnb-JJ-J8klMSV6e1XiAil5rDykgHUgQ/viewform

Questionnaire for the students' evaluation of career decision making (IO5)

https://docs.google.com/forms/d/e/1FAIpQLSdxXKDh9tR5FhBvhwvzApCPymq1CeBkTKEZ3nGU6pwikJT40A/viewform

Questionnaire for the teachers' evaluation of the teaching efficacy

https://docs.google.com/forms/d/e/1FAIpQLSeq-OlJcqVzRkEX1sKP-KwbJHFzo2fJi8LlVsxo5bdQD6S0sw/viewform

Questionnaire for the teachers' evaluation of the teaching effectiveness

https://docs.google.com/forms/d/e/1FAIpQLScTM4W4tyhpWTAfptunSbv4SQBW59WEVEQZ42JT4agRhdKpqw/viewform

Questionnaire for the evaluation of the feasibility of a Learning Unit (optional):

For teachers: https://goo.gl/forms/6mSs7pByhbMI5t7q1
For students: https://goo.gl/forms/K3nvJKupO42KnFdC3

10. Annex 2 – Examples of learning units

Some of these Learning Units have been developed in specific contexts, so consider them as examples that should be adapted to your local territory by searching local historical sources of information and contacting local experts.

The river and the geology

Module theme: Hydrogeological risk
Total duration: 6 hours
Field work: yes
List of materials:
- PC, beamer (IWB)
- Internet
- Geological map of the area
- Sieves (2 and 0.5 mm)
- Plastic bags
- Shovels
- Smartphones

Worksheets: 1 to be developed by students
Students' age: 16-18
Use of apps/software: Google Earth; Siftr

Brief disciplinary introduction

The main activity of the river is transporting sediments from the highlands to the valley. The size of the elements transported gives indications about the energy of the flowing water. Moreover, the type of sediments gives indications on the geology of the landscape from which the river comes from. Sometimes the stones found along the river banks, are the same used for the construction of monuments and buildings in the town. Walking along the river and observing the sediments can be an important activity for understanding the territory. The river moves the sediment and it generates a landscape in continuous transformation. Time after time the morphology of the riverbed changes and often in a small river these changes can be observed. In this learning unit students will focus on their river by observing its water course on digital images (e.g. Google Earth) and investigating the water flow energy by the observation of the sediments in different locations along it. They will understand how much information can be gained from observing and analyzing the river sediment, and how covering the rivers causes a potential loss of information to the citizens.

Objective of the learning unit

To learn about
- ✓ Geological and geomorphological survey techniques
- ✓ Recognize the stones from the territory

To be able to
- ✓ Acquire skills about how observing the "river-scape" to understand the energy of the river.
- ✓ Work in group
- ✓ Discuss and collaborate in carrying out conclusions

Introduction (orientation)

Time estimated: 10 minutes
Where the activity takes place: in the classroom
Method (how the students have to work): class brainstorming
Instructions for teachers:
Show some photos or videos of the river in your town or area, or in general, of rivers in town or in areas with anthropogenic pressure. Then, ask students:

Do you know if the landscape has been always like this?
What is the main modeling agent in your country?
How familiar are you (students) with activities connected to rivers?

Conceptualization

Time estimated: 30 minutes
Where the activity takes place: in the classroom/lab
Method (how the students have to work): group-work
Instructions for teachers:
Ask students:
What kind of information on the landscape come out from the observation of a watercourse?
Are the stones important elements of the landscape?"
Take some sediments and pebbles to show to the class and focus on those ones the students pay more attention on. To facilitate the discussion, ask students
How would you describe a pebble?
In groups, the students prepare a list of descriptive aspects from observing the sediment or peddles, in schematic form as in the example below:

Size	
Roundness	
Angularity	
Main color	
Presence of visible minerals	
....	

When students are ready, pose some questions, for instance
What do you think is the relationship between the characteristic of the sediments and river energy?
How would you explore this?

Starting from this first in-class experience, students define and prepare own worksheet that will be used to gather the information in an outdoor activity.
The students will use the worksheet in small groups, filling the proper fields according to what they have learned in this session.

Investigation

Time estimated: 5 hours
Where the activity takes place: in the classroom and outdoor

Method (how the students have to work): group-work
Instructions for teacher:
In the classroom, the students are divided in groups.

1) Planning

a) Open the free software *Google Earth, where* it is possible to give an overview about the river course, from the spring, across the mountain, along the valley and across the urban area, until its mouth. It can be useful to look at a geological map of the area and to an atlas of the rocks (or the science schoolbook) to understand what type of rocks you expect to see along the river banks.
b) Students identify the most interesting "river locations" or "stops" to collect samples of sediments along the river banks. If in the area there is a hidden river, students should plan to take samples also after and before the covering of the river.
c) Students plan the activities to run at each stop and list the useful materials, besides taking photos of the place where the samples are collected and of the landscape around. They prepare a worksheet for the characterization of the river and sediments, and list the materials (e.g. shovel, sieves, plastic freezer bags, notebooks and cameras, mobile phones - on this regard they can use app such as Siftr (see www.siftr.org) to collect simultaneously photos and notes).

The different groups and the teacher agree on the final worksheet and locations for the investigation of the river sediments.

2) Performing

Outdoor, at the chosen river location along the river.

a) At each stop, each group of students analyze one square meter of terrain in the river bank and fill in the worksheet that they have prepared for the characterization of the river and sediments. According to the type of sediments, they will perform different activities.

<u>If there are mostly stones, each group:</u>

1) Collect some small stones. It will be important to take a detailed photo of the area to verify that the sample is representative of the sediments in that stop.
2) Analyze the morphology and the nature of the stones with the worksheet.
3) Take a photo of each stone collected and analyzed. The students can bring at school only a few samples, the more interesting and representative.

<u>If there are fine sediments, each group:</u>

1) Take a photo of the square meter of terrain and collect around 500 gr of samples (to help this task it is possible to fill a plastic container of about half a liter capacity).
2) Separate the materials using two sieves for the particle size distribution (gravel/coarse-medium-fine sand/silt-clay) and put them in one plastic bag each.

Don't forget to take one extra sample (not separated nor filtered) to school for repeating the analysis if needed.

"How students can inspect the particle size and texture of the sediments? and therefore understand the transport capacity?"
For the finer sediments, they can use one sieve (2 mm grid size) to separate the gravels from the finer particles (coarse sand). The coarse, medium and fine sand can be in turn sieved with a 0.5 mm grid size to separate from finer particles (silt and clay). The result of sieving will be the texture size composition of the river sediments. It will be enough to weigh the

different bags (one with gravels, one with sands and one with silt and clay). Another method is to shake a jar with sediments and water and let sink the different particles for 48 hours. The stratification can be used to determine the soil texture with the triangle of soil textures.

Conclusion

Time estimated: 10 minutes
Where the activity takes place: in the classroom
Method (how the students have to work): group-work
Instructions for teacher:
Students should make the connection between the particle size classes of the sediments and the energy variation of the river flow along its course.
Looking at the images of the river from Google Earth, students can trace the water course and indicate for each stop the relevant characteristics and reflect about the flow energy on the base of the landscape characteristics and the river sediments.

Discussion

Time estimated: 10 minutes
Where the activity takes place: in the classrooms
Method (how the students have to work): class discussion
Instructions for teacher:
Ask students some questions to reflect about the whole investigation, such as:
How can the information from the observation of the river be useful for the citizens?"
What about the river in your town?

Co-funded by the Erasmus+ Programme of the European Union
Project 2017-1-IT02-KA201-036968 – IO2

River ecosystems: plant biodiversity

Module theme: Impacts of human intervention on river ecosystem
Total duration: 9 hours
Field work: Yes
List of materials:
Materials for collecting plants
Cameras/Smartphones
Vegetation guides
Plastic bags
Meter
Worksheets: 6
Students' age: 15-18
Use of apps/software: Google maps/Siftr

Brief disciplinary introduction

The biodiversity is indispensable to support the correct functioning of the system formed by the living beings with the environment they inhabit. In the ecosystems linked to water the nutrient cycle, the water cycle, the soil genesis and soil retention, the resistance to invasive species, the climate regulation and the pollution are aspects highly influenced by the living beings. To know the number of present species in an area, as well as which species are more abundant is indispensable to understand the functioning of the ecosystems linked to the water currents and to value them.

Keywords: acequia (irrigation channel), azarbe (draining channel), rambla (ephemeral and intermittent stream), biodiversity, vegetation cover, functional group, vertical structure, erosion.

Objective of the learning unit
To learn about:

- Plan and carry out a research project following the steps of the scientific method
- Evaluate the plant diversity on studied ecosystems
- Influence of the presence of open water channels on the plant diversity on the surrounding zones.

To be able to:

- Quantitatively estimate the vegetation biodiversity in natural and agricultural and urbanized areas.

Introduction (orientation)

Time estimated: 25 minutes
Where the activity takes place: in the classroom
Method (how the students have to work): work-groups
Instructions for the teacher:
Collect some pictures, photographs of a specific type of water stream, for instance a rambla (ephemeral and intermittent stream).
After an introduction by the teacher, the students meet in groups. They are asked to observe a series of photographs of some characteristic species of the ramblas (ephemeral and intermittent streams), and they are asked to answer the following questions.
Afterwards, the answers will be shared among the groups.
"Do you know some ramblas (ephemeral and intermittent streams)?"
"Could you describe the characteristic landscape of the ramblas?"
"What kind of plants and animals do you think live in the ramblas?"
"Do you know the term biodiversity? What its meaning is?"

Conceptualization

Time estimated: 10 minutes
Where the activity takes place: in the classroom/lab
Method (how the students have to work): work-groups
Instructions for the teacher:
After the orientation about biodiversity in the ecosystems linked to the ramblas, the students have to elaborate one or several hypotheses to be tested along the research.

The hypothesis have to be related to the plant biodiversity and the variables could influence it.

Investigation

Time estimated: 75 minutes in the classroom and one day field trip
Where the activity takes place: in the classroom, field work by the river
Method (how the students have to work): group-work
Instructions for the teacher:
In the classroom, the students are divided in groups for starting *"Studying the plant biodiversity on ramblas (ephemeral and intermittent streams) and acequias and azarbes (irrigation and draining channels)".*

1. Planning

Duration: 75 minutes
In Planning, students should arise the following questions:
1. Where will we be studying the plant biodiversity?
With the support with tools as Google Maps or Siftr the students have to locate several points along the rambla or the acequias and azarbes for sampling. Although this is not an essential task, it is adequate to plan the completion of a simple handmade map as well as photographs of the zone. This help us to have a global vision of the study area

2. How do we measure the plant biodiversity?
The students will decide the sampling method to be used to quantitatively measure the plant biodiversity. They can be informed about different methods (use of quadrats, line transects with a rope, etc.) as well as different techniques to random choosing the sampling points.
In any case it will be emphasized the importance of an adequate planning, the rigorous work on the sampling as well as the importance of replication to obtain valid data useful for statistical analyses.

3. How do we estimate the vertical structure of the vegetation?
Besides to estimate the number of different species and their frequency in an area, it is important to classify the sampled species by their functional groups, to see which are the dominant functional groups. (trees, shrubs, chamaephytes, etc.)

4. What materials do we need to measure the biodiversity and to collect plant samples in the field?
The students have to list the necessary material to estimate the plant biodiversity and to collect and to conserve in good conditions the specimens found in the field (pruning shears, field notebook, tables for data collection, newspapers, photographic camera, maps, quadrats, rope, ...)

5. What method will we select to collect and conserve the specimens?
It is convenient to know all the steps to a good sample collection (to collect specimens with leaves, flowers, fruits...; to photograph the specimen and of the environment; as well as prepare a field sheet to annotate date, geographical coordinates and name of the person collecting each specimen).

6. How to identify the plant samples?
As a full taxonomical classification requires a long expertise out of reach for a learning unit it will be proposed the use of a photographical guide of the zone elaborated by a botanist.

7. How to elaborate information sheets about the observed plants?
Students will be supplied with files containing information taxonomy, habitat and characteristics of the species, with a photograph. The information about habitat will include its classification depending of soil humidity (dry, middle, wet, wery wet, saturated).

2. Performing
Duration: one day
Organization: In the field (ramblas), each group (of 5 students) will work in a concrete zone. It is better in spring (March to May) to find most of the species with flowers and/or fruits.
Materials: The materials proposed by the students for the collection and conservation of plant specimens.

3. Data analysis
Duration: two sessions of 55 minutes each one.
Organization: In the classroom and/or home, in groups of 5.
Materials: the material and the data collected on the fieldwork, computers, photographic guide and field sheets.
Once the specimens are identified and after searching information on Internet the students will elaborate information sheets of the most important species found. Students will be reported of adequate internet directions for the task as well as consultation literature.
On the other hand, with the data collected on the field sheets they will proceed to calculate Simpson's biodiversity index.

$$D=\Sigma\ n\ (n-1)N\ (N-1)$$

Where n = number of individuals/cover per species and N = total number of individuals/cover in the community.
The values of D range from 0 to 1, 0 is an infinite biodiversity while 1 is a one species community. As lower is D higher is biodiversity.
After calculating biodiversity per sampling point, the total average and conclusions will be reached in relation with the soil conditions in relation to the water course.

Conclusion

Time estimated: 3 hours
Where the activity takes place: in the classroom
Method (how the students have to work): group-work
Instructions for the teacher:
Part 1. Draft the conclusions of the experimentation
Duration: One session of 55 minutes
Materials: the map of the study area, the sheets elaborated by the different groups, the notes taken on the field and the results obtained by the biodiversity index calculation.
The groups provide their conclusions. They compare the plant biodiversity found in the different points and try to answer the questions asked in the conceptualization phase, testing their hypotheses.
Later students will write a report including:

- The identified species by them on the study area
- The vertical structure of the vegetation (relative abundance of trees, shrubs, subshrubs and herbs)
- The conclusions about the plant biodiversity
- Valuation of the importance of the species appearing in the zone (usefulness, protected species, ...)

The conclusions should determine plant richness and diversity of these ecosystems including the presence of endangered and protected species and the influence of some factors as the distance to the watercourse as well as the presence of pollution point sources on the plant biodiversity. Also, they should include a valuation of the *ramblas* and other water courses as biodiversity refuges and hotspots in their area.

Part 2. Development of the presentation:
Duration: 2 hours
Organization: In the PC room and at home.
Materials: computers with presentations software (Powerpoint; Prezzi)
Each group will prepare a presentation on Power-point or Prezzi explaining steps on the research process and the obtained results.

Discussion and communication

Time estimated: 30 minutes, each group
Where the activity takes place: in the classroom, or in a public event (Multipurpose Classroom, Cultural Week, meeting with parents, etc.)
Method (how the students have to work): group-work or with the whole group
Instructions for the teacher:
Students can prepare their presentation with software for presentations (Power-point; Prezzi). Also the can be prepared posters about the research and information sheets. The students will be available for the rest of the education community for solving questions and to explain concrete aspects of their work.

Annexes are available online.

Co-funded by the Erasmus+ Programme of the European Union
Project 2017-1-IT02-KA201-036968 – IO2

River effects on microclimate

Module theme: Impacts of human intervention on river ecosystem
Total duration: 4 hours
Field work: Yes
List of materials:
Air thermometer (and hygrometer)
Questionnaire
Map of the town
Worksheets: 3
Students' age: 15-18
Use of apps/software: Google map
Worksheets: 6
Students' age: 15-18
Use of apps/software: Google maps/Siftr

Brief disciplinary introduction

Water flowing through urban rivers and streams can moderate the local climate by creating "cool islands" within an otherwise overheated city. The basis for this cooling effect can be understood based on the energy balance between the body of water and the surroundings, which includes energy exchanges by radiation, convection and evaporation. The radiative cycle of a river is dominated by solar absorption during the day and long-wave emission at night –but the river modifies these fluxes in several ways. The albedo of the water surface varies with sun angle more than it does for most other types of ground cover, as the river becomes highly reflective at shallow sun angles (for instance in the early morning and late afternoon) and this large effective albedo limits the rate of heating. In addition, because flowing water is a dynamic rather than a static medium, heat absorbed during the day at one point (such as in the city center) will ultimately be re-radiated during the night at another point downstream (possibly outside the built-up area). If the surface of the river is cooler than the air flowing over it, a sensible cooling effect may be noticeable.

Objective of the learning unit

To learn about:

- Meteorological parameters
- Climate vs. microclimate
- Soil-atmosphere interaction
- Land cover
- Effects of land cover on microclimate
- Thermal comfort
- Urban planning

To be able to:

- Work in groups
- Plan a scientific investigation
- Use a data management software
- Data acquisition
- Use informatics software
- Orienteer by using georeferenced information

Introduction (orientation)

Time estimated: 5 minutes
Where the activity takes place: in the classroom, using PC, beamer and Internet
Method (how the students have to work): class brainstorming
Instructions for the teacher:
Ask students
"Where do you usually go in a hot summer day in town? Why?" or "Where did people use to go before air conditioning? Why?"
Answers might include: swimming pools, river, forest mountain.. why? Because these places are cooler than the town.
Show a video on the urban heat island:
Urban heat Islands https://youtu.be/s_apVv7dbMQ (2:11 min)
Then you can ask students "*what do they think it might reduce the temperature in town".*

Conceptualization

Time estimated: 5 minutes
Where the activity takes place: in the classroom
Method (how the students have to work): group-work, use worksheet 1.
Instructions for the teacher:
In the classroom, the students are divided in 4 groups. They formulate the hypothesis about
"Which types of areas are the hottest in your town? And the coolest ones?"
(They should indicate the totally sealed areas as the hottest, and the green and blue areas as the coolest).
Then, the students map these critical areas in Google Map.

Investigation

Time estimated: 2 hr 30 minutes
Where the activity takes place: in the classroom and outdoor
Method (how the students have to work): group-work, use worksheet 1, 2.
Instructions for the teacher:
In the classroom, the students are divided in 4 groups (2 groups will deal with mapping and 2 groups with the definition of the methodology for investigating the thermal comfort).

1. Planning

Time: 30 minutes
Ask students *"How would you investigate the effect of the river on climate conditions and thermal perceptions?"* (worksheet 1)
Give two groups of students a map of the town.

- Students should select a route on the map where they want to perform the investigation

Give the other two groups the task to decide how to perform the investigation

- Students should come out with an investigation plan (materials, methods) on human thermal perceptions.

Time: 15 minutes

The groups present their plans (methods and routes on the map) and reach an agreement. The teacher shows students the Worksheet 2 (questionnaire for the thermal comfort investigation) to compare it with their plans. They can decide the tools to use.

Expected result:
Students mark a route on a map, like a transect perpendicular to the river and identify 4-5 "Stops" for taking measurements (meteorological parameters) and thermal perception data. The "Stops" should be different in terms of distance from the river, presence vs. no-presence of vegetation, shade vs. sun. Ask students how they would analyze the thermal comfort. They can use their own questionnaire, or compare it with worksheet 2. The questionnaire can be transferred on an online google form and used on site using mobile devices, in order to make easier data digitalization and elaboration.

2. Performing

Students perform a 45 minutes walk along the agreed route.
At each stop, they record environmental variables using a digital air thermometer and hygrometer and fill in the questionnaire (their version or that one in worksheet 2) on thermal comfort and climate perceptions by human body.
If the questionnaire are prepared as online version, students can use their mobile devices to record the data. Each student should answer the questionnaire.

Date: .... **Time:** .... **Age:**		**Gender** • Male • Female
Clothing	• T-shirt • Shirt (Short/ Long/No sleeves) • Sweater (thin/normal/thick) • Shorts, Pants (thin/normal/thick), • Skirt (thin/thick), • Dress (thin/thick) Colour • dark • light	• Jacket (thin/thick) • Coat Colour • dark • light • Shoes (thin/thick soled) • Boots • Socks (long / short) • Sunglasses • Scarf
Type of food / drink taken within 15 minutes prior to the walk **Cold** YES ☐ NO ☐ **Warm** YES ☐ NO ☐		

FIRST STOP – Evaluation of the environmental conditions

Environmental conditions	**1. Indicate how you currently feel**				
Time: Air temperature: Air humidity: Shade/Sun • Big road • Narrow road	Cold	Cool	Neither cold or warm	Warm	Hot
	2. How would you prefer to feel at this moment?				
	Cooler		No change		Warmer
	3. **How do you think that your thermal condition would be improved at this moment?**				

• Park • River bank • With trees • Without trees	In relation to air temperature □ higher □ no change □ lower	In relation to humidity □ higher □ no change □ lower	In relation to wind speed □ higher □ no change □ lower	In relation to irradiance □ higher □ no change □ lower

1. Indicate the most ANNOYING variable in this moment			
Temperature	Humidity	Sun	Lack of sun
Air motion	Lack of wind	None	Other (indicate):
2. Indicate the most PLEASANT variable in this moment			
Temperature	Humidity	Sun	Lack of sun
Air motion	Lack of wind	None	Other (indicate):
3. How do you judge the overall condition?			
Acceptable		Non acceptable	

INTERIM STOP – Evaluation of the environmental conditions

Environmental conditions	**4. Indicate how you currently feel**				
Time: …………………… Air temperature: Air humidity: Shade/Sun • Big road • Narrow road • Park • River bank • With trees • Without trees	Cold	Cool	Neither cold or warm	Warm	Hot
	5. How would you prefer to feel at this moment?				
	Cooler	No change		Warmer	
	6. How do you think that your thermal condition would be improved at this moment?				
	In relation to air temperature □ higher □ no change □ lower	In relation to humidity □ higher □ no change □ lower	In relation to wind speed □ higher □ no change □ lower	In relation to irradiance □ higher □ no change □ lower	
7. Do you feel any difference compared to the previous site?					
Colder	Cooler	No change	Warmer	Hotter	
8. Why? Is there any different element in the space around you?					
9. Indicate the most ANNOYING variable in this moment					
Temperature	Humidity	Sun	Lack of sun		
Air motion	Lack of wind	None	Other (indicate):		
10. Indicate the most PLEASANT variable in this moment					
Temperature	Humidity	Sun	Lack of sun		
Air motion	Lack of wind	None	Other (indicate):		
11. How do you judge the overall condition?					
Acceptable	Non acceptable				

LAST STOP – Evaluation of the environmental conditions

<table>
<tr><th>Environmental conditions</th><th colspan="5">1. Indicate how you currently feel</th></tr>
<tr><td rowspan="5">Time:
……………………

Air temperature:
Air humidity:
Shade/Sun
• Big road
• Narrow road
• Park
• River bank
• With trees
• Without trees</td><td>Cold</td><td>Cool</td><td>Neither cold or warm</td><td>Warm</td><td>Hot</td></tr>
<tr><td colspan="5">2. How would you prefer to feel at this moment?</td></tr>
<tr><td colspan="5">Cooler | No change | Warmer</td></tr>
<tr><td colspan="5">3. How do you think that your thermal condition would be improved at this moment?</td></tr>
<tr><td colspan="5">In relation to air temperature
☐ higher
☐ no change
☐ lower

In relation to humidity
☐ higher
☐ no change
☐ lower

In relation to wind speed
☐ higher
☐ no change
☐ lower

In relation to irradiance
☐ higher
☐ no change
☐ lowerl</td></tr>
</table>

4. Do you feel any difference compared to the previous site?

Colder	Cooler	No change	Warmer	Hotter

5. Why? Is there any different element in the space around you?

6. Indicate the most ANNOYING variable in this moment

Temperature	Humidity	Sun	Lack of sun
Air motion	Lack of wind	None	Other (indicate):

7. Indicate the most PLEASANT variable in this moment

Temperature	Humidity	Sun	Lack of sun
Air motion	Lack of wind	None	Other (indicate):

8. How do you judge the overall condition?

Acceptable	Non acceptable

9. **How many different thermal sensations did you perceive during the walk?**

10. Excluding the POINTS, have you noticed other different conditions along the way? (if so, indicate on the map in which point /i)

☐ No ☐

11. What did you like most along the way?

Shade	Sun	Clouds	Strong wind
Breeze	Lack of wind	Other: ____________	

12. Thermally speaking, indicate the most PLEASANT aspect during the walk

Aspect ________________________ Position along the walk ____________________

13. Thermally speaking, indicate the most ANNOYING aspect during the walk

Aspect ________________________ Position along the walk ____________________

14. Did you take any initiative to increase your sense of well-being during the journey? (ingested liquids/foods, changed clothing….)___________________________________

3. Concluding

Time: 60 minutes

In the computer lab or at home, students report the data of the filled-in questionnaires into an Excel file (template available). They can elaborate the questions in terms of:

- At each stop, characterize the climatic conditions
- At each stop, calculate the frequencies of each scale point regarding thermal comfort
- Make comparisons between stops
- Make comparisons between different nationalities (if any) and genders.

They will answer the questions on worksheet 3.

Which is the hottest stop along the route? What are the characteristics?
Which variable was the most annoying for most respondents by the river?
Which variable was the most pleasant by the river?
Which variable is the most annoying farther from the river for most respondents? What are the characteristics?
Which variable is the most pleasant farther from the river for most respondents? What are the characteristics?
Are there differences between males and females in the thermal perception?
"In urban planning, what kind of areas are important to provide the best thermal comfort?"
Design on the map of your town where you would include green or blue infrastructures for improving the thermal comfort.

Conclusion

Time estimated: 20 minutes
Where the activity takes place: in the classroom
Method (how the students have to work): group-work, use worksheet 3.
Instructions for teacher:

The different groups (or the whole class) report their conclusions from the questions in worksheet 3. They compare their findings with the formulated hypothesis or check if they answered the generated questions in the conceptualization phase.

The conclusions lead to understand the benefits of rivers and streams but also unsealed surfaces for the urban community, in terms of thermal mitigation.

They also help to identify the services for citizens connected to the rivers.

Discussion

Time estimated: 30 minutes
Where the activity takes place: in the classroom
Method (how the students have to work): group work, use worksheet 3.
Instructions for teacher:

This phase aims to transfer students' acquired knowledge in practice.

"In urban planning, what kind of areas are important to provide the best thermal comfort?"
Design on the map of your town where you would include green or blue infrastructures for improving the thermal comfort.

Eutrophication

Module theme: Impacts of human intervention on river ecosystem
Total duration: 6 hours
Field work: Yes
List of materials:
Map of the river
Science lab with equipment for chemical- physical-biological such as beakers, flasks, test tubes, funnel for experiments on water
Chemical reagents
Photometer
Microscope
Worksheets: 3
Students' age: 15-18
Use of apps/software: videos

Brief disciplinary introduction

The word "eutrophication" has Greek roots.
Eutrophication, which comes from the Greek eutrophos, "well-nourished", has become a major environmental problem. Natural eutrophication is a very slow process. Watercourses and bodies of water change very gradually, thus maintaining habitat for various species for long periods. Human activities such as the discharge of waste water, deforestation, wetland drainage, development of arable land and fertilization have accelerated the eutrophication process several times.
Cow manure, agricultural fertilizer, detergents, and human waste are often to blame as well. Nitrates and phosphates, especially from lawn fertilizers, run off the land into rivers and lakes, promoting the growth of algae and other plant life, which take oxygen from the water, causing the death of fish and mollusks. Today, many areas of the oceans worldwide, some more than 20,000 square miles in extent, have become "dead zones", where almost no life of any kind exists.
https://www.merriam-webster.com/dictionary/eutrophication
http://www.upplandsstiftelsen.se/UserFiles/Archive/4947/Factsheets/Factsheet_Effects_of_Eutrophicat ion.pdf

Objective of the learning unit

To learn about:

- Relationship between chemical nutrients (nitrates and phosphates) in water and algal mass
- Organoleptic, physical, chemical and microbiological parameters
- Water properties
- Eutrophication in its many aspects

To be able to:

- Carry out a sampling of river water
- Apply water survey techniques (chemical investigations, microscopy, photometry)

Introduction (orientation)

Time estimated: 10 minutes
Where the activity takes place: in the classroom
Method (how the students have to work): class brainstorming and group-work
Instructions for the teacher:
In order to arise students' curiosity a video and a Power Point presentation are shown to introduce eutrophication.
Link to video: https://www.youtube.com/watch?v=y_8oz_4irQE
Link to PowerPoint video: https://youtu.be/G6qspGgeE8U
Link to PowerPoint: https://1drv.ms/p/s!AqWmU2xlGjjZjHGx5fbQBmFlwRKg
Then there is a brainstorming session to bring out the students' previous knowledge and experiences about this issue. Students are asked to schedule an experiment to be carried out in the science lab that simulates this phenomenon in an aquatic ecosystem (obtained by taking samples of water from the local river Sarno).
Then the students are asked the following questions:
"Why do so many plant organisms grow so strongly in rivers, in the sea, but especially in lakes or ponds?"
"Can river water be used to irrigate fields or you think it may harm crops and plants?"
"What causes the disappearance or the reduction of fish?"

Conceptualization

Time estimated: 20 minutes
Where the activity takes place: in the classroom
Method (how the students have to work): group-work, use worksheet 1.
Instructions for the teacher:
The students are asked to formulate a hypothesis about the causes of eutrophication, the causing mechanism and the effects.
Then, they are given worksheet 1 to discuss the causes of eutrophication, the bio-chemical transformations which occur and what their final effects are.
They are asked the following questions:
"How can water quality be assessed for agricultural and civil uses?"
"Does eutrophication take place through different phases?"

Investigation

Time estimated: 4 hrs
Where the activity takes place: outdoor by the river and in the science lab
Method (how the students have to work): group-work, use worksheet 1, 2.
Instructions for the teacher:

1. **Planning**

Location: in classroom
Ask students
"How and where would you investigate the effects of eutrophication?"

- Students decide where they want to carry out the survey and select different areas of the river Sarno on the map
- Students decide how to conduct the survey (measurements, materials, methods).
- The groups present their survey plan and agree on the most reliable and feasible one.

Time needed: 30 minutes

2. Performing

Phase 1 location: by the river

Materials: Water-testing equipment to collect water samples along the river and to carry out a physical- chemical and biological analysis of the water in the field (e.g. photometer).

The students are given worksheet 2 to fill in: the students walk along the pre-established path and fill in a questionnaire about the environmental conditions (of the river) at sampling points.

Use Worksheets 1 and 2.

Then, in the lab, the students observe and describe the organoleptic characteristics (color, odor, transparency) of the samples of water taken.

Using the microscope, the students observe the water sample identifying the algae and the bacteria present.

Using the pH meter, the students determine the pH of water samples:

Using the photometer and reagents available, the students determine the amount of dissolved O2.

Using the photometer and the reagents available, determine the nitrates and phosphates present in the water samples.

Finally, the students observe the total number of solids present in water samples:

Time needed: 60 minutes

Phase 2 location: in the science lab

Materials:

Worksheet 2 and PC with worksheets (for example: Excel worksheet)

The students systematically report the data of their physical-chemical and biological analysis of the water samples taken from the river Sarno (data processing boards).

Time needed: 3 hours (1hr/day)

Conclusion

Time estimated: 30 minutes

Where the activity takes place: in the classroom

Method (how the students have to work): group-work, use worksheet 3 (Document Survey).

Instructions for the teacher:

The different groups report their conclusions on the activities carried out:

- variations in the physical, chemical and biological characteristics of the water samples analyzed over some days;
- awareness of the problem and the importance of recovering the integrity of ecosystems
- awareness of the degradation of the "Sarno river ecosystem"

Students compare the final results of their survey with the hypotheses formulated in the conceptualization phase (worksheet1 and worksheet 2).

Co-funded by the Erasmus+ Programme of the European Union
Project 2017-1-IT02-KA201-036968 – IO2

After careful discussion and comparison, students report their observations in a final worksheet (worksheet 3) by answering the following questions:
What are the components of an ecosystem?
What are the main fertilizers used in agriculture and what are their characteristics?
What do "photosynthesis and respiration" consist of?
What does this mean and which examples can you give of aerobic and anaerobic microorganisms?
What is the general structure of a water purification plant?
What fertilizers are used in agriculture and what are their characteristics?
What do you plan to do if man continues to pollute water without changing his behavior?
What are the possible solutions to the problem of eutrophication in your opinion?

Discussion

Time estimated: 30 minutes
Where the activity takes place: in the classroom
Method (how the students have to work): group work, use worksheet 3 (Document Survey)
Instructions for the teacher:
The different groups are involved in a discussion about the main causes of eutrophication in their area, the role of water treatment plants and the possible solutions to this threat.

River pollution and economic impact

Module theme: Impacts of human intervention on river ecosystem & River Management
Total duration: 7 hours
Field work: Yes
List of materials:
Map of the town/area of investigation,
Digital camera, a video camera.
Questionnaire on pollution factors and economic activity.
Video
PPT with photos, paintings, cards, maps
PC
Worksheets: 5
Students' age: 16-18
Use of apps/software: Excel or worksheets

Brief disciplinary introduction

The immense impact of environmental pollution on people's daily lives has increased the importance of conducting research that will enable scientists to assess environmental damage in economic terms. Such an assessment will improve the ability of the public to quantitatively grasp the impact of environmental pollution and the effectiveness of existing environmental policies. In recognition of these facts, environmental economists have begun searching for viable methods to estimate economic losses resulting from environmental pollution. The economic impacts of river pollution are an important factor to determine the priorities for investments in pollution reduction projects. By reviewing economic activities such as fishing, tourism, shipping, hydro-power etc. as well as the economic dependence on access to reliable water resources, the value of pollution reduction can be more adequately assessed. With this small research we will try to evaluate the economic impact of river pollution on industry, Farm Yields, Livestock, Fisheries and tourist activities but also in the human health by measuring the economic losses that arise in the local economy.

Keywords: pollution, economy, environmental and economic variables, economic consequences.

Objective of the learning unit
To learn about

- The relationship between pollution and economy.
- The economic impact of river pollution on industry, farm yields, livestock, fisheries and tourist activities
- The economic impact of river pollution on the human health by measuring the economic losses that arise in the local economy.
- The priorities for investments in pollution reduction projects

To be able to:

- Plan an investigation
- Make observation and use Excel or open source worksheet

Introduction (orientation)

Time estimated: 10 minutes

Where the activity takes place: in the classroom, using PC, beamer and Internet

Method (how the students have to work): class brainstorming

Instructions for the teacher:

1. Introduction to the topic

Power Point presentation videos are shown to introduce the topics (pollution, economy, environmental and economic variables, economic consequences).

https://www.youtube.com/watch?v=pjl54VRgjSM

https://www.youtube.com/watch?v=YoJ7BR9xdhU

Then there is a brainstorming session to bring out the students' previous knowledge and experiences about this issue. Students are asked to make a conversation about river pollution and economic consequences. For instance, by asking:

"Have you noticed if there are garbage and other wastes in the river in your area?"

"Do you think they are having financial consequences?

Image source: *https://cbf.typepad.com/chesapeake_bay_foundation/2014/11/a-better-environment-is-a-proven-path-to-a-better-economy.html*

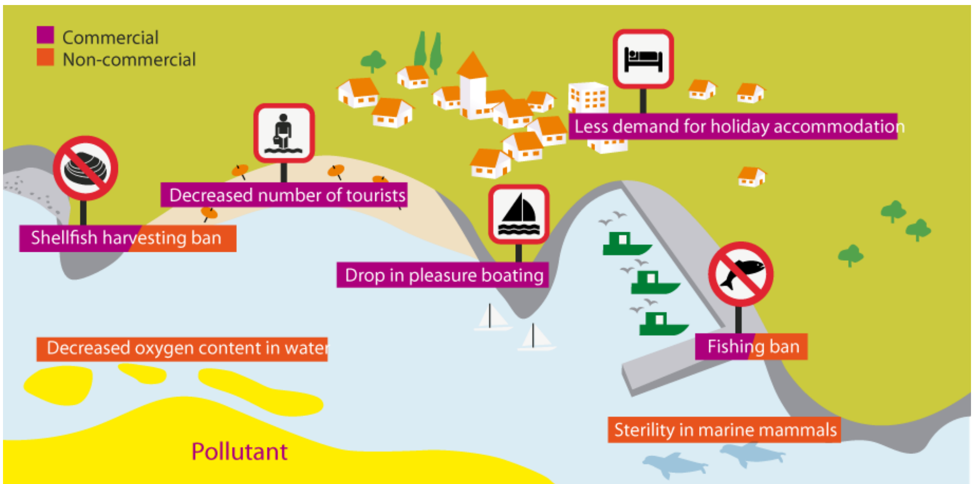


Image source: *https://www.chemical-pollution.com/en/impact/economic-impact.php*

Conceptualization

Time estimated: 20 minutes
Where the activity takes place: in the classroom
Method (how the students have to work): group-work
Instructions for the teacher:
The students, divided in groups, formulate a hypothesis about the pollutants and the economic effects.
Then they are given the worksheet 1 to make a discussion.
According this worksheet, they are asked the following questions:
"Which pollutants and from which source (garbage, waste, materials …) exist in the river?
"What economic impacts they may have?"
"Which economic sectors of the local and wider economy are affected?"

Investigation

Time estimated: 90 minutes
Where the activity takes place: in the classroom and outdoor
Method (how the students have to work): group-work and as whole class
Instructions for the teacher:
In the classroom, the students are divided in groups.

1. Planning

In the classroom, ask students:
"How we could measure the economic impact of river pollution on the local economy?"
The students should generate an investigation plan. The objective is to assess the influence of the river pollution on the local economy.
Duration: 20 minutes

- Students select on the map an area where they want to perform the investigation
- Students decide how to perform the investigation (materials, methods).
- The groups present their investigation plans and find an agreement for the most reliable and feasible.

2. Performing

Outdoor, at the river, with the whole class, students implement their investigation plan. They use the materials listed in the previous step, make photographic surveys with video and photo-cameras. They use worksheets 2 (about observation on waste and financial consequences) and 3 (to indicate the type of investigation about economic effects).

"Have you noticed if there are garbage and other wastes in the river in your area?" "Do you think they are having financial consequences?"

TYPE OF GARBAGE & WASTE	FINANCIAL CONSEQUENCES
….	…..

"What is the effect of the river pollution on the local economy? How would it be without?"

EFFECT ON LOCAL ECONOMY	HOW WOULD IT BE WITHOUT
…	….

Students walk along the path and fill in the questionnaire (worksheet 3) at the agreed stops. They also record environmental and economic variables.

"How would you investigate the economic effects of the river pollution?"
Group activity. Decide where on the river and how you would investigate the economic effects of the pollution of the river of your town. Give an explanation to your decisions and list the materials you will need.

RIVER AREA	TYPE OF INVESTIGATION / MATERIALS
…	…

Duration: 60 minutes

3. Data analysis

In the computer lab or at home, the whole class or in groups, students report the data of the filled-in questionnaires into an Excel file (template available). They can elaborate the questions in term of frequencies for each scale point used in the questions, make comparisons between stops and gender comparisons.
Duration: 40 min

Conclusion

Time estimated: 30 minutes
Where the activity takes place: in the classroom
Method (how the students have to work): group-work
Instructions for the teacher:
The different groups report their conclusions on the activities carried out using worksheet 4 and 5:
• Variations of pollution factors and number of observations.
• Awareness of the problem and the importance on the economic effects on the local economy.
• Awareness of the type of economic activity being affected.

Type of pollution	*Number of observations*	*Type of economic activity being affected*	*Number of observations*
Plastic		Fisheries	
Glass		Tourism	
Metal		Industry	
Odor Embalmment		Trade	
Water color change			
Odors			

Type of economic activity being affected	Economic impact	*Type of economic activity being affected*	Economic impact
Fisheries		Industry	
Tourism		Trade	

The Students compare the final results of their survey with the hypotheses formulated in the conceptualization phase. After careful discussion and comparison, students report their observations in a final worksheet.
The conclusions should lead to understand the economic problems that river pollution creates in local and wider economy.

Discussion
Time estimated: 60 minutes
Where the activity takes place: in the school auditorium
Method (how the students have to work): in groups
Instructions for teacher:
Students in groups present their findings to the whole school and discuss them in comparison to the hypothesis they formulated in the conceptualization phase. They can use PowerPoint, etc.
The discussion should lead to understand the economic problems that river pollution creates in local and wider economy.

Co-funded by the Erasmus+ Programme of the European Union
Project 2017-1-IT02-KA201-036968 – IO2

River integration to the urban space

Module theme: River management
Total duration: 8 hours
Field work: Yes
List of materials:
Printed maps or online mapping software on mobile devices (smartphones or tablets), e.g. Google My Maps
Photo camera or smartphones/tablets
Worksheets (e.g. Questionnaire, interview questions)
Worksheets: 1
Students' age: 16-18
Use of apps/software: Google forms/Siftr

Brief disciplinary introduction

Planners often depict a city as a human body. Transportation, communication, rivers and sewer systems become arteries and veins pulsing through the city; parks and open spaces become urban lungs detoxifying the air they breathe. But what about water itself? Surely it is vital for all of these things beyond anthropomorphic attributions? In nature we have access to the sea, a river, a stream, a lake or a wetland. Perhaps it's our attachment to nature, but in urban areas people of all ages prefer public spaces where water is present. In urban planning this creates challenges: what if these public spaces are not enough? What if they are not accessible to all? What if we cut people off from public water so they can't feel it, play in it or even drink it? Water in a public space is not only a decorative element. It performs other important functions and has benefits that go way beyond the social aspects. It can be an ideal meeting and relaxation point in the urban fabric. Look at any city and you'll find people gathered along a restored riverfront or by fountains. Humans are attracted to water. Sustainable solutions for urban design must include water elements at different scales, even to the point of affecting urban microclimates. A stream or a wetland can reduce the heat island effect, improve air quality and enhance local biodiversity. As a consequence, the city can be more livable and attractive to people and businesses.

Spatial planning can benefit significantly from the integration of water into urban spaces at an early stage, making a city more livable and more resilient. Boosting the presence of blue elements like rivers, streams, canals, artificial wetlands, reservoirs, etc. in urban areas can shape blue-green corridors that revitalize cities.

Reclaiming the historic role of rivers as key transport 'arteries', by introducing taxi boats or cruise boats, can enhance a city's transportation system and offer an alternative touristic attraction. This can also relieve the congestion of conventional traffic systems. A stream, integrated in a park, can connect two or more isolated neighborhoods with a green corridor.

Water management and spatial planning integration have become a major concern for urban planners in recent decades. Climate change, floods and rapid urbanization are driving the adoption and integration of all the elements that are a part of the complex system called a city: nature, infrastructure, utility networks, economy and society. The IWA Principles for Water Wise Cities have been developed towards that end.

The pressures on urban water management mean that it needs to be integrated at the earliest stages of spatial planning; it cannot be considered as optional any more. It also needs to consider the point of view of water users: the people who live in the urban environment, whose experiences matter, but who are often ignored by planners.
So beyond the well-being the water provides in public spaces, it actually can connect people to each other and can be the champion to cross-sectoral, trans-disciplinary urban planning to achieve resilient cities. Acting together to meet a common goal means getting individual benefits from different perspectives.
Water can also facilitate activities that are beneficial for the health such as walking or jogging along the river or stream or rowing and canoeing if the flows allow it.
Observing biodiversity and learning about it – water and the natural habitats that are usually being developed around it, are education grounds and can be used as such to educate the general public on basic environmental protection principles.
In conclusion, for town planners, linear water ways that cross the city and their buffer zones have multiple value: they represent recreation grounds, physical exercise opportunities, education sources and green travel routes, as well as valuable natural areas that help reduce the heat island effect, improve air quality and enhance local biodiversity. Caution: in considering all the above benefits of rivers as integral elements of the city plan one should always take into account the need to preserve the river habitats and the biodiversity that is developing along the banks.

Chrysa Triantafyllidou, "Benefiting From Integrating Water Into Public Spaces", International Water Association http://www.iwa-network.org/benefiting-from-integrating-water-into-public-spaces/

Objective of the learning unit

Students will focus on a river/stream/canal in their local area and embark in a research in order to formulate their proposals for the blue element's optimal integration in the city plan.
Students will perform an online research on good European practices, will engage in field visits in order to examine the current level of integration to the urban space, will interview a local expert (urban planner) in order to get input on the current city plans for integration, and will analyse this input in order to formulate their proposals for future interventions through text and using informatics and geo-referencing information for visualisation.
To learn about:

- Blue infrastructure (rivers, streams, canals, etc.), their role of the in the life of a city,
- Urban planning ways of integrating it in the urban space in order to maximize environmental, economic and social benefits.
- Urban planning (how it works and its role in shaping the lives of urban population,
- Potential benefits from successfully integrating a blue spatial element (e.g. river, stream, canal) in the urban fabric.

To be able to :

- Work in groups
- Exercise their online research skills and develop their field research and interview skills
- Develop their analytical skills and exercise in teamwork and collaborative techniques
- Develop skills in using GIS software in order to visualise and communicate spatial information
- Enhance their awareness and attitudes regarding active citizenship and civic democracy.

Co-funded by the Erasmus+ Programme of the European Union
Project 2017-1-IT02-KA201-036968 – IO2

Introduction (orientation)

Time estimated: 20 minutes

Where the activity takes place: in the classroom, using PC, beamer and Internet

Method (how the students have to work): class brainstorming

Instructions for the teacher:

The teacher should introduce the topic through posing stimulating questions to the class or different groups of students regarding the existence of blue elements in their locality and their role/uses in the everyday life of the locals. The questions should be phrased simply and directly, addressing all students regardless of prior interest in the topic or performance in related school subjects. Questions should not include scientific terminology. The exact phrasing of the questions depends on the local context regarding the integration of rivers/streams/canals in the urban space and the life of the locals. Indicative questions are:

"Can you think of a river or stream in our town/city/area? Would you say it is a positive, negative or neutral element?"

"What would it be like for the city if tomorrow it wasn't there anymore? (In the case of a covered river/stream, the question should be reversed, i.e. …if tomorrow it resurfaced?)"

"How do people use the river/stream today? What do they do near it or in it?"

"Do you think the river/stream/canal has a role in the city? What is this role? Could this role be improved?"

Conceptualization

Time estimated: 45 minutes

Where the activity takes place: in the classroom

Method (how the students have to work): group-work

Instructions for the teacher:

Ask students to formulate a hypothesis based on the input of the first session "Orientation". This hypothesis could be phrased as a question or a statement. Break the hypothesis into a set of questions that need to be answered. Examples of a hypothesis would be:

"How would the local river be best integrated to the city? i.e. become a part of the city that most people use to gain benefits (name the benefits) while the river habitats and biodiversity are protected."

"What uses could be developed in different parts along the river?"

"Does the current city plan integrate the river in the urban fabric? How?"

Investigation

Time estimated: 5 hrs, 15 minutes

Where the activity takes place: in the classroom and outdoor

Method (how the students have to work): group-work

Instructions for the teacher:

1. **Planning**

Location: In the classroom

Time: 45 minutes

Materials:

Map of the town

Apps for collecting data online (Google forms, Siftr)

Ask students
"How would you go about investigating your hypothesis?" (or the questions you have broken it down to in the first session)
Set the framework by introducing different investigation techniques, i.e. literature review, field visit, interview with an expert (a planner or local authority official), interview or survey with locals (i.e. their parents, local businesses, etc.).
Give the student groups 20 minutes to generate an investigation plan each. The objective is assessing the role of the local blue infrastructure in focus (rivers, streams, canals, etc.) in the life of the city, exploring ways of integrating it in the urban space in order to maximize environmental, economic and social benefits. By generating their investigation plan, students need to:

- Select on the map the area where they want to focus the investigation
- Decide how to perform the investigation (techniques, equipment needed, materials).
- Create a timetable where they set the order of the investigation activities.

The groups present their investigation plans and reach an agreement for the most reliable and feasible. It could be a combination of the plans presented.
The teacher may then offer feedback, proposing alternatives or adjustments to the investigation plan proposed by the students. The feedback should aim at making the plan feasible and concrete in terms of time management, access to proposed resources and availability of the persons to be interviewed/consulted.
The outcome should be an investigation plan complete with the activities to be implemented, the timetable for implementing them, the groups/persons responsible for implementing them, the necessary equipment and software, and the communication and info sharing arrangements. The investigation plan should allow for preparation time, i.e. preparing certain equipment (e.g. survey questionnaire design) or software (Siftr, Google My Maps) to be used.

2. Performing

Location: in town
Time: 4 suggested activities of about 45 minutes each
Materials:
Siftr/Google Maps
The investigation plan can be implemented on the basis of the following activities:

- Field visit: The students can walk along the river/stream/canal area selected and document the current land uses and problems/conflicts using printed maps or through certain software introduced for that purpose (Siftr and Google My Maps are recommended for this activity). Students will collect documentation material, i.e. photos and/or videos, to support their findings. Duration: 45 minutes.
- Survey: The students may perform a survey regarding the views of locals (inhabitants, businesses, visitors) on the role of the river and the problems and opportunities regarding its better integration to the city life. The survey should follow a short questionnaire and may also include a focus group meeting inviting locals to participate and share their views. This activity can be combined with the Field visit activity. Duration: less than 60 minutes.

Co-funded by the Erasmus+ Programme of the European Union
Project 2017-1-IT02-KA201-036968 – IO2

- Expert interview: The students may, through their teacher, make an appointment with an expert in urban planning (i.e. an urban planner, a planning officer of the local government, etc.) for an interview. The interview questions should be prepared and communicated to the expert prior to the interview. It is recommended to combine the interview with the field visit, i.e. make the interview while walking along the river. Duration: less than 60 minutes.
- Literature review / online research: The students may perform an online research regarding good practices regarding the integration of urban rivers in the city fabric and innovative initiatives, both on a national and international level.

3. Concluding

Location: in classroom

Time: 2 suggested activities of about 45 minutes each

In the school computer lab or at home, students proceed to the analysis of the data collected and report the main findings. The analysis may vary depending on different research techniques employed:

- Field visit: Analysis may include an interpretation of the Siftr or Google Map created, or the input from the printed maps.
- Survey: Analysis of the questionnaire results through Excel tables and generation of selected diagrams.
- Expert interview: Outline the main findings from the interview regarding the students' hypothesis.
- Literature review / online research: Outline the main findings from the online research. Make sure to include good practice case studies or innovative interventions that have a potential for implementation in your case.

Conclusion

Time estimated: 45 minutes

Where the activity takes place: in the classroom

Method (how the students have to work): group-work

Instructions for the teacher:

The different groups (or the whole class) report their findings from the investigation activities. They compare their findings with the formulated hypothesis or check if they answered the generated questions in the conceptualization phase.

The findings from different investigation activities need to come together and be presented in one place (maybe on the classroom walls or on an interactive board). The teacher may then lead a discussion inviting comments from students on certain attributes of the findings or in cases where the findings may seem conflicting.

Discussion

Time estimated: 45 minutes

Where the activity takes place: in the classrooms

Method (how the students have to work): class discussion

Instructions for the teacher:

This phase aims to verify students' knowledge at school. The learning activity outcomes are evaluated by the teacher and the students can present their findings in front of their colleagues and teachers.

The teacher invites the students to come up with proposals for the river's better integration to the urban fabric, based on the findings of their investigation.

The findings, proposals and documentation material, with references to specific places in town, may be used for the development of a Location Based Game (LBG) or the creation of a proposals map with the use of QGIS.

Co-funded by the Erasmus+ Programme of the European Union
Project 2017-1-IT02-KA201-036968 – IO2

The symbiosis between river and people. Sarno example

Module theme: River management
Total duration: 7 hours
Field work: Yes
List of materials:
Blackboard/ IWB
Internet for Youtube video
PC
Mobile device/camera
Notepads
Worksheets: 4
Students' age: 16-18
Use of apps/software: Google forms/Siftr

Brief disciplinary introduction

The life of the people living in the Sarno area has always been connected to their river. This relationship has had a strong historical, economic and social impact on the area.
In his De Bello Gothico the Greek historian Procopius called the river Sarno "Dragon" because of its winding course.
Some scholars believe Pelasgi-Sarrastri-Tirreni-Pirati people settled in the area happily mingling with the local population. They called the river of this place "Saron" after a river in their homeland.
In the Roman period the city of Pompeii flourished also thanks to the river and its Fluvial port in Moreggine. The oldest representation of the river appears in the Tabula Peutigeriana dating from about the twelfth and thirteenth centuries where it illustrates its winding path that runs along Pompeii and flows into the sea near Castellammare. In the Middle Ages some significant churches were built by the river, such as the church and cloister of the Cistercian Abbey of Realvallewas built by Carlo I D'Angiò in the village of San Pietro north of Scafati to celebrate his victory in 1270 and the church of Santa Maria delle Vergini built in 1524.
Mills managed by the lords of the farms were built along its bank to produce wheat, barley and maize by using the hydraulic power of the river. In the 19th century spinning mills, paper mills, cotton mills and textile industry were the engine of the economic system of the valley.

http://www.campuspompei.it/2015/01/24/forme-urbane-ed-architetture-nel-paesaggio-idrografico-della-valle-del-sarno/

Objective of the learning unit

To learn about:

- The evolution and changes concerning the river and its area in relation to people's lives and activities

Introduction (orientation)

Time estimated: 15 minutes
Where the activity takes place: in the classroom
Method (how the students have to work): group work
Instructions for the teacher:
In order to arise students' curiosity they are asked the following questions:
Have you ever noticed that many cities and towns are near rivers?
Is your city near a river?
What reasons do you think made people settle down near streams?
The students work in group and then the teacher writes their answers on the blackboard
After that they are shown a short video https://youtu.be/AJ2FeWvCRjI and asked to find out the reasons why civilizations started near rivers (given in it) and compare them with their suggestions.
Watch the video and write down the reasons why civilizations started near rivers. Are they the same as yours?
Tick the reasons which have been mentioned in the video and those suggested by you in the following chart.

Reasons mentioned in the video	Reasons given by me
Agriculture	
Raising livestock	
Fishing	
Trade	
Communication	
Boundaries	
Military defenses	
Bathing	
Recreation	
Religious purposes	

Conceptualization

Time estimated: 20 minutes
Where the activity takes place: in the classroom
Method (how the students have to work): group-work
Instructions for the teacher:
The students are given a worksheet with the reasons mentioned in the video for settlements near rivers. They have to tick the activities they mentioned in the previous session (use worksheet 1).
After completing the activity they are asked to formulate a hypothesis about the role of the river in their area.
Hypothesis "The river Sarno and its tributaries have had an important role in our area for thousands years"

Investigation 1

Time estimated: 2 hrs

Where the activity takes place: in the classroom and outdoor, and at home

Method (how the students have to work): group-work, individual work

Instructions for the teacher:

1. **Planning**

Location: at home

Time: 30 minutes

Materials: paper and pen, worksheet 2.

At home students in groups or individually prepare a set of questions to ask people on their field trip to the river. The aim is to find out about activities, artifacts, boats, fish and recipes. (worksheet 2).

How long have you lived in this area?

What did you grandparents do for a living?

Did any of the people you know or have known live on fishing?

Were any of the plants growing by the river used to make baskets or herbal teas?

Were there any particular boats which were used to cross the river or go fishing?

What river food did people eat/sell?

Do you know of any recipes which make use of the river Sarno fish or plants?

2. **Performing**

Location: in town and at school

Time: 60 minutes

Materials: paper and pen, camera/smartphones.

Field work by the river with all the students. The activity carried out is cross-curricular and concerns all the modules about the river. During the field trip the students take photos of the areas they visit and interview people;

1. The students take photos of some areas along the river, interview people.

Back at school they perform activities 2 and 3:

2. The students are given a passage to read about the history of the river and its area
3. The students are shown a PPT with pictures of old 19th and 20th century paintings, cards and photos

Location: in the computer lab

Time: 45 minutes

Materials: Worksheet 3, Google maps

1. The students highlight names of people and places in the passage. Then by the means of a google map of their area they find out which of the names they have highlighted still survive in today's toponymous (worksheet 3)
2. The students look at the pictures on the PowerPoint and tick the activities performed by the people in 19th and 20th century pictures, then they compare them to the ones in the photos they took on their trip to the river Sarno (worksheet 3)

Activities	Activities performed in the past	Activities, if any performed today
industry		

swimming		
agriculture		
defense		
Boat racing		
fishing		
travelling		
trading		

3. Concluding
Location: at home
Time: 30 minutes
At home-the students summarize the information gathered from the interviews and highlight differences and/or similarities with the pictures and photos (worksheet 3)

Investigation 2
Time estimated: 1 hr
Where the activity takes place: in the classroom
Method (how the students have to work): group-work
Instructions for the teacher:

1. Planning
Time: 5 minutes
Materials: Worksheet 4.
The students are given some short extracts from the writings of ancient Greek and Latin authors: Lucan, *Bello civile*; Pliny the Elder, *Naturalis Historia*; Procopius of Caesarea, *De Bello Gothico;* Virgil, *Georgicorum*.

Lucanus, Marcus Anneus, *Bellum civile* o *Pharsalia* (about 61 B.C.)

II, 422-424. ...Dilabitur inde / Volturnusque celer, nocturnaequae editor aurae / Sarnus...

Plinius Secundus, Caius, *Naturalis historia* (Written from 50 al 77 B.C.)

III, 60-62. Hinc felix illa Campania, ...Tenuere Osci, Graeci, Umbri, Tusci, Campani. Litore autem Neapolis, Chalcidensium et ipsa, Parthenope a tumulo Sirenis appellata, Herculaneum, Pompei haud procul spectato monte Vesuvio, adluente vero Sarno amne, ager Nucerinus et novem milia passuum a mari ipsa Nuceria, Surrentum cum promontorio Minervae Sirenum quondam sede.

Vergilius Maro, Publius, *Georgicorum* VII, 733-738.

Nec tu carminibus nostris indictus abibis,
Oebale, quem generasse Telon Sebethide nympha
fertur, Teleboùm Capreas cum regna teneret,

iam senior; patriis sed non et filius arvis contentus
late iam tum ditione premebat Sarrastes populos et
quae rigat aequora Sarnus.
http://www.arborsapientiae.com/allegati_articoli/3_nbp_3_fonti_classiche.pdf

2. Performing

Location: in town and at school

Time: 55 minutes

Materials: paper and pen (worksheet 4)

The students translate the extracts from Latin and read the Italian translation from De Bello Gothico. Then they fill in a chart and write down the information they have found in the texts: author, work, main ideas (worksheet 4).

Author	Work	Main information
..	..	..

Investigation 3

Time estimated: 1 hr

Where the activity takes place: in the language/computer lab

Method (how the students have to work): group-work

Instructions for the teacher:

1. **Planning**

The students are shown a Power Point with some maps of the Sarno area and are given the web links to them in order to look for specific details.
For instance, regarding the Sarno river:

https://drive.google.com/open?id=1CRD4JhkLE93f5VX7igSoXAgoSLOacuTr

- Tavola Peutigeriana is the most ancient map about the river Sarno area
- Sheet n. 14 is from a 19th century map of the Reign of Naples. On it the Bottaro, Mills, the bridge of Persica, the Inn of Longobardo and other ancient places can be seen.
- A map of the Reign of Naples. A bridge on the downstream of the river can be seen
- A map about the roads and streams in the town of Nocera published in Rome by Domenico de' Rossi in 1714.

2. **Performing**

The students go on the following sites and compare the area of the river Sarno on the maps.

- teca.bncf.firenze.sbn.it;
- www.hs-augsburg.de
- Ambrogio Leone: De Nola opusculum distinctum, plenum, clarum, doctum, pulcrum, verum, graue, varium, & utile, Venezia 1514.
- www.igmi.org

Then they answer the following question and discuss the changes they have noticed
"Look at the maps of the river Sarno area. Do you notice any changes?"

"Discuss these changes in relation to their causes, such as natural disasters, man's land use etc."
"Add your findings to the data collected in Investigation 3 in the learning activity Ancient artifacts of the Sarno river"

Conclusion and discussion

Time estimated: 2 hrs
Where the activity takes place: in the classroom
Method (how the students have to work): group-work or individually
Instructions for the teacher:
Students in groups or individually present their findings to the whole class and discuss them in comparison to the hypothesis they formulated in the conceptualization phase. They can use apps like thinglink, PowerPoint, etc. The purpose is to point out the changes which have taken place in the Sarno area over time and highlight how they have affected people's lives.
At the end of the activity they can create a story about the life of a group of people in a period in the past and describe the setting and daily events in relation to the river Sarno. The story can be used to create a game based on these fictional people's life (LBG).

11. References

Almuntasheri S., Gillies R.M., Wright T., 2016. The Effectiveness of a Guided Inquiry-based, Teachers' Professional Development Programme on Saudi Students' Understanding of Density. Science Education International 27(1), 16-39.

Audet R.H., Paris J. 1997. GIS Implementation Model for Schools: Assessing the Critical Concerns. Journal of Geography 96(6), 293-300. DOI: 10.1080/00221349708978810

Balmori D. 2014. Drawing and Reinventing Landscape. John Wiley & Sons Ltd. ISBN: 9781118541173.

Bednarz, S.W., Ludwig G. 1997. Ten things higher education needs to know about GIS in primary and secondary education. Transactions in GIS 2(2), 123–133.

Berg C.A.R., Bergendahl V.C.B., Lundberg B., Tibell L. 2003. Benefiting from an open-ended experiment? A comparison of attitudes to, and outcomes of, an expository versus an open-inquiry version of the same experiment. International Journal of Science Education 25(3), 351-372.

Bøe M. V., Henriksen E. K., Lyons T., Schreiner C. 2011. Participation in science and technology: Young people's achievement-related choices in late-modern societies. Studies in Science Education 47(1), 37–72.

Bonney R., Phillips TB., Enck J., Shirk J. and Trautmann N. (2015) CITIZEN SCIENCE AND YOUTH EDUCATION, Cornell Lab of Ornithology. http://sites.nationalacademies.org/cs/groups/dbassesite/documents/webpage/dbasse_089993.pdf

Bruce B.C., Casey L. 2012. The practice of inquiry: a pedagogical 'sweet spot' for digital literacy? Computers in the Schools, 29, 191–206. doi:10.1080/07380569.2012.657994.

Bruder R., Prescott A. 2013. Research evidence on the benefits of IBL. ZDM 45.6, 811-822.

Buckingham Shum, S., Aberer, K., Schmidt, A. et al. Eur. Phys. J. Spec. Top. (2012) 214: 109. https://doi.org/10.1140/epjst/e2012-01690-3

Bybee R., Taylor J.A., Gardner A., van Scotter P., Carlson J., Westbrook A., et al. 2006. The BSCS 5E instructional model: Origins and effectiveness. Colorado Springs, CO: BSCS.

Chin C. 2007. Teacher questioning in science classrooms: Approaches that stimulate productive thinking. Journal of research in Science Teaching 44(6), 815-843.

de Jong T. 2006. Computer simulations – technological advances in inquiry learning. Science 312, 532–533. DOI:10.1126/science.1127750.

Demirci A., Karaburun A., Ünlü M. 2013. Implementation and Effectiveness of GIS-Based Projects in Secondary Schools. Journal of Geography 112(5), 214-228. DOI: 10.1080/00221341.2013.770545.

Dewey J. 1933. How we think. Independent Publishing Platform. Boston. Heath ISBN: 9781985251946.

Davidson J., Cameron L., Smith M., Bond L. 2009. Emotion, Place and Culture - Ed. Ashgate.

Di Fabio A., Palazzeschi L., Ugolini F., Massetti L., Cecchi F., Buselli E., Francini A., Minnocci A., Lanini M., Pellegrino L., Rossini G., Screti C., Tagliaferri G., Sebastiani L., Raschi A. 2013. Evaluation of the effectiveness of Acariss project: new perspectived for developing talents in the field of science. In Proceeding of the International workshop: Science education and guidance in schools: the way forward. Firenze 21-22/10/2013. ISBN 978-88-903469-2-7.

England Marketing 2009. Report to Natural England on childhood and nature: a survey on changing. ©England Marketing 2009, Cambridgeshire, UK.

European Commission 2004. Europe Needs More Scientists: Report by the high level group on increasing human resources for science and technology. European Commission. Brussels.

Favier T.T. 2011. Gepographic Information Systems in inquiry-based secondary geography education. Ph.D. Dissertation. Vrije Universiteit, Amsterdam, The Netherlands.

Fitzpatrick C., Maguire D.J. 2000. GIS in schools: Infrastructure, methodology and role. In GIS: A Sourcebook for Schools, ed. D. R. Green. Taylor & Francis. New York, pp. 61–62

Germann P.J., Haskins S., Auls S. 1996. Analysis of nine high school biology laboratory manuals: Promoting scientific inquiry. Journal of Research in Science Teaching 33(5), 475-499.

Ghersi A. 2005. Politiche europee per il paesaggio- proposte operative. Ed. Gangemi. EAN: 9788849211870.

Gillies R. M., Nichols K., Burgh G., Haynes M. 2012. The effects of two strategic and meta-cognitive questioning approaches on children's explanatory behaviour, problem-solving, and learning during cooperative, inquiry-based science. International Journal of Educational Research 53, 93-106.

Haas J. 2005. The situation in industry and the loss of interest in science education. European Journal of Education 40(4), 21–27.

Howe J. 2006.The Rise of Crowdsourcing, Wired Magazine, June 2006.

Johansson, T. 2003. GIS in teacher education - Facilitating GIS applications in secondary school geography. ScanGIS 2003 On-line Papers, 285–293. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.124.3454&rep=rep1&type=pdf

Justice C., Warry W., Cuneo C.L., Inglis S., Miller S., Rice J., et al. 2002. A grammar for inquiry: linking goals and methods in a collaboratively taught social sciences inquiry course. In The Alan Blizzard Award paper: The award winning papers. Windsor: Special Publication of the Society for Teaching and Learning in Higher Education and McGraw-Hill Ryerson.

Kaltman G.S. 2010. Hands-on learning. Childhood Education 87(2), S7+. Academic OneFile.

Kerski, J.J. 2003. The implementation and effectiveness of geographic information systems technology and methods in secondary education. Journal of Geography 102(3), 128–137.

Kerski J.J. 2008. The role of GIS in digital earth education. International Journal of Digital Earth 1(4), 326–346.

Kerski, J.J., Demirci A., Milson A.J. 2013 The Global Landscape of GIS in Secondary Education. Journal of Geography 112(6), 232-247. DOI: 10.1080/00221341.2013.801506

Landenberger R.E., Warner T.A., Ensign T.I., Nellis M.D. 2006. Using remote sensing and GIS to teach inquiry-based spatial thinking skills: An example using the GLOBE program's integrated Earth systems science. Geocarto International 21(3), 61–71.

Lemberg D., Stoltman J.P. 2001. Geography teaching and the new technologies: Opportunities and challenges. Journal of Education 181(3), 63 76.

Lim B. 2004. Challenges and issues in designing inquiry on the web. British Journal of Educational Technology 35, 627–643. DOI:10.1111/j.0007-1013.2004.00419.x.

Maaß K. 2011. Report about the survey on inquiry-based learning and teaching in the European partner countries. EU-Project Information: PRIMAS. http://www.primas-project.eu.

Mäeots M., Pedaste M., Sarapuu T. 2008. Transforming students' inquiry skills with computer-based simulations. In 8th IEEE International Conference on Advanced Learning Technologies, 1–5 July, Santander, Spain. DOI:10.1109/ICALT.2008.239.

Meyer J.W., Butterick J., Olkin M., Zack G. 1999. GIS in the K-12 curriculum: A cautionary note. The Professional Geographer 51(4), 571 – 578. DOI: 10.1111/0033-0124.00194

National Academy of Sciences: Committee on Science Engineering and Public Policy 2007. Rising above the gathering storm: Energizing and employing America for a brighter economic future. Washington: The National Academies Press.

Natural England 2012. Learning in the Natural Environment: Review of social and economic benefits and barriers. Natural England Commissioned Report NECR092. www.naturalengland.org.uk. ISSN 2040-5545, pp. 48.

Ofsted 2008. Learning outside the classroom: how far should you go? Ref.: 070219. Crown, London, UK, pp. 28.

Palmer M., Reidy Liermann C.A., Nilsson C., Flörke M., Alcamo J., Lake P.S., Bond N. 2008. Climate change and river basins. Frontiers in Ecology and the Environment 6(2), 81-89.

Papageorgiou F., Kolovou E., Saridaki M., Ugolini F., Rossini G., Gosselin E., Zappella L., Giosma K., Panoriou E., Zevnik P., Honvári P. 2015a. A guide for learning facilitators. PRISMA, Athens, Greece. ISBN: 978-960-6676-25-3. http://www.involen.eu/images/EN/Involen_Guide_eng_final.pdf

Papageorgiou F., Kolovou E., Saridaki M., Ugolini F., Rossini G., Gosselin E., Zappella L., Giosma K., Panoriou E., Zevnik P., Honvári P. 2015b. A toolkit for learners. PRISMA, Athens, Greece. ISBN 978-960-6676-23-9.

http://www.involen.eu/images/EN/Involen_Toolkit_final-links_web.pdf Pedaste M., Mäeots M., Siiman L.A., de Jong T., van Riesen S.A.N., Kamp E.T., Manoli C.C., Zacharia Z.C., Tsourlidaki E. 2015. Phases of inquiry-based learning: Definitions and the inquiry cycle. Educational Research Review 14, 47–61. DOI. http://dx.doi.org/10.1016/j.edurev.2015.02.003

Paprotny D., Sebastian A., Morales-Nápoles O., Jonkman S.N. 2018. Trends in flood losses in Europe over the past 150 years. Nature Communications 9, Article number: 1985. https://www.nature.com/articles/s41467-018-04253-1

Pedaste M., Mäeots M., Siiman L.A., de Jong T., van Riesen S.A.N., Kamp E.T., Manoli C.C., Zacharia Z.C., Tsourlidaki E. 2015. Phases of inquiry-based learning: Definitions and the inquiry cycle. Educational Research Review 14, 47–61. http://dx.doi.org/10.1016/j.edurev.2015.02.003

Pollino M., Fattoruso G., La Porta L., Della Rocca A.B., James V. 2012. Collaborative Open Source Geospatial Tools and Maps Supporting the Response Planning to Disastrous Earthquake Events. Future Internet 4(2), 451-468. DOI:10.3390/fi4020451

Scanlon E., Anastopoulou S., Kerawalla L., Mulholland P. 2011. How technology resources can be used to represent personal inquiry and support students' understanding of it across contexts. Journal of Computer Assisted Learning 27, 516–529. DOI:10.1111/j.1365-2729.2011.00414.x.

SIS.net. 2012. Science education policies in the European Commission: towards responsible citizenship. Policy Brief. No 2 October 2016. http://www.sisnetwork.eu/media/sisnet/Policy_Brief_Science_Education.pdf

Sui D.Z. 1995 A pedagogic framework to link GIS to the intellectual core of geography. Journal of Geography 94, 578–591.

Thomas, G., Thompson G. 2004. A child's place why environment matters to children. Green Alliance. London, UK.

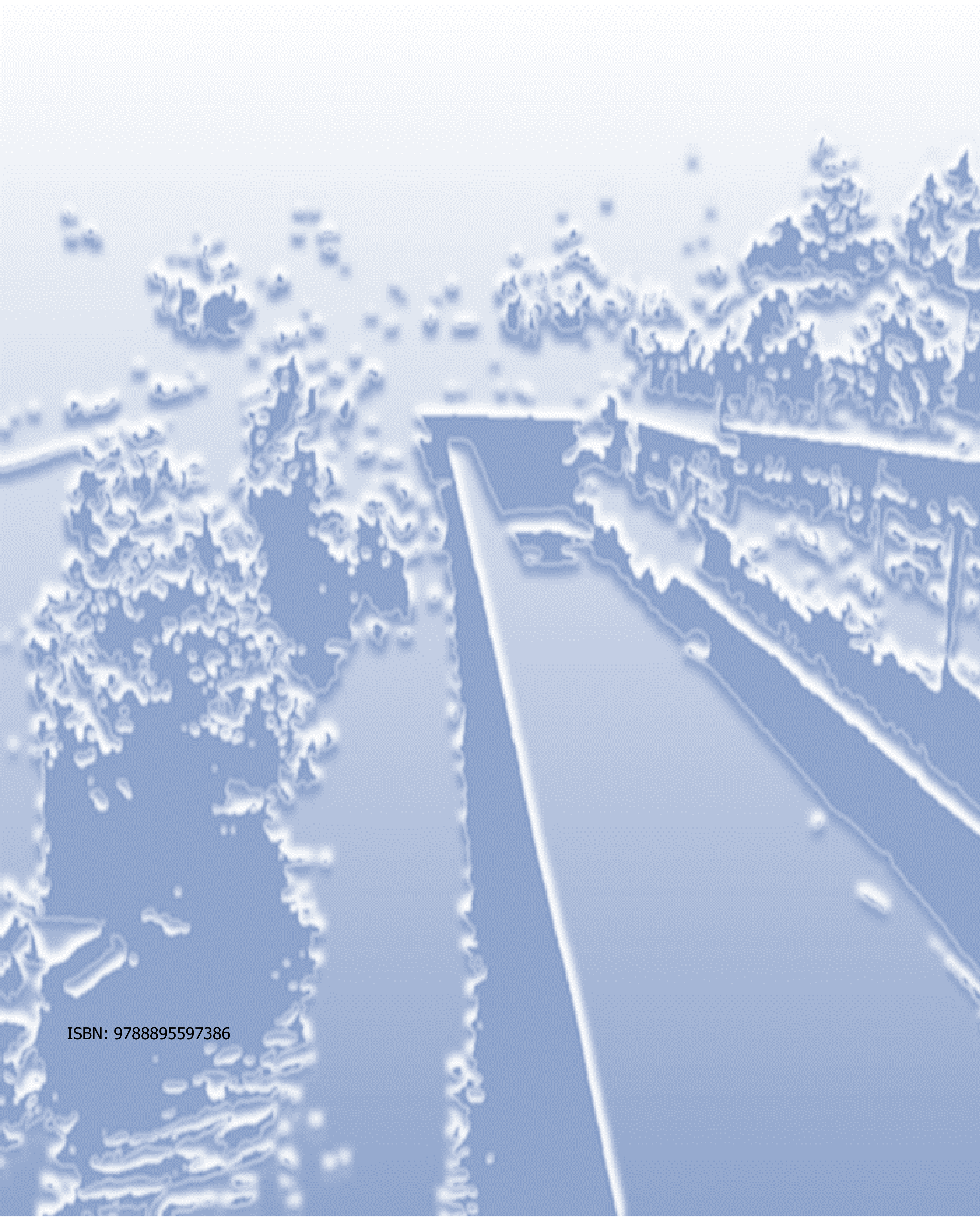
TSP Report: http://www.scientistsinschools.edu.au/downloads/SiSPilotEvaluationReport.pdf).

White B.Y., Frederiksen J.R. 1998. Inquiry, modeling, and metacognition: making science accessible to all students. Cognition and Instruction 16, 3–118. DOI: 10.1207/s1532690xci1601_2.

White B.Y., Frederiksen J. 2005. A theoretical framework and approach for fostering metacognitive development. Educational Psychologist 40, 211–223.

Wiegand P. 2001. Geographical Information Systems (GIS) in Education. International Research in Geographical and Environmental Education 10(1), 68-71. DOI: 10.1080/10382040108667424

Wilhelm J.A., Walters K.L. 2006. Pre-service mathematics teachers become full participants in inquiry investigations. International Journal of Mathematical Education in Science and Technology 37, 793–804. DOI:10.1080/00207390600723635.



ISBN: 9788895597386