



Cross-cutting geospatial and environmental STEAM instruments for the new generation

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A2 Spatial Thinking and STEAM resources and tools for learners

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1. Introduction

Spatial literacy is an ability to capture and communicate knowledge in the form of maps, understanding, interpreting and recognising the world and spatial patterns as viewed from above, thus realizing that the academic field of geography is more than merely a list of places on our planet. By fostering this knowledge, individuals will see the value of geography as a key concept “for organizing and discovering information, thus comprehending core concepts as scale and spatial resolution, thereby providing a set of abilities related to working and reasoning in a spatial world and to making a picture truly worth a thousand words” (Goodchild 2006, 1).

As the United States National Research Council (2006) reports, it is essential to learn how to think in spatial terms. Without focusing on spatial thinking, it will be impossible to equip the coming generations with necessary knowledge of life and work in the 21st Century. Ultimately, spatial literacy should be seen as an integral part to succeed for all students, as our world is situated in space, and interactions between humans must be understood along the lines of location, distances, directions, shapes and patterns (NRC, 2006).

Spatial literacy has become even more important as Global Positioning Systems (GPS), access to the Internet, portable devices and mass storage hard drives have transformed our ability to incorporate spatial and geographic data into our daily lives (Gordon et al, 2016). As a result, teachers have been educating students in spatial thinking around the world to increase our understanding of such matters; Well-known activities or tools for increasing spatial literacy that have been tested include:

- Production of mapping products in order to strengthen students’ knowledge in geospatial technologies
- Utilizing GPS-receivers when collecting spatial data (including distance, speed and acceleration)
- Collecting and analysing spatial data by using open/free web cartography and geographic information software.

Nevertheless, it is of value to distinguish between different types of spatial resources/tools to an even higher degree than seen above in order to help teachers and students grasping the internet landscape of spatial learning. This report seeks to categorise, list and describe some of the most popular open spatial resources/tools available on the web. Of course, numerous open web resources/tools could be useful to strengthen students’ spatial knowledge. Yet, the authors have chosen to select 40+ approved

resources/tools to narrow down the scope for this report. The main objective of this text will be to present an overview of these resource/tools - in the long run potentially helping to transfer academic knowledge and research practices to secondary education.

The tools/resources have also been inserted into the Open School for Open Societies (OSOS)

GOSTEAM community: <https://portal.opendiscoveryspace.eu/en/community/gosteam-861717>

2. Links to a survey on spatial and environmental education of secondary school age students

In order to explore the state-of-the-art in spatial and environmental education of secondary school age students in GOSTEAM consortium member states, a small-scale survey was conducted in the context of the project. The survey was conducted as part of Activity “IO1/A1 Guidelines and best practices for incorporating spatial thinking in STEAM education” with the findings presented in detail in the final report for that activity. As part of this survey, educators were asked to answer questions related to e.g. the current use of different types of learning resources; spatial concepts/skills considered important; teaching and ICT tools and resources suitable for developing students’ spatial thinking skills; and proposals for open educational resources/tools relevant to cultivating spatial and environmental awareness.

It is therefore important to see this report as a complement to the analysis presented in the final report for Activity IO1/A1.

3. Categorisation of open spatial resources/tools

Note: A general categorisation was made in the table below with reference to a limited set of overarching areas of applications. The findings of the survey conducted as part of IO1/A1 (see previous section 2) presents elements/subtopics considered particularly useful for the development of spatial thinking skills in secondary school students, including for Sciences (in general), Natural sciences, Astronomy, Chemistry, Earth sciences, Geography, Human Body, Physics, Mathematics, Informatics, and Languages/communication.

Category	Resources/tools
Map Making/ Visualization	AMAP Austria, Bing Maps, Cesium, Drive Me, Geobee Study Toolkit, Geodata in Greece, Google Maps, Google Earth, Grolier Online Atlas, Flash Earth, MapQuest, Marble, National Geographic's MapMaker, Open Street Maps, Outline Maps, PERMAP, QGIS, Scribble Maps, USGS Earth Explorer, WorldMapper, Yahoo Maps.
Data Collection	Cesium, Permap, QGIS.
Application 1: Disaster Management	European Atlases of the Sea, Earthquake Calculator, Natural Hazards Viewer, Tasking Manager.
Application 2: Politics and Economy	Bouncy Maps, Gapminder, National Geographic's MapMaker, Urban Observatory, WorldMapper.
Application 3: Health	Gapminder, Mapquest, National Geographic's MapMaker, Task Manager, Urban Observatory, WorldMapper.
Application 4: History & Literature	Grolier Online Atlas, Old Maps Online, Google Lit Tours.
Application 5: Climate and Global Warming	National Geographic,'s MapMaker, PHET, Satellite and Information Service from NOAA, Urban Observatory, WorldMapper
Application 6: Geo-Games with Learning Objectives	Atmospheric Phenomena Quiz, Geocashing, Geoguessr, Geostory, Guess the place, Jetpunk Mapquiz, Ornance Survey, National Geographic's Kahoot Quiz, Play Geography, Seterra, View from above, World Geography Games.

4. Listing of open spatial resources/tools

Resource	Link
AMAP Austria	http://www.amap.at/amap/
Atmospheric Phenomena Quiz	http://www.funtrivia.com/html5/index.cfm?qid=50603
Bouncy Map	www.bouncymaps.com
Bing Maps	http://www.bing.com/maps/
Cesium	http://cesiumjs.org/index.html
Drive Me	http://www.driveme.gr/
Earthquake Calculator	https://earthquake.usgs.gov/education/calculator.php
European Atlas of the Sea	http://ec.europa.eu/maritimeaffairs/atlas/maritime_atlas/#lang=EN;p=w;
Flash Earth	http://www.flashearth.com/
Gapminder	http://www.gapminder.org
GeoBee Study Toolkit	https://media.nationalgeographic.org/assets/file/GeoBee_Study_Toolkit_2019-2020.pdf
Geocaching	https://www.geocaching.com/play
Geodata in Greece	http://geodata.gov.gr/maps/
Geoguessr	https://www.geoguessr.com/education
Geostory	https://www.geostory.se
Google Earth	https://www.google.com/earth/
Google Maps	https://maps.google.com/
Google Lit Trips	https://www.googlelittrips.org
Grolier Online Atlas	http://go.grolier.com/atlas
Guess The Place	https://www.nationalgeographic.org/activity/guess-the-place/
Jetpunk Mapquiz	https://www.jetpunk.com/tags/fill-in-the-map
Marble	https://marble.kde.org/
MapQuest	http://www.mapquest.com/
Natural Geographic's MapMaker	https://mapmaker.nationalgeographic.org
National Geographic's Kahoot Quiz	https://www.nationalgeographic.org/interactive/continents-europe/
Natural Hazard's Viewer	https://maps.ngdc.noaa.gov/viewers/hazards/
Old Maps Online	http://www.oldmapsonline.org
OpenStreetMaps	www.openstreetmap.org

Ordnance Survey	https://www.ordnancesurvey.co.uk/mapzone
Outline Maps	http://www.eduplace.com/ss/maps/
PERMAP	http://www.newmdsx.com/permap/permap.htm
Play Geography	https://www.playgeography.com
PHET	http://phet.colorado.edu/en/simulation/greenhouse
QGIS	https://www.qgis.org/en/site/forusers/download.html
Satellite and Information Service from NOAA	http://www.nesdis.noaa.gov/imagery_data.html
Scribble Maps	https://www.scribblemaps.com
Seterra	https://online.seterra.com/en/
Tasking Manager	http://tasks.hotosm.org/
Urban Observatory	https://www.urbanobservatory.org
USGS Earth Explorer	http://earthexplorer.usgs.gov/
View From Above	http://qz.com/304487/the-view-from-above-can-you-name-these-countries-using-only-satellite-photos/
World Geography Games	https://world-geography-games.com/world.html
World Mapper	http://www.worldmapper.org/
Yahoo Maps	https://maps.yahoo.com/

5. Descriptions and pathway ideas for open spatial resources/tools

AMAP Austria

<http://www.amap.at/amap/>

A website containing maps of Austria.

Pathway idea:

1. The teacher asks the question “Do you know where Austria is geographically positioned in relation to its’ neighboring countries?”.
2. The teacher continues by suggesting that the students should draw on a piece of paper, only by memory, Austria and its neighboring countries. “Take 5 minutes for this and include as many details as possible”
3. Next, the teacher shows the map on AMAP Austria, and tells the audience to compare with the drawings they just made – are they similar? What did they miss? Discuss in class common mistakes when drawing maps.
4. Students can contemplate and discuss in small groups of four whether Austria’s geographical position in Europe have provided the country with any specific advantages. Which nations are the neighboring countries to Austria – and does that matter? Are there other countries that have similar geographical positions as Austria? The teacher should constantly be present and support the discussion, and be ready to answer questions on the topic. In the case of a misunderstanding between students, the teacher can mediate between them to foster the discussion. The discussion should last for at least 15 minutes.
5. Last, each group should present a summary of their discussion to the whole class, ultimately leading up to a discussion between all of them.
6. Follow up activity: The students are asked to work at home and conduct a small historical research on Central European geography. Subjects that they can choose from are: Central European geography, Austrian Geography, Austrian neighbors.

Owner: BEV

Atmospheric Phenomena Quiz

<http://www.funtrivia.com/html5/index.cfm?qid=50603>

A website where you can learn facts about the atmosphere in a free quiz.

Owner: FunTrivia

Bing maps

<http://www.bing.com/maps/>

A web mapping service providing street maps, satellite photos, aerial maps and bird's eye views, as well as driving directions, traffic details and road conditions.

Owner: Microsoft Corporation

Pathway idea: See Google Maps.

Bouncy Maps

www.bouncymaps.com

A website where users select subjects related to people, planet, business, politics, and living and watch the countries on the map change their size: instead of land mass, the size of each country represents the data for that subject.

Owner: Mapping Worlds

Pathway Idea:

1. The teacher begins the lesson with a basic introduction of key terms regarding economy, energy and resources, such as GDP, GDP/capita, oil reserves, gas reserves, nuclear reactors, solar and wind energy etc.
2. Next, the teacher shows the website, and points to the fact that people, money and resources are not evenly divided over the world's nations. For example, Russia is much larger than India – yet, India has a much bigger population. Likewise, Belgium is much smaller than Norway – yet, it has a bigger population. Perhaps the audience can name two countries that are very different from each other, just like the above-mentioned examples?
3. The teacher continues by asking the audience if they can make a “Top 10-list” of the most important measurements for a nation's wellbeing (they can find these on the website, oil reserves, coal reserves, mineral reserves, GDP, Obesity, under 5 –mortality etc.). How well does *your* country perform on the student's own “Top-10 list”, compared to the rest of the world? Check on the website!
4. Students can anticipate potential grounds for international and domestic conflict. Bouncy Maps estimates more than 11 billion people living on earth in 2100. With the growing electrification of our society, batteries (cobalt) are needed. How will this influence a country like the Democratic Republic of Congo, which has almost 50 % of the cobalt on our planet? The teacher should constantly support to the discussion, and be ready to answer questions on the topic. In the case of a misunderstanding between students, the teacher can mediate between them to foster the discussion. The discussion should last for 10 minutes.
5. Last, each group should present a summary of their discussion to the class, ultimately leading up to a discussion between all of them.

Cesium

<http://cesiumjs.org/index.html>

A WebGL virtual globe and map engine. While satellites, land vehicles, and drones are busy gathering 3D-information, it remains difficult to use. Cesium is an end-to-end platform that unleashes the potential of 3D data by making it easy for developers to visualize, analyze, and share 3D content.

Pathway idea:

1. The teacher introduces the concept of 3D maps and why they are important. The teacher asks if the students can give examples of some 3D maps we use in our daily lives?
2. Next, the teacher begins to guide the audience in these concepts, using the Cesium website
3. Students can then create 3D maps as well as collecting different kinds of data in order to get a more holistic understanding of the spatial world.
4. Follow up activity: Students are asked to explore Cesium further, and share 3D content with each other in class.

Owner: Analytical Graphics Inc.

Drive Me

<http://www.driveme.gr/>

Online web mapping service that provides maps and geographic information for **Greece**. Supports locating addresses, route planning and presents points of interest relative to several categories (e.g., banks, shopping, sports, public services, entertainment, etc.)

Pathway idea:

1. The teacher begins by asking the audience if they have ever heard of Driveme.gr, and introduces the website and how to manage it properly.
2. In groups of three, Students can make lists of what they want to buy/do in Greece and then make routes of how to get there the fastest.
3. Next, they present their routes to the class.
4. After that, students should discuss in there are faster ways of getting to your address, depending on the time of the day. For this part, students should discuss what time slots that are famous for having a lot of traffic. The morning rush, or the traffic rush after work? For example, heavy traffic at 5 a clock may hinder a fast journey, leading the groups to make new routes depending on what time it is.
5. Finally, their newly created routes should be presented in front of the class.

Owner: ForthNet

Earthquake calculator

<https://earthquake.usgs.gov/education/calculator.php>

A web tool allowing learners to compare between two earthquakes of different magnitudes so that they realise how bigger an earthquake really is compared to another of lower magnitude.

Pathway idea:

1. The teacher asks the audience if they have ever heard of the Richter Scale. He continues telling them that The Richter scale is a scale used to indicate the strength of earthquakes. The scale is a logarithmic scale where each step corresponds to an increase in the amplitude of the wave motion by 10 times. This corresponds to about 32 times more energy.
2. Then the teacher begins with an introduction of earthquakes and what they are a result of. Next, he/she gives a number of specific examples, such as the Sumatran earthquake in 2004 and the Tohoku earthquake in Japan 2011.
3. The teacher continues by presenting the earthquake calculator for students to compare the magnitude of different earthquakes.
6. After that, students will compare different earthquakes to each other and discuss their respective impact on nature and humans in small groups of three people. What regions are most prone to experience earthquakes and why? Can earthquakes be a result of both natural and human causes? If yes, how? Also, what is the difference between *epicentre* and *hypocentre*? The teacher should constantly support to the discussion, and be ready to answer questions on the topic. In the case of a misunderstanding between students, the teacher can mediate between them to foster the discussion. The discussion should last for 10 minutes.
7. Last, each group should present a summary of their discussion to the whole class, ultimately leading up to a discussion between all of them.

Owner: U.S. Geological Survey

European Atlas of the Seas

http://ec.europa.eu/maritimeaffairs/atlas/maritime_atlas/#lang=EN;p=w;

A free online atlas offering various information about Europe's seas and coasts, their environment, related human activities and European policies.

Pathway idea:

1. The teacher begins by explaining that Life on earth is believed by some to have begun in the oceans, which today contain a great richness of species - from cyanobacteria to the blue whale, the largest living animal species. It is the availability of water that has been the prerequisite for life on earth and even today about 40 percent of the earth's population lives near the sea. He/she can highlight interesting facts such as that the oceans cover 70 percent of the earth's surface and consist of about 1.368 billion cubic kilometers of water. The average depth in the oceans is about 3729 meters; about 90 percent of the oceans are deep seas. The largest depth is the Challenger

Depth in the Marian Grave, which reaches approximately 10,971 meters below sea level. The salinity (salt level) of the world's oceans is relatively constant, 3.5 percent.

2. Next, the teacher asks the audience "Have you ever heard of the atlas of the seas, where you can find all kinds of information on our seas?". This might be a better way for the audience to grasp the vast nature of the planets seas.
3. He/she then introduces them to the website and how you can use it to get a greater understanding of the seas on our planet.
4. Students will investigate the waters in and around Europe. They will learn where in the continent the water is deep and where flooding risks are high (The Netherlands for example). Also, they learn how to analyze up-to-date and long-term satellite data.
5. Finally, student will engage in a small group discussion of three on how to solve the issue of rising sea levels, is it enough to build walls like they have done in the Netherlands? The teacher should constantly be present and support the discussion, ready to answer questions on the topic. In the case of a misunderstanding between students, the teacher can mediate between them to foster the discussion. The discussion should last for 10 minutes.
6. Last, each group should present a summary of their discussion to the whole class, ultimately leading up to a discussion between all of them.

Owner: European Commission's Directorate-General for Maritime Affairs and Fisheries

Flash Earth

<http://www.flashearth.com/>

An application for viewing satellite and aerial imagery of the Earth from multiple mapping websites (NASA Aqua, Bing Maps, HERE Maps, Earth at Night, ArcGIS, and MapQuest).

Pathway idea:

1. The teacher begins by asking the question what time it is in New York. Next, he/she describes the time zones and why Greenwich is central to it.
2. After that, the teacher shows the audience the Flash Earth website and how to manage the maps in it. For example, there are many map layers (e.g. Live satellite, Daily satellite, Daily fire spots and Storm tracks. Here, student can try to add/exclude whatever layer they want in order to put focus on different things on earth.
3. Next, should discuss time zones in relation to the map on flashearth.com. Why do we have time zones? How does this affect communication between continents? When is the most people awake? And why is there barely any sunlight in the Scandinavian countries in the Winter? The teacher should constantly support to the discussion, and be ready to answer questions on these topics. In the case of misunderstandings between students, the teacher can mediate between them to foster the discussion. The discussion should last for 10 minutes.
4. Last, each group should present a summary of their discussion to the whole class, ultimately leading up to a discussion between all of them.

Owner: Microsoft Corporation, Imagery NASA

Gapminder

<http://www.gapminder.org>

A number of free resources and tools are available on the Gapminder website. ready to use in the classroom including a development quiz.

Pathway idea:

1. The teacher starts off the lesson with an introduction on poverty connected to geography. For example, he/she can highlight the fact that Geography of poverty (GOP) or poverty geography is a branch of human geography, which studies the geographical patterns, distribution characteristics, areal types and evolution mechanism of poverty and the relationship with geographical environment as well as antipoverty measures. Here, students can discuss how geographical position can be a factor for income level and if they have any suggestions to cope with such problems.
2. Next, the teacher present and describe the Gapminder website, created by Hans Rosling, Anna Rosling Rönnlund and Göran Roslund in 2005. Essentially, it is a web site constructed to educate people on global trends and proportions. Here, students can briefly engage in a discussion on why factfulness is so important in our time where social media is so pervasive.
3. If students look at the first tool (the one with bubbles) they can see how well different nations perform on income level and life expectancy. Is there a correlation between income level and life expectancy? If so – why? When students observe the tool called “Maps” o the website, they may also discuss in small groups of 4 why so many live in China and India, and why the African continent is the fastest growing continent in terms of population. The teacher should constantly support to the discussion, and be ready to answer questions on these topics. In the case of misunderstandings between students, the teacher can mediate between them to foster the discussion. The discussion should last for 10 minutes.
4. Last, each group should present a summary of their discussion to the whole class, ultimately leading up to a discussion between all of them.

Owner: Gapminder

GeoBee Study Toolkit

https://media.nationalgeographic.org/assets/file/GeoBee_Study_Toolkit_2019-2020.pdf

This study toolkit is designed to help your students learn more about our world. It includes blank maps of the U.S., the world, and Africa, as well as past GeoBee questions related to each. Students should challenge themselves to fill out each map using their own knowledge and any atlases they may have available.

Owner: National Geographic

Pathway idea:

1. The teacher begins by telling the audience that today’s lesson will be different, as the students will test their knowledge about the American, African and World Map in a new way.

2. Next, the teacher shows the GeoBee study toolkit, and asks for the student break into teams of 4 for the assignments written in the toolkit. In each groups, the students will ask question to each other (2 vs 2) and count the score. They will begin the question on the US. For each question, they have 1 minute to answer.
3. If the teams find it difficult or get stuck on some questions, they have the internet to help them in their search for answers.
4. After that, each team will swap two members, in order to meet another pair in African geography. Apart from this, the procedure is the same as before.
5. Finally, each team will swap two members again, meeting a third pair in World Geography. Again, it is the same procedure.

Geocaching

<https://www.geocaching.com/play>

Use this free app to navigate to a geocache nearby. Once you find the geocache, sign and date the logbook. Place the geocache back where you found it and log your experience online.

- Learn how to navigate/read maps

Owner: Groundspeak Inc.

Geodata in Greece

<http://geodata.gov.gr/maps/>

Online map viewer of free geospatial data provided by Greek Public Administration organizations.

Owner: IMIS, Athena, OpenGov.gr

Geoguesser (1 free round a day)

<https://www.geoguessr.com/education>

A web-based geographic discovery game which requires players to guess their location in the world using only the clues visible from Google Street View.

Owner: Geoguessr

Geostory

<https://www.geostory.se>

An app where you learn about your country's cultural heritage and discover spatial and historical places.

Owner: Geostory

Google Earth

<https://www.google.com/earth/>

A virtual globe providing satellite imagery, maps, terrain, and 3D buildings, as well as driving directions and Sightseeing Tours.

Pathway idea:

1. The teacher starts by asking how many of the student that have heard about google earth?
2. Next, he/she proceeds by going to www.google.com/earth and teaches the student how to use the website, for example by utilizing the 'I'm Feeling Lucky' Button to start exploring the world and navigating the Earth experience.
3. Teach your students how to find the latitude and longitude coordinates in the map display. As you move your mouse over different locations, coordinates will be displayed in the lower right corner. Have your students go to different parts of the world and observe how the numbers changes.
4. Once students are familiar with the concept, you can also turn gridlines on and off in the Map Style panel. This will give your students a global view of the gridlines. You can begin to test their understanding of how the lines work by looking at different locations around the world. Here it may help the students if they go to this link: https://storage.googleapis.com/gwebearth/education/pdf/ClassroomActivity_GetStartedEarth_EN.pdf (five steps to start creating in google earth).
5. Next, the teacher should lead the audience into having an open discussion in class on why a tool such as google earth is so valuable.
6. As a final activity, the teacher should break the classroom up into small teams of 5. Each group should select 5 locations/regions around the world. The students will then come up with clues for their peer's to guess what locations/regions they have selected. Add the lat/long points to the classroom computer display and you can revisit the locations in the future to test your student's knowledge. This step should not take more than 20 minutes.

Owner: Google

Google Maps

<https://maps.google.com/>

A desktop and mobile web mapping application which offers street maps, satellite imagery, 3D maps and Street View perspectives, as well as functions such as a route planning for travelling by foot, car, bicycle, or with public transportation.

Pathway idea:

1. The teacher begins by asking if the audience know other features in Google maps, except the map feature. He/she continues by introducing the street view perspective, as well as the route planning –and map creating features.
2. Next, the teacher should have his/her students create their own custom Google Map. With this Maps feature, they can choose all the points they want to place on the map. They can use this in

- a variety of fun and/or educational ways, such as a) Add all locations on the map you want to visit, b) Add all locations on the map you've been to before.
3. After that, the audience should try to measure distances. Students can draw a line from one location to another and get the distance between those two points. They can uncover the size of various countries or continents, find the distance between a variety of locations that the teacher has pre-selected for them.
 4. For the next part of the lesson, students can conduct interviews with their peers that are pretending to be from a certain location (in groups of 4). For example, they can use some of the words used "their" country, or name a few neighboring countries. Students will have to ask all the right questions to uncover where they're from. Give everyone a specific amount of guesses (not more than 10) so they are more likely to wait until they have all the information they think they need.
 5. Once they think they know the location, have them pin it on the map and see if they're right.
 6. Finally, the classroom should engage in a short discussion on what locations that were different to pin and why some places were hard to identify. Here, the teacher can introduce the issues with countries/regions/areas that speak the same language (Latin America, France-Canada for example). If there is time, students might discuss *why* some countries speak the same languages.

Owner: Google

Google Lit Trips

<https://www.googlelittrips.org>

Google Lit Trips combines literature with geography. Students can follow in the footsteps of the people in the stories, looking at the environments and places that they visited. Also, it provides downloadable files that mark the journeys of characters from famous literature on the surface of Google Earth.

Owner: Google

Grolier Online Atlas

<http://go.grolier.com/atlas>

An online website providing geopolitical, historical, thematic and exploration maps.

Owner: Scholastic Inc

Guess the place

<https://www.nationalgeographic.org/activity/guess-the-place/>

A website where students play a guessing game, using questions and maps, to identify the name of a city, state, country, or major physical feature in a continent of your choosing, or the United States.

Owner: National Geographic

Jetpunk Mapquiz

<https://www.jetpunk.com/tags/fill-in-the-map>

Quizzes on different continents, countries and capitals.

Owner: H Brothers Inc.

Marble

<https://marble.kde.org/>

A virtual globe of the Earth, the Moon, Venus, Mars and other planets.

Owner: KDE

MapQuest

<http://www.mapquest.com/>

A free web mapping application offering street maps and satellite imagery, driving directions, traffic and road conditions, and nearby businesses and services (health information, lodging, restaurants, travel, shopping, activities, and local services).

Owner: MapQuest

National Geographic's MapMaker

<https://mapmaker.nationalgeographic.org>

An online free map making application that allows users to make maps of any continent or region by selecting different basemaps (e.g., topographic, terrain, street, ocean, etc.) and adding layers of information relating to water, earth systems, human population, food, environment, energy, culture, economy, etc.

Owner: National Geographic

National Geographic's Kahoot Quiz

<https://www.nationalgeographic.org/interactive/continents-europe/>

This quiz tests students on their spatial knowledge about Europe.

Owner: National Geographic Partners, LLC.

Natural Hazards Viewer

<https://maps.ngdc.noaa.gov/viewers/hazards/>

A free online website where learners can view maps of the world including natural hazards (tsunamis, earthquakes etc).

Pathway idea:

1. The teacher show the autonomy of tsunami via this link
<https://www.pbslearningmedia.org/resource/ess05.sci.ess.watcyc.anatomytsunami/>
2. As a class, have students discuss what they know about the impacts Tsunamis and hurricanes can have on coastal communities Ask the students: What makes a tsunami or a hurricane a natural hazard?
3. Ask students to think about and name other types of natural hazards. As they brainstorm, write the hazards they name on the board. When the audience is satisfied with the list, they can name similarities and differences among them and try to define the different natural hazards.
4. After that, the teacher asks the students to form pairs. From here on, they will investigate the impact on particular hazards, which are selected on the website (Natural Hazards Viewer). Each pair should gather information on a) high risk areas for the hazard, b) select a few specific hazards and record what year they happened, efforts that were taken to reduce the damages and the specific damages and costs of these hazards.
5. When students have completed their research, have them present their findings to the class. Record on the board what the students learned about each of the hazards. You may want to record student information in a chart on the board so that they can compare the various hazards. Categories in the chart might include: location, seasonal influences, costs, efforts to minimize damage, and so on.
6. Next, each pair should shift focus to investigating a particular area. They can select one of these places in the US: Cape Hatteras, NC, Louisville, KY, Fargo, ND, Harrisburg, PA, Ventura, CA, Donner Pass, CA, Hilo, HI, Mammoth Lakes, CA, Tacoma, WA.
7. Here, they should do internet research on the hazard risk for each place, and what types of hazards which may occur. They can also gather information of specific hazards that have happened and info around those (year, costs etc.).
8. If there is time, the pairs can briefly present their research to the class. Ideally, they can also engage in a final general discussion of what measures that could be taken to reduce the impact of natural hazards.

Owner: NOAA

Old Maps Online

<http://www.oldmapsonline.org>

Pathway Idea:

1. The teacher should begin the lesson by asking the students how they think ancient and medieval explorers managed to find their way through the seas.
2. Then the teacher starts drawing examples from historical accounts such as: sailors navigating in the Mediterranean made use of several techniques to determine their location, including staying in sight of land and understanding of the winds and their tendencies. The Minoans made sea voyages to the island of Thera and to Egypt. Both of these trips would have taken more than a day's sail for the Minoans and would have left them traveling by night across open water. Here the sailors would use the locations of particular stars, especially those of the constellation Ursa Major, to orient the ship in the correct direction. The pole stars were used to navigate because they did not disappear below the horizon and could be seen consistently throughout the night. Phoenicians used a sound weight, a tool was bell shaped, made from stone or lead, with tallow inside attached to a very long rope. When out to sea, sailors could lower the sounding weight in order to determine how deep the waters were, and therefore estimate how far they were from land. Also, the tallow picked up sediments from the bottom which expert sailors could examine to determine exactly where they were. In fact, this method was widely used by Romans and Greeks too. Sandstones (used by the Vikings), magnetic compass and the sextant were also important navigational tools before the modern GPS.
3. After that, the teacher will introduce the website oldmapsonline.com to the audience and show how to manage it properly.
4. Next, Students can compare old and new maps to gain understanding of the revolution of navigation as well as mapping.
5. Finally, the students can break out in small groups of four for a short discussion on whether the evolution of navigation has come to an end or not. Such a discussion can last for not more than 10 minutes.
6. Follow up activity: The students are asked to work at home and conduct a small historical research on navigation. Subjects that they can choose from are: historical navigators, navigational instruments, great discoveries, ancient navigation, and modern navigation.

Owner: Jisc, The University of Portsmouth, and Klokan Technologies GmbH

Open Street Map

www.openstreetmap.org

An open street map of the world, created by people and free to use under an open licence.

Owner: OpenStreetMap Foundation

Ordnance Survey

<https://www.ordnancesurvey.co.uk/mapzone>

The Ordnance Survey website contains some brilliant kid-friendly activities that are sure to encourage students to learn more about geography. Students can practice map skills, play geography-related games, and use Geographic Information Systems (GIS) to learn more about their world.

Owner: Ordnance Survey

Outline Maps

<http://www.eduplace.com/ss/maps/>

A free website containing maps of the world and the continents that may be printed and copied for personal or classroom use.

Owner: Houghton Mifflin Harcourt Publishing Company

PERMAP

<http://www.newmdsx.com/permap/permap.htm>

A free, Windows-based, real-time interactive program for making perceptual maps (also called product maps, strategic maps, sociograms, sociometric maps, psychometric maps, stimulus-response maps, relationship maps, concept maps, etc.).

Owner: Professor Ronald B. Heady

Play Geography

<https://www.playgeography.com>

A free website where you find lots of games on countries, cities, flags, rivers, seas etc.

Owner: TeachMe

PHET – Greenhouse effect simulator

<http://phet.colorado.edu/en/simulation/greenhouse>

Via this free tool, students can simulate the greenhouse effect.

Pathway idea:

1. The teacher asks the audience the rhetorical question “Is climate change real?” and gets a nod by the students. To engage the students to the topic further, students can discuss why some actors

have interests in putting doubt in peoples' minds whether climate change is real or playing down the risks of it.

2. The teacher introduces the concept of climate change and explains its key causal components (greenhouse effect etc.). The teacher may also explain why the atmosphere is a key term in relation to global warming. Here, the teacher may show some of the evidences from NASA's website <https://climate.nasa.gov/evidence/> to illustrate that the temperature is rising, ice caps are shrinking and sea levels are rising.
3. The teacher continues to present some of the main drivers related to climate change such as the Industrialization and Urbanization etc. Here, the audience may give examples of their own.
4. The teacher introduces the audience to the website and tell them to try the Greenhouse effect simulator on their own.
5. Students can engage in discussions in small groups of 4 on climate change and how much of an impact it has on the earth's atmosphere. What has to be done in order to lower global carbon emissions? Come up with possible solutions and name their weaknesses/strengths. The teacher should constantly support to the discussion, and be ready to answer questions on these topics. In the case of misunderstandings between students, the teacher can mediate between them to foster the discussion. The discussion should last for not more than 10 minutes.
6. Last, each group should present a summary of their discussion to the whole class, ultimately leading up to a discussion between all of them.

Owner: University of Colorado

QGIS

<https://www.qgis.org/en/site/forusers/download.html>

QGIS (previously known as "Quantum GIS") is a cross-platform free and open-source desktop geographic information system (GIS) application that provides data viewing, editing, and analysis capabilities.

Owner: QGIS Development Team

Satellite and Information Service from NOAA

http://www.nesdis.noaa.gov/imagery_data.html

Environmental satellite data and derived products covering Earth's atmosphere, oceans, land and near-space conditions.

Pathway Idea: A discussion on real-time weather patterns and why they are important could be held. What is the difference between a geopolitical map and a satellite map? Strengths and weaknesses?

Owner: NOAA

Scribble Maps

<https://www.scribblemaps.com>

A tool that allows you to draw and make your own maps. The user is able to map their journeys with road and flight maps – which could be used for lessons on transport etc.

Owner: 52 Stairs Studio

Pathway Idea:

1. The teacher begins the lesson by asking the students if they have prior to this day made their own road and flight maps digitally.
2. Next, the teacher introduces the audience to the Scribble Maps website, which is a tool that allows you to draw and make your own maps.
3. The next step of learning is to challenge the Students in creating transit routes by using road and flight maps where they have been and where they want to be. This learning step can be done in pairs, for at least 10 minutes.
4. They should then, in small groups of 5, discuss issues/advantages with being a nation or a company in the spatial centre/periphery (Export/Import costs). In addition, they can discuss whether globalization has drawn countries closer to each other, and how it may influence domestic culture and national identity.
5. Follow up activity: The students are asked to work at home and conduct a small research paper (max 300 words) on a specific country's geographical position and what problems/advantages it may entail. Ideally, they should select a country which they do not a lot about.

Seterra

<https://online.seterra.com/en/>

Quizzes about countries, capitals, flags, oceans, lakes and more. Introduced in 1997 and available in 39 different languages, Seterra has helped thousands of people study geography and learn about their world.

- learn all types of name geography - countries, flags, Swedish landscapes, seas, states, capitals and other cities in Europe, Asia, Africa, South America and North America.

Owner: Seterra AB

Tasking Manager

<http://tasks.hotosm.org/>

A global community putting the world's most vulnerable people and places on the map to support humanitarian aid and sustainable development. The tool shows what needs to be mapped, which areas need to be reviewed and validated for quality assurance and which areas are completed.

Owner: OpenStreetMap Foundation

Urban Observatory

<https://www.urbanobservatory.org>

A free tool comparing and contrasting maps of cities around the world by showing maps in a variety of themes.

Owner: Richard Saul Wurman, RadicalMedia, and Esri

USGS Earth Explorer

<http://earthexplorer.usgs.gov/>

A web application that provides users the ability to search and view satellite images, aerial photographs, and cartographic products from several sources.

Owner: U.S. Department of the Interior U.S. Geological Survey

View from above

<http://qz.com/304487/the-view-from-above-can-you-name-these-countries-using-only-satellite-photos/>

An online quiz about satellite images all over the world.

- Use satellite photos to guess where you are in the world, thus improving your spatial perspective.
- Improve your understanding on cities in different countries/areas look like.

Owner: Quartz Media, Inc.

World Geography Games

<https://world-geography-games.com/world.html>

A free website containing different games where the student can find the countries, regions, lakes, islands etc.

- Learn about continents, continents, islands, seas, cities, the atmosphere and much more.
- Improve your spatial understanding of where all of the above-mentioned things are.

Owner: EastDock Media

Worldmapper

<http://www.worldmapper.org/>

A free collection of world maps where territories are resized on each map according to the subject of interest. The maps give powerful visual impact and clarity to current patterns in development and present an accessible and knowledge-based view of the world as it is now.

Owner: Worldmapper

Yahoo maps

Online mapping portal offering street maps, driving directions, traffic, and satellite imagery.

<https://maps.yahoo.com/>

Owner: Yahoo

6. Examples of Spatial Teaching – High school level Educational Pathways

Navigation then and now

https://portal.opendiscoveryspace.eu/sites/default/files/authoring_tool_uploads/attachments/833441/edu_obj_833441.pdf?fbclid=IwAR3_09bZtBk1TG1l40CxCyy7iqVPu8FD-zuTwPD7-hftLfkZATqbKDEtg4

The art of navigation is presented. Using a historical perspective, students start from the era of ancient navigators, to the Vikings, the great explorers and finally to the ways that we navigate today.

Distances and Scales

https://portal.opendiscoveryspace.eu/sites/default/files/authoring_tool_uploads/attachments/833437/edu_obj_833437.pdf?fbclid=IwAR3Bk7GnICyBRNETzC55vtOsQmcgxJ8dlEB0jMnYoAgo-ArIAHIUkhhTfrY

This activity aims to have the students comprehend the use of scales in maps. Different distances need different scales in order to be accurately depicted on a map.

Starting from simple paper maps, the students move to e-maps and during a hands on activity, optimize the scale for various pairs of locations.

World Market Routes Exercise

https://portal.opendiscoveryspace.eu/sites/default/files/authoring_tool_uploads/attachments/774665/edu_obj_774665.pdf?fbclid=IwAR3Bk7GnICyBRNETzC55vtOsQmcgxJ8dlEB0jMnYoAgo-ArIAHIUkhhTfrY

This is an educational pathway which aims at highlighting the navigational skills of the students and to develop their understanding of the world. Through a game where they have work in groups in order to design the best routes among different places in Europe they familiarize with distances and with the relation of time and distance. Along, they are learning to apply the knowledge gained by designing their own routes on an interactive map.

Outdoor Air Pollution

<https://ourworldindata.org/outdoor-air-pollution?fbclid=IwAR3Bk7GnICyBRNETzC55vtOsQmcgxJ8dlEB0jMnYoAgo-ArIAHIUkhhTfrY>

The main purpose of this educational link is to introduce the students to concepts and components of light pollution which in the last few years it has been recognized as a serious pollution problem with negative consequences on environment and human health.

Will the air be clean enough?

https://www.nationalgeographic.org/lesson/will-air-be-clean-enough-breathe/?fbclid=IwAR37s7yAcHy8WEdo_gxoRbEwTBfljgg_AsOhHpYpfLoh53sAOn6BsuYE9pk

Students explore the question, will the air be clean enough to breathe? They will be guided through the analysis of models and real-world data as they explore the interactions of factors that affect a region's air quality. Students will not be able to answer the module's framing question at the end of the module, but they will be able to predict the effect of human development on a region's air quality.

Sea ice from space

https://www.esa.int/Education/Teachers_Corner/Sea_ice_from_space_-_Investigating_Arctic_sea_ice_and_its_connection_to_climate_TEACH_WITH_SPACE_G04

In this set of activities students will investigate Arctic sea ice. They will learn where in the world it is possible to find sea ice and analyse up-to-date and long-term satellite data about sea ice concentration in the Arctic.

Physical Geography and borders

<https://www.nationalgeographic.org/lesson/more-physical-geography-and-borders/>

Students research four additional examples of physical geography and borders. They explore how mountains, oceans, and islands create physical barriers that affect the country borders in Europe.

7. References

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