GEOGRAPHY STANDARD 1: How to use maps and other geographic representations, geospatial technologies, and spatial thinking to understand and communicate information

Image credit: NOAA/Will von Dauster

Data visualization using Science On a Sphere® at the NOAA Earth System Research Lab, Boulder, CO.

Image credit: Joseph J. Kerski

Using a Global Positioning System (GPS) device, students can identify specific locations (georeference) where data are collected using latitude and longitude coordinates.

The geographically informed person must use maps and other geographic representations, geospatial technologies, and spatial thinking to acquire, understand, and communicate information. Knowing how to identify, access, evaluate, and use appropriate geographic representations will ensure college and career readiness for students. Students will have an array of powerful problem-solving and decision-making skills for use in both their educational pursuits and their adult years.

Therefore, Standard 1 contains these themes: Properties and Functions of Geographic Representations, Using Geospatial Data to Construct Geographic Representations, and Using Geographic Representations.

Thinking about the world in spatial terms (spatial thinking) allows students to describe and analyze the spatial patterns and organization of people, places, and environments on Earth. Spatial thinking skills are essential in processing geospatial data. Geospatial data link physical and human attributes of points or places on Earth's surface (such as roads, other built features, and rivers) and can be compiled, organized, stored, manipulated, and represented in many ways. Maps are graphic representations of selected aspects of Earth's surface and are still a key geographic mode of representation. Globes, graphs, diagrams, and aerial and satellite images (remote sensing) also allow us to visualize spatial patterns on Earth. No single representation, however, can show everything, and the features depicted on each representation are selected to fit a particular purpose.

Geospatial technologies such as geographic information systems (GIS), remote sensing (RS), and global positioning systems (GPS), as well as Internet-based mapping sites such as digital globes and geospatial visualizations, allow us to analyze and represent geospatial data in powerful ways.

At all grade levels, students need practice and experiences in how to collect and display information (data) on maps, graphs, and diagrams. They must understand what a map is and what it can—and cannot—do. They need to be able to read and interpret maps and other geographic representations. And finally, students must know how to make maps, from hand-drawn sketch maps to more complex representations using a range of appropriate technologies.

By learning to think spatially, students can understand such basic concepts as scale, alternative map projections that show Earth from different perspectives, and the relationships between spatial processes and spatial patterns. By understanding these themes, students will be equipped with tools that provide important problem-solving and decision-making skills in geography and across the entire K–12 curriculum.

Essential Element: The World in Spatial Terms

GEOGRAPHY STANDARD 1: How to use maps and other geographic representations, geospatial technologies, and spatial thinking to understand and communicate information

4th GRADE

the student knows and understands:

Properties and Functions of Geographic Representations

1. Properties and functions of geographic representations—such as maps, globes, graphs, diagrams, aerial and other photographs, remotely sensed images, and geographic visualizations

Therefore, the student is able to:

A. Identify and describe the properties (position and orientation, symbols, scale, perspective, coordinate systems) and functions of geographic representations, as exemplified by being able to

- Identify and describe the properties of a variety of maps and globes (e.g., title, legend, cardinal and intermediate directions, scale, symbols, grid, principal parallels, meridians) and purposes (wayfinding, reference, thematic).
- Identify and describe the functions of a variety of geographic representations.
- Identify and describe the properties and functions of maps students collect from magazines, news articles, and tourist brochures.

B. Describe how properties of geographic representations determine the purposes they can be used for, as exemplified by being able to

- Identify the maps or types of maps most appropriate for specific purposes, (e.g., to locate physical and/or human features, to determine the shortest route from one town to another town, to compare the number of people living at two or more locations).
- Describe how a variety of geographic representations (maps, globes, graphs, diagrams, aerial and other photographs, GPS) are used to communicate different types of information.
- Describe how maps are created for a specific purpose (e.g., school fire-drill map, the route from home to school, classroom map of learning center materials).

8th GRADE

the student knows and understands:

Properties and Functions of Geographic Representations

1. The advantages and disadvantages of using different geographic representations—such as maps, globes, graphs, diagrams, aerial and other photographs, remotely sensed images, and geographic visualizations for analyzing spatial distributions and patterns

Therefore, the student is able to:

A. Analyze and explain the properties (position and orientation, projections, symbols, scale, perspective, coordinate systems) and functions of geographic representations, as exemplified by being able to

- Analyze geographic representations based on their properties (e.g., orientation, grid system, scale, resolution, and content) and purposes (e.g., using GIS and digital globes to explore geographic information and relationships at a range of scales).
- Analyze the properties of three geographic representations of the same place (such as a street map, a topographic map, and a satellite image) and explain how each might be suitable for a different purpose.
- Explain how different geographic representations are used in a variety of settings (e.g., a GIS in a computer lab, topographic map for backcountry hiking, GPS navigation for car travel).

B. Evaluate the appropriate use of geospatial representations for specific geographic tasks, such as analyzing spatial distributions and patterns, as exemplified by being able to

- Explain why particular maps are appropriate for a specific purpose (e.g., a cartogram to illustrate total population, a remotely sensed image to observe land-use change, topographic maps to consider the best location for a wind farm, a highway map to consider best routes for new transportation corridors).
- Identify and evaluate specific maps and/or geospatial technologies for use in different occupations (e.g., ambulance driver, airline pilot, ship's captain, cross-country truck driver, business analyst).
- Compare the patterns shown by geographic representations at different scales (e.g., neighborhood, city, state, country).

12th GRADE

the student knows and understands:

Properties and Functions of Geographic Representations

1. The advantages of coordinating multiple geographic representations—such as maps, globes, graphs, diagrams, aerial and other photographs, remotely sensed images, and geographic visualizations to answer geographic questions

Therefore, the student is able to:

A. Explain the advantages of using multiple geographic representations to answer geographic questions, as exemplified by being able to

- Explain how multiple geographic representations and geospatial technologies (e.g., GIS, GPS, RS, and geographic visualization) could be used to solve geographic problems (e.g., help determine where to locate a new playground, or identify dangerous street intersections within a community).
- Describe how an analysis of urbanization can be done using different geospatial technologies (e.g., RS for land use, GIS data layers to predict areas of high/low growth, GPS and GIS for identifying transportation issues regarding growth).
- Explain how multiple geospatial technologies can be used to solve land-use problems (e.g., effects of new farming technologies on the sustainable production of food, preservation of wetlands in bird migration flyways).

Essential Element: The World in Spatial Terms

GEOGRAPHY STANDARD 1: How to use maps and other geographic representations, geospatial technologies, and spatial thinking to understand and communicate information

4th GRADE

the student knows and understands:

Using Geospatial Data to Construct Geographic Representations

2. Geospatial data are connected to locations on Earth's surface

Therefore, the student is able to:

A. Identify examples of geospatial data, as exemplified by being able to

- Identify landmarks on the school grounds and describe their size, shape, and location.
- Identify the spatial location of each student's assigned seat in the classroom.
- Identify the locations and types of trees in the neighborhood of the school.

B. Construct maps and graphs to display geospatial data, as exemplified by being able to

- Construct a map that displays geospatial data using symbols explained in a key (e.g., a sketch map to illustrate a narrative story, a map of cars in the school parking lot showing type and color, a classroom map showing different types of tables, desks, and chairs).
- Describe the results of a survey of classmates about a geographic question concerning their school (e.g., where to add another swing set, where to add a cover over existing playground equipment, where to place more drinking fountains) using graphs and maps.
- Construct a map of the United States using symbols to show quantities by state (e.g., population, professional sports teams, mountain peaks over a certain elevation).

8th GRADE

the student knows and understands:

Using Geospatial Data to Construct Geographic Representations

2. The acquisition and organization of geospatial data to construct geographic representations

Therefore, the student is able to:

A. Identify the variety of geospatial data sources (e.g., student-generated data such as surveys, observations, and fieldwork or data sources such as US Census data, US Geological Survey (USGS), and the United Nations) and formats (e.g., digital databases, text, tables, images), as exemplified by being able to

- Identify examples of different sources of geospatial data related to population, land forms, road networks, weather, etc. (e.g., Census Bureau, [USGS], Environmental Protection Agency).
- Identify the different data formats that can be used to organize data sets for population, land forms, road networks, weather, etc. (e.g., tables, graphs, maps, remotely sensed images).
- Identify the data to include in student-generated geospatial data sets to capture human or physical characteristics of the school neighborhood (e.g., count and map the location, amount, and directions of pedestrian traffic on streets near the school).

B. Construct maps using data acquired from a variety of sources and in various formats (e.g., digital databases, text, tables, images), as exemplified by being able to

- Construct paper maps to illustrate the links between geographic patterns (e.g., examine associations among geographic phenomena such as water resources and population distribution or topography and Civil War troop movements).
- Construct different types of maps to illustrate the distribution of population (e.g., cartograms, choropleth maps, isopleth maps, graduated circles maps).
- Construct flow maps to explain the amount, source, and direction of movement (e.g., international petroleum trade, migration of refugees, flyways of bird migration, immigration to North America during the 1800s).

12th GRADE

the student knows and understands:

Using Geospatial Data to Construct Geographic Representations

2. The technical properties and quality of geospatial data

Therefore, the student is able to:

A. Identify and explain the metadata properties (e.g., resolution, date of creation, and method of collection) of geospatial data, as exemplified by being able to

- Explain how the metadata information is used to understand differences in the creation and design of datasets (e.g., land use/land cover, street/storefront property uses, terrain features, scale) and to determine the usefulness of the data for mapping.
- Analyze the relationship between the quality of data and the source of the data (e.g., differences in reported population data by countries, boundaries as reported by different adjacent countries).
- Describe how metadata assist in determining appropriateness of the data set in relation to use or layering with other data sets.

B. Evaluate the quality and quantity of geospatial data appropriate for a given purpose, as exemplified by being able to

- Describe the many purposes for which a data set would be appropriate (e.g., 1:1,000,000 scale maps, 30-meter pixel satellite images, tables of state health data).
- Explain how data that are appropriate for a task at one scale may be inappropriate for a similar task at a different scale (e.g., census blocks and tracks for local data, county/parish for state or national data).
- Analyze a variety of data sets that present variations in space and time (e.g., Arctic ice in January and July, population counts for metro areas at different time periods, location and number of influenza infections by month).

Essential Element: The World in Spatial Terms

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4th GRADE

the student knows and understands:

Using Geospatial Data to Construct Geographic Representations

3. Geospatial technologies—Internet-based mapping applications, GIS, GPS, geovisualization, and remote sensing—display geospatial data

Therefore, the student is able to:

A. Compare how different geospatial technologies are used to display geospatial data, as exemplified by being able to

- Identify and describe the types of information communicated by different Internet-based mapping technologies.
- Describe and analyze the similarities and differences among the results from different online navigation systems.
- Compare the similarities and differences of information presented in online road maps, satellite images, or street-view data.

8th GRADE

the student knows and understands:

Using Geospatial Data to Construct Geographic Representations

3. Geospatial technologies—Internet-based mapping applications, GIS, GPS, geovisualization, and remote sensing—can be used to construct geographic representations using geospatial data

Therefore, the student is able to:

A. Construct and analyze geographic representations using data acquired from a variety of sources (e.g., student-generated data such as surveys, observations, fieldwork, etc., or existing data files) and formats (e.g., digital databases, text, tables, images), as exemplified by being able to

- Analyze environmental change by annotating a series of remotely sensed images of the same location taken at different dates.
- Construct map overlays of GPS-based geospatial data using GIS (e.g., types of housing, local historical structures, neighborhood bus stops).
- Construct a map displaying the results of a community survey on a local issue (e.g., locating a new park or school, stream flooding, zoning decisions).

12th GRADE

the student knows and understands:

Using Geospatial Data to Construct Geographic Representations

3. The appropriate and ethical uses of geospatial data and geospatial technologies in constructing geographic representations

Therefore, the student is able to:

A. Evaluate the appropriate and ethical uses of different geospatial technologies and methods for acquiring, producing, and displaying geospatial data, as exemplified by being able to

- Evaluate the appropriateness of using geospatial data that may identify particular individuals (e.g., use of cellular phone geolocation data, license plates and faces in street-view data).
- Describe and evaluate the conditions under which geospatial data should be restricted (e.g., availability of infrastructure data on web-sites, sensitive areas not displayed on satellite imagery, confidentiality of individuals when displaying health data).
- Describe and explain the appropriate documentation needed to assess the credibility of a GIS-based project (e.g., quality of data files used, processes used, steps to duplicate the project).

GEOGRAPHY STANDARD 1: How to use maps and other geographic representations, geospatial technologies, and spatial thinking to understand and communicate information

4th GRADE

the student knows and understands:

Using Geographic Representations

4. The interpretation of geographic representations

Therefore, the student is able to:

A. Describe and analyze the ways in which geographic representations communicate geospatial information, as exemplified by being able to

- Describe the purpose and components of a typical map key or legend.
- Describe and analyze the similarities and differences in information displayed at different scales.
- Analyze the different ways of symbolizing geospatial data (e.g., graduated circles, cartograms, choropleth versus isopleth maps).

8th GRADE

the student knows and understands:

Using Geographic Representations

4. The use of geographic representations to ask and answer geographic questions

Therefore, the student is able to:

A. Analyze geographic representations to ask and answer questions about spatial distributions and patterns, as exemplified by being able to

- Analyze printed and digital maps to observe spatial distributions and patterns to generate and answer geographic questions (e.g., use digital census data to determine demographic patterns in a state, or analyze census data and transportation routes to identify and locate services, such as a day-care center or stores needed in a region).
- Analyze choropleth maps to examine spatial relationships (e.g., between the number of doctors and mortality rates, between corn production and hog production, between global energy production and consumption).
- Analyze the overlap among multiple geospatial data layers to identify potential locations of interest (e.g., site for a new park, route for a new road, location of high incidences of crimes).

12th GRADE

the student knows and understands:

Using Geographic Representations

4. The uses of geographic representations and geospatial technologies to investigate and analyze geographic questions and to communicate geographic answers

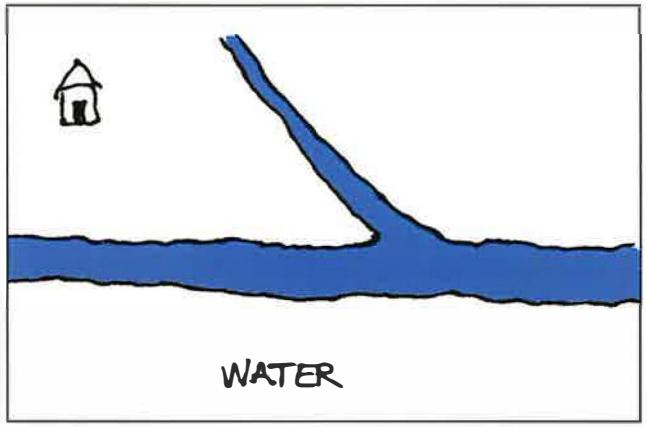
Therefore, the student is able to:

A. Analyze geographic representations and suggest solutions to geographic questions at local to global scales using geographic representations and geospatial technologies, as exemplified by being able to

- Construct a presentation using multiple geographic representations and geospatial tools that illustrates alternative views of a current or potential local issue.
- Construct maps using Web-based mapping of national forest areas showing terrain, vegetation, roads, hiking trails, campsites, and picnic sites to identify possible new areas of public use, trails and roads, and areas to close for habitat recovery.
- Analyze the possible relationships between global human and physical changes using GIS (e.g., the relationship between global climate change, sea level rise, and population distribution).

Where are bridges needed?

Students can use the basic GIS concept of overlay to answer geographic questions.



Basic GIS Step 1: Sketch the first data layer, in this case water, and the location of a house that will serve as a reference point for all data layers.

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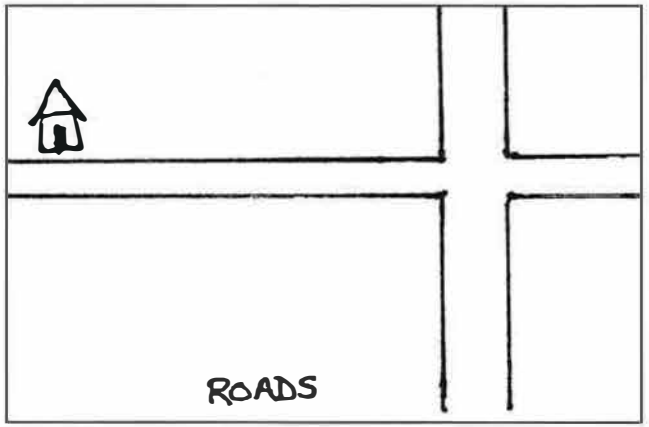

Basic GIS Step 2: Sketch the second data layer, in this case roads, and include the location of the house as the reference point.

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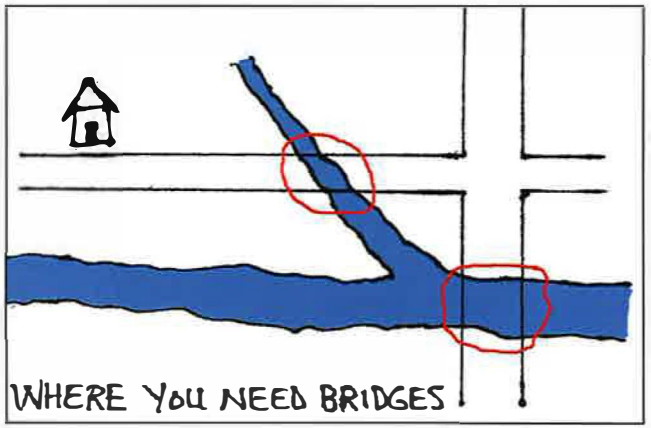
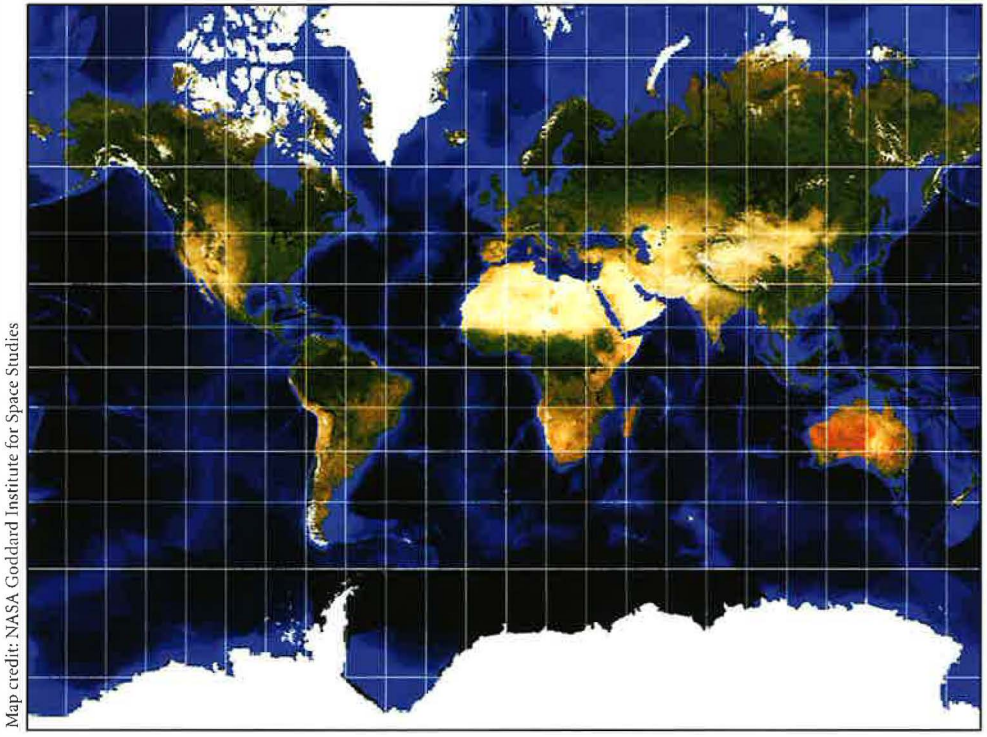


Basic GIS Step 3: Ask students to overlay the second data layer over the first using the house as the reference point and identify relationships between the two data layers, in this case where you need bridges for roads to cross the water.

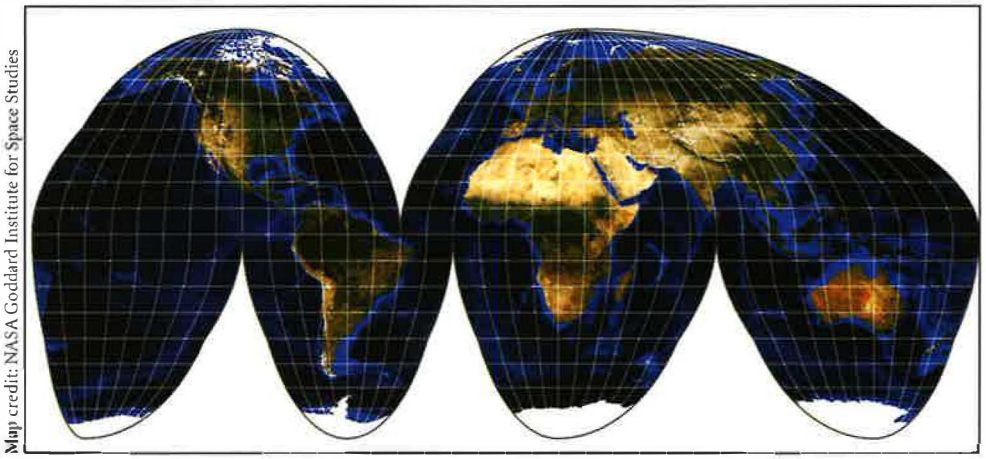
GEOGRAPHY STANDARD 1: How to use maps and other geographic representations, geospatial technologies, and spatial thinking to understand and communicate information

Projecting the round Earth onto flat paper presents problems for geographers because it always introduces some degree of distortion in at least one of the following four spatial properties: shape, area, distance, and direction. The Mercator Projection presents true shape (except at the poles) and true direction, but wildly distorts relative areas of land masses. Compare the shape of Greenland and South America, for instance, on the Mercator Projection and a globe. The Goode Homolosine Projection was developed as an antidote for the widespread use of the Mercator Projection in the early twentieth century. It maintains true relative areas and tries to minimize distortion in the other three spatial properties by using "interruptions," or cuts, through the oceans. It is called an equal-area projection. The Winkel Tripel Projection is a compromise because it tries to mediate between maintaining true shape and equal-area relationships, both of which still have some slight distortion.



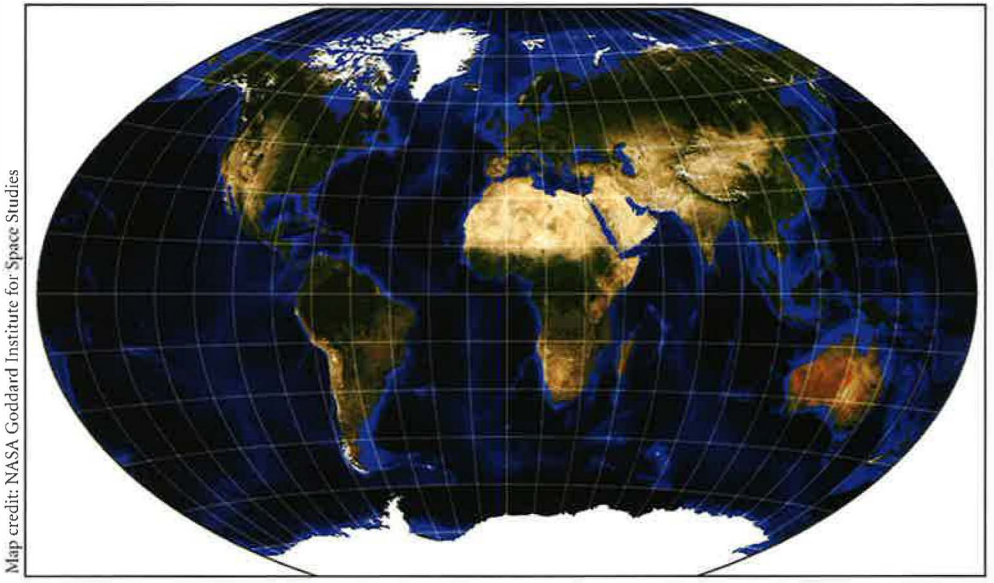
Map credit: NASA Goddard Institute for Space Studies

Mercator Projection.



Map credit: NASA Goddard Institute for Space Studies

Goode Homolosine Projection.



Map credit: NASA Goddard Institute for Space Studies

Winkel Tripel Projection.