



ASTROEDU

Peer-reviewed Astronomy Education Activities

Country Movers - Visualizing Spatial Scales in Planetary and Earth Sciences

**Move your whole country to another
planet**

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 AGE 12+	 LEVEL Primary, Middle School, Secondary, University
 TIME 30min	 GROUP Group
 SUPERVISED No	 COST PER STUDENT Low Cost
 LOCATION Small Indoor Setting (e.g. classroom)	 CONTENT AREA FOCUS Earth Science
 ASTRONOMY CATEGORIES Planetary systems	 EARTH SCIENCE KEYWORDS Geoscience, Geography
 SPACE SCIENCE KEYWORDS Space Habitation	

CORE SKILLS

Planning and carrying out investigations, Analysing and interpreting data, Constructing explanations, Communicating information

TYPE(S) OF LEARNING ACTIVITY

Guided-discovery learning, Modelling

KEYWORDS

Geography, Spatial thinking, Planetary science, App

GOALS

- Develop a sense of sizes and distances in geography, especially in extraterrestrial bodies.
- Develop extraterrestrial planetary geological knowledge and thus understand better the uniqueness of Earth.
- In the meantime, play with projections (cartographic) and GIS



LEARNING OBJECTIVES

- Students will be able to describe the outlines of geography of a part of another planet.
 - Students will do comparative spatial analysis, i.e., be able to compare landforms between their country/US State and an extraterrestrial body.
 - They will be able to draw a map of a given portion of Mars, the Moon, Venus, Io or Titan using online photomosaics or DTMs.
 - Students will have a practice on choosing sites for fictional human settlements on another planet or moon based on the geography of the site using multicriteria analysis, thus simulating the landing site selection process.
 - Students will be able to use names from the IAU Gazetteer of Planetary Nomenclature.
 - Students will practice drawing a (planetary) map, learning the basics of cartography.
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EVALUATION

Below list a few of the potential evaluation methods that can be used to evaluate how well the students were able to achieve the learning objectives listed above. The following numbered activities each are based on each previous one. The students can go as far as available time permits. Alternatively, the whole class may participate in the activity together, led by the teacher.

- 1) Ask the student to choose a planetary body they will work with. The basic goal is to find a location for a country/state-sized human self-sustaining (imaginary) infrastructure. The most common choice could be Mars since it is the most Earth-like world with diverse landscapes, however, the Moon may also be a good choice since humans already visited it. The student may also choose more exotic worlds.

- 2) Ask students to choose a “landing site” on a planetary body for their home country/state. They should be able to argue for their choice, which may include local science goals (geology, astrobiology), engineering concerns (geological, safety of constructing buildings or routes), meteorological or astronomical (day/night) factors or just similarities in topography.
- 3) Ask students to draw a physical geographic sketch map (on paper) of the country/state after moving it to any of the available planetary bodies, based on what individual features they can identify on the screen view (topography/relief, albedo). They can also use a grid, scale etc. The map should contain at least the generalized outline or symbol of the main features seen on the map, within the outlines. This activity may require more explanation from the instructor on the features’ formative processes and boundaries.

- 4) Ask students to display the official IAU names if/where appropriate. This activity ensures that they can pair names with features. However, a smaller region may not include named features.
- 5) Ask students to describe the new geography of the country and list the landform types (mountain, crater, volcano etc.) within the borders of the country/state on the planetary body. Students should use the names of local geographical features of their country/state or names of cardinal directions in order to be able to explain which new landforms are in which part of their “new” country/state. Although it is not a part of the App’s sensu stricto goals, students should also understand the nature of the features they see on the map. Using morphology or relief as a key for identification, students should produce the previously mentioned list of the graphically identified features on their map, with preferably three parameters:
 - 1) a description (high cone, lineated terrain, circular cavity – with their own words),
 - 2) a geological term that reveals their origin (impact crater, volcano, ice cap, dune field etc.), which shows that the student understands the nature of the feature; and
 - 3) a placename for that feature.
- 6) Ask students to add settlements and roads in the map and explain why they have chosen those locations or routes for transportation, what kind of vehicles they plan to use and what kind of road they will build (just poles to show directions or actual road).
- 7) Ask students to identify up to five landmarks that can be used for surface operations, i.e. are visible from the surface and distinct.
- 8) Ask students to name their new settlements and roads (by either actual names or some other form of designation they invent.)
Alternative activity:
- 9) FIELD TRIP TO EARTH
Users may simulate a planetary exploration here on Earth. In Earth map view they can start from the place they live. Users may plan exploration routes and define “science areas of interest” to visit within 100 km circle (similar to the concept of human Exploration Zones, listed among the countries in the App). They can describe each “traverse”, their potential science results and hazards. This task can be continued in an actual field trip where students can record their observations during the planned route and discuss differences between planning and actual execution of the plans in the field. We note that for a planetary analog study, no special equipment (e.g., simulated space suit) is needed, as shown by NASA’s BASALT (Biologic Analog Science Associated with Lava Terrains) research program. Students can explore the mission planning, scheduling, execution, real-time and post-mission analysis of data from many perspectives, including logistics, effective recording of data, communication between astronauts and mission control. In locations where no planetary analog terrain is present, a vegetated terrain provides analog to a fictional exoplanetary exploration. This application can be considered a gamification of a traditional class field trip in biology, ecology, geology, geography. Students may be asked to also observe humans as an “alien species” and find reasonable explanations of their observable behaviors, extending the range of disciplines to social sciences (for example: why do people move to cities where no food is available locally).

These tasks may be made either orally during class or as a short composition / drawing that the teacher can subsequently collect and evaluate.



MATERIALS

- Computer/laptop/smartphone – one per student, - student group or class, depending on setting
 - Internet access
 - Projector optional for class-wide activity
 - Paper
 - Pen
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BACKGROUND INFORMATION

Estimating sizes and distances on planetary surfaces is a difficult task on spacecraft imagery because of the lack of familiar landmarks of known sizes, the ubiquity of scale-independent landforms (craters, cracks, cones, dunes), and also due to the different radius of planets and satellites.

To estimate the extent of features and distinct regions is therefore almost impossible on a planetary surface without a scale. A map that the student is familiar with greatly helps estimating sizes and distances since it projects the known environment onto the planetary surface, virtually placing the student into a known 3D environment. The basic goal, however, is not just to add a sense of sizes to a map view, but to help the virtual exploration in the environment of another planetary surface. Ultimately, by exploring a lifeless planet in imagination with a sense of the real scale, the unique characteristics of our own, well-accustomed terrestrial environments will be emphasized.

A few unusual phenomena that will likely be encountered in viewing orbital images or planetary maps are: the inability to discriminate sizes of simple craters and the abundance of craters; problems in viewing craters and hills in inverted relief, the large sizes of canyons, troughs, volcanoes, lava flows; the large sizes of terrains with undifferentiated (similar, or repetitive) relief features in general (without vegetation and man-made features that would otherwise segment an undifferentiated geologic substrate).

Students should also focus to delimitate single features by identifying boundaries where a terrain changes. These are the contact lines of geologic units or features, and even think about their origin, stratigraphic relations (which was produced first, and which cut into that or covered that subsequently) or relief changes. This is a basic requirement to be able to identify and discriminate standalone “features” on the landscape.

How the App works

The outline of a chosen country, U.S. state or a standard 100 km radius Mars Exploration Zone can be displayed and moved on the surface of another planet or moon (currently, Mars, Venus, the Moon, Io, Titan and Jupiter), keeping its

original size. This comparison can be done either on the surface of a rotatable globe model or on a 2D map in Web Mercator projection.

FUNCTIONS

Select and display maps: The user can select thematic raster maps from eight planetary bodies. Scale and legend is included in the maps in rasterized form.

Navigation:

- Zoom in-out: mouse scrolling or +/- button on screen
- Position of the globe within the screen: Shift+drag mouse
- Rotate globe: drag mouse
- Change center of perspective: ctrs+shift+drag mouse
- Start/end line measurement: mouse click
- Reset distance measurement tool: turn the tool off and on

****Country overlay:** The user can overlay the vector outline of any country or U.S. State or a standard 100-km-radius Exploration Zone on any embedded planetary body. The outline can be displayed and moved on the surface, keeping its original size, in both 2D and 3D views. When drawing the country outlines, the radius differences of the bodies are taken in account.

Projection: The maps have two views: a 2D flat map in Web Mercator projection, and a 3D rotatable virtual globe model (no surface relief is shown in 3D). These two different view modes offer various uses. The flat version can also be used to demonstrate the high area distortions of the Mercator projection e.g. by moving Greenland to lower latitudes (Fig. 3). However, due to the properties of Mercator projection (poles are projected to infinite distance), polar regions cannot be explored effectively in the flat view, only on the 3D globe. The virtual globe mode is a useful tool to demonstrate the size differences of the planetary bodies. For instance, Australia on the Moon would cover almost an entire hemisphere (Fig. 4).

Distance measurement: This tool is used to draw a polyline, calculates and displays distance and travel time between the two end points, in various units that includes the maximum speed of a walking astronaut, an automatic rover, a human-driven rover and a car on a blacktop freeway.

Coordinate display: It shows the position (IAU geographic coordinate) of the cursor. Earth and Moon coordinates are displayed in the ± 180 longitude system, Mars and Venus in the 0-360° Eastern longitudes system and the other bodies in the 0-360° Western longitudes system.

Colors: The user can determine the color of the measurement polyline and the country outline.

Screenshot: Using the screenshot feature built into the App, users can save the current view as a png image file that includes any traverses the user created but excludes the user interface), providing a printable background map for further activities. The user can continue working on this map in an external image processing application where they can add settlements, roads, regions of scientific interests etc., learning the concepts of planetary physical geography, toponymy, cartography, mission and city planning. These aspects are discussed in Chapter 4 in detail.

Place names: Place names are rasterized or “burnt into pixels”, so that we could use the full spectrum fonts can provide, including font faces, sizes and styles, to distinguish places of different type, size and landscape hierarchy level. This function is not available in nomenclature vector layers that are not feature polygon-linked, as is the case for the majority of planetary map platforms. The major disadvantage of the rasterized nomenclature, however, is that it is not scale-dependent: by zooming into the view, the names become disproportionately large and place names cannot be searched for.

Info (about): This window contains information on the Tool, including links to references and online tutorials.

PLANET OVERVIEWS

The Mercury globe is a green-to-red color hillshade MESSENGER Global DEM topographic map. Mercury is characterized by densely cratered terrains and less cratered smooth volcanic plains. Some large basins resemble those on the Moon. Wrinkle ridges (long ridges) occur in all parts of the planet, likely resulted from the cooling of the crust.

The Venus view is a monochromatic colorized mosaic of Magellan radar images in which bright tones show rough areas (trough systems, tectonically deformed tesserae, and lava flows), medium tones show lava plains, and dark tones represent smooth, dust covered regions.

The Moon topographic map is based on the Lunar Reconnaissance Orbiter Camera Wide Angle Camera (LROC WAC) DEM data. The Moon is a relatively small body, with two distinct terrains colored according to their different altitude range blue and yellow: lowland plains (maria) and highlands, respectively. This topographic difference coincides with the albedo difference visible to the naked eye: volcanic (basaltic) maria are dark and megabreccia-dominated anorthositic highlands are bright. This difference is partly due to the different materials and the different roughness of the two terrain types: basalt is darker and these plains are also smoother, while anorthosite is brighter and highlands are also densely cratered. Prominent features of the map are the rings of multiring basins usually with a mare plain at their centers. The enormous, ancient South Pole-Aitken Basin is also evident in the relief map but remains hidden in the photomosaic view.

Mars has two views: one topographic and one albedo. The topographic color hillshade map of Mars is based on MOLA gridded DEM and displays the lowlands and basins in white to yellow, highlands in brown, high shield volcanoes in dark brown. The albedo globe shows the permanent, bright ice caps, medium-toned dust covered regions and dust-free dark areas that may be covered with basaltic sand. The albedo map is produced from the Mars Global Surveyor Mars Orbiter Camera (MGS MOC) photomosaic and shows both albedo and topographic place names.

The map of Io is a false color Galileo-Voyager photomosaic in which the most distinct features are the red, sulfur-rich plume deposits of active volcanic centers (symbolized by red asterisks) and dark lava-filled calderas. The yellow coloration of the surface is caused by sulfur coating while the brightest areas are covered by a volatile, sulfur dioxide frost, deposited from volcanic degassing. Most irregular patterns represent lava flows, while the over 100 mountain blocks are most apparent in the south polar region where they are shown casting long shadows in this mosaic. Mountain peaks are indicated by black triangles and peak heights are displayed in meters. These symbols are taken from terrestrial maps and are not usual parts of planetary maps.

The map of Jupiter shows the cloud bands with nomenclature, in which any country can be easily placed into the white ovals and the Great Red Spot. The map background is the color image of Jupiter produced by the Hubble Space Telescope OPAL Program. Since Jupiter has no solid surface, this map only shows the size of the planet and its atmospheric features (clouds, cyclones) relative to others. NOT SUITABLE FOR LANDING - NO SOLID SURFACE.

The composite (infrared+radar) Titan globe shows the Cassini infrared (ISS) view of the satellite that shows dark equatorial dunes, dark polar liquid methane filled lakes and bright terrains made of rocks of H₂O ice. Stripes of Cassini radar images give a higher resolution view in the north polar regions.

In addition to the above listed maps, Google's photomosaics of Mars (THEMIS daytime thermal infrared mosaic at 100 m/px raster data resolution) and the Moon (Clementine albedo mosaic, 100 m/px resolution) are also embedded into the App without any modification, and provide the highest resolution background maps.

MAP TYPES

The maps have somewhat different themes. This difference is partly due to the differences in planetary mission designs, instruments and surface conditions: for instance, the atmosphere of Venus and Titan is opaque in visible wavelength and therefore an optical image mosaic of the surface is not available for this body.

Photomosaic maps show the surface at a particular wavelength(s) and solar incidence angle. Low-sun mosaics are composed of images taken when the Sun is near the horizon. These images emphasize relief by showing long shadows. High-sun images show albedo, or reflectivity, of the surface that may represent differing composition, grain size, or surface roughness. Albedo features may or may not correspond to topographic features (relief). These maps are usually monochromatic (greyscale), and may show the surface in visible, near infrared or thermal infrared wavelengths. Mosaics of images taken at different wavelengths may be combined into a color image. These are usually false color mosaics and include visible and infrared bands. Examples: Mars, Moon, Io

Imaging radar maps show the radar reflectance properties of the planetary surface. A radar instrument onboard the orbiting spacecraft "illuminates" the surface by cm-scale radar pulses emitted by the spacecraft's transmitter. A portion of this electromagnetic radiation is reflected from the surface and is received by the antenna of the radar instrument. The radar echo or radar return depends on the roughness of the surface relative to the radar wavelength used for the mapping. Typically, dusty or sandy (particles less than a centimeter) areas do not reflect cm-scale radar waves and remain dark and rocky surfaces (particles greater than a cm) produce strong radar return signal and are represented as bright areas on radar maps. Radar maps are typically displayed in monochromatic (greyscale) form. Examples: Venus, Titan (partially).

Topographic maps show surface elevation and relief. Although the initial topographic dataset (digital elevation model, DEM) has no associated colors and could be displayed in greyscale shades, these maps are typically displayed in a custom-made color ramp (color coding) combined with hill-shading that enhance the sense of relief. This visualization provides the most familiar cartographic picture of a surface. The color ramp for topographic maps of different bodies could be similar, however, we chose different color ramps to reflect a color-related mental association of the particular body. These colors are symbolic and do not correspond to the real color of the body, neither follow the color ramp of terrestrial physical geographic maps where colors are related to the presence of water or are symbolic, simplified representations of zonal vegetation. Students should familiarize with the color ramp before studying the map (rasterized legends are available in the maps). Planetary topographic data may be obtained from radar altimetry, laser altimetry or stereo imaging etc., techniques. Examples: Mercury, Mars, Moon.

Merged themes. A map product may combine different themes. Relief can be shown by colors or shadows (either in a low-sun photomosaic or by producing hillshading from a digital elevation model). Surface material / compositional units may be emphasized in albedo maps, high-sun (local noon) or nighttime infrared photomosaics taken when shadows are equally absent. While noon images show the reflectance of surface materials, nighttime thermal infrared images show thermal inertia properties.



FULL ACTIVITY DESCRIPTION

Before the activities the teacher should check the App to make sure it is compatible with the video card / computer that will be used. Three options can be chosen:

- a flat Google API, <http://countrymovers.elte.hu/g.html>
- a flat Cesium API, and a 3d (virtual globe) Cesium API. <http://countrymovers.elte.hu/countrymovers.html>

Whichever the most stable should be chosen for classroom demonstration. This activity consists of a mixture of student activities on handout, teacher demonstrations and student discussions.

FULL ANALOGUE VERSION

If computers are not available, the teacher can prepare an analog version of the App: print out a planetary map detail at the appropriate scale and draw or print the outlines of your country/state on a transparency film and cut it out. The students may move this transparency film on the map to find its new location. The best result is when a planetary globe is available on which the transparency film can be moved.

ACTIVITY 1 - PREPARATION

1. Display the map using a classroom projector or computer screen(s).
2. Display your country or state on Earth.
3. **STUDENT ACTIVITY ON HANDOUT** On a piece of paper, draw the outlines of your chosen country/state. Don't include any geographic features, draw only the outlines. It can be a rough outline, the details are not necessary.
4. Choose a planetary body (planet or moon) for all further activities. We recommend the topographic map of Mars or of the Moon for starting activities. Do not use Jupiter in this exercise, it has no solid surface.

Specific activities:

ACTIVITY 2 - DISPLAY COUNTRY/STATE ON ANOTHER PLANET

Choose your country/state from the drop-down menu and choose the target body from the other drop-down menu.

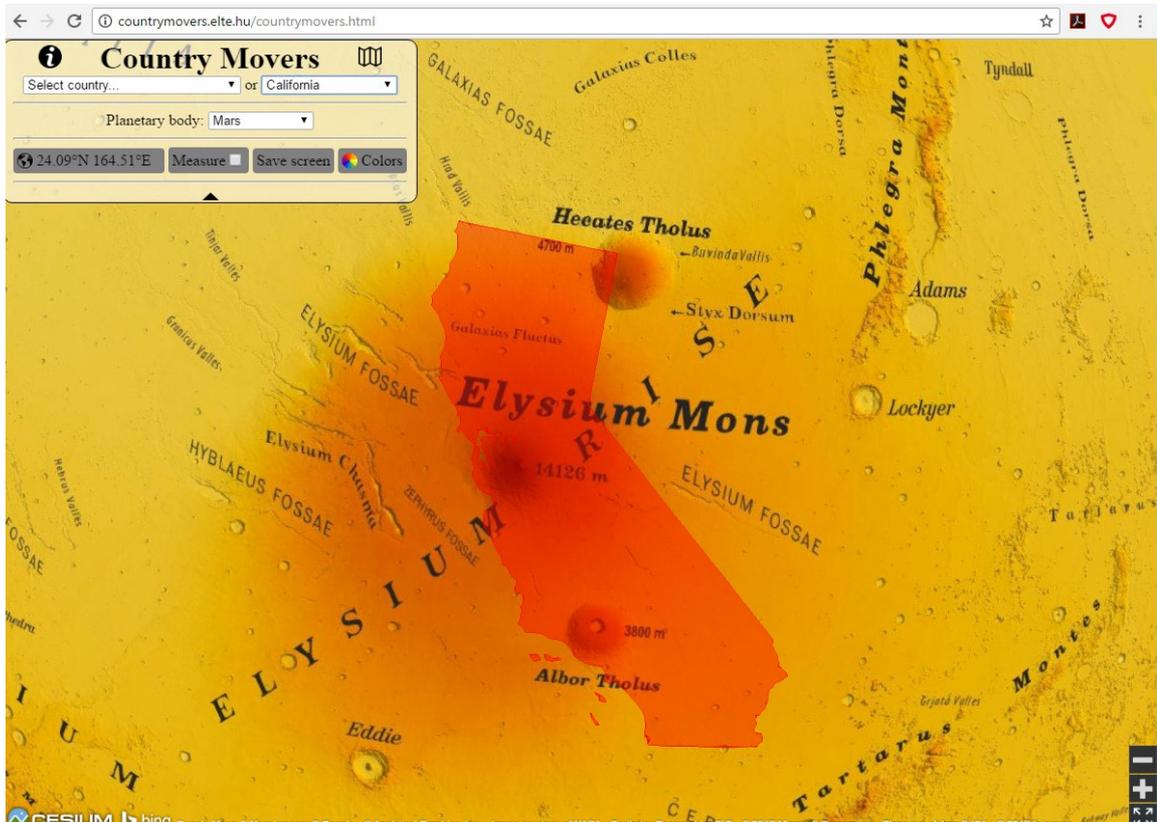
1. The outline will be initially displayed at the coordinate where it is located on Earth. This is the easiest, but it may place the country onto a featureless area. Advantage: fast, no need for student input. You may keep this view or move the outline. If the area is featureless, you should move it to another place. In this case, rotate the globe first to give a global overview of the geography of the planet or moon.

Now read or tell students about the general geography of the chosen body, and a short explanation on what the map shows, based on the Planet overviews in the "Background materials" section of this document. You may also summarize how to interpret the image data (from Map types descriptions).

California at its terrestrial coordinates, placed onto Mars.

1. You may move the outline to another location where local geography is more varied or resembles the actual terrestrial relief. Choose a site that

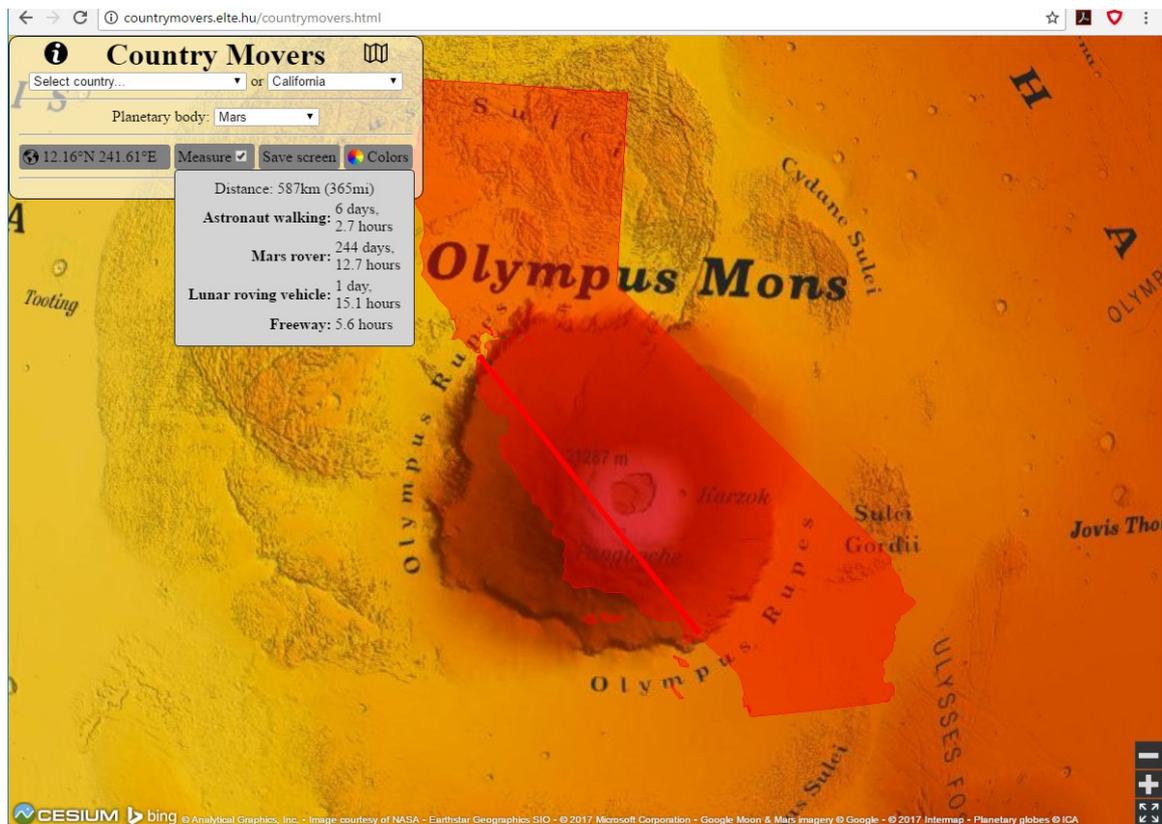
contains several different prominent feature types. Drawback: may be time consuming.



California moved to a geologically more diverse location

ACTIVITY 3 - COMPARE SIZES

Choose a prominent geographic feature within the outlines and measure its width, and say their sizes in absolute distance (km/mile), relative distance (compared to real features in that country/state) and travel time units (displayed in the App).



Olympus Mons is as large as the distance from San Francisco to LA and it would take 5 hours to travel from one side to the other by car if there were a blacktop highway on Olympus Mons.

ACTIVITY 4 - COMPARE PROJECTIONS

1. Compare routes: Create a measurement line (route) between two distant points. Change the view from 2D to 3D in the Cesium app view. Observe how the route is changing from like to arc as you change view and rotate the 3D globe view.

The route from Elysium to Olympus Mons. a) 2D flat view, b) 3D globe view

1. Compare outlines: Move the outlines in N-S direction in the 2D flat view. You may move the outline of your country/state on the Earth map. Observe as the outline changes. Now repeat this in the 3D view (no size change is observed).

California at low (below) and high (above) latitudes in 3D flat map view.

ACTIVITY 5 - DESCRIBE GEOLOGY

1. Split the country into terrain types. Identify major features ("units") within the country/state outlines by differentiating the different textures/patterns/relief types/colored areas etc. on the map.
2. STUDENT ACTIVITY ON HANDOUT Draw the outlines (called "contacts") of the identified units using paper and pencil. Identify only major/prominent features, not more than 5.
3. Describe each unit in morphologic terms (high, low, cone-shaped, bowl-shaped, basin, flat terrain, hilly, knob, rolling etc.)

4. Provide interpretation. To answer the question “why are they different”, create a model of the unit’s geology that includes the followings for each identified feature:
 - 1) origin (the geologic process that produced the feature, for example impact, volcanic, aeolian, fluvial, marine, glacial, tectonic etc.),
 - 2) material (basalt lava for volcanoes and lunar maria, impact breccia for craters, H₂O and CO₂ ice for polar caps of Mars, sand for dunes, ice rich regolith for patterned ground, methane for lakes on Titan etc.).
 - 3) ADVANCED / IF APPLICABLE: the sequence of the formation of the landscape (geologic evolution). The sequence can be established from
5. stratigraphy, observing which features is younger, for example where a crater is emplaced upon another or a lava flow floods an older crater, or a fracture cuts through a preexisting feature;
6. using crater counting (crater frequency) where densely cratered surfaces are older and less cratered is younger
7. STUDENT ACTIVITY ON HANDOUT: name each feature type with a descriptive name and display the initial letters of the words for types on the map.

The most prominent features visible on this background map layer with four landform/terrain types. Explanation of letters: C: crater, P: peaks, Pl: plain, Ch: chasm. The new location of California is on a diverse terrain. We changed state color to grey for better transparency.

ACTIVITY 6 - COMPARE GEOLOGY TO EARTH

Discuss the difference between Earth and the target area. Basically, ALL regions in ALL planets are DESERTS from terrestrial perspective. Exceptions may be: active lava lakes (Io), rivers and lakes (Titan) and high rocky mountains (slopes). All other surfaces are cold or hot deserts

So the major difference is related to the absence of vegetation, liquid water and human made features (roads etc).

A few topics for discussion:

- What would the relief look like on Earth (with vegetation and water).
- Give an example of a similar terrain on Earth.
- What are the major landmarks on this terrain? (As seen from the surface).
- What material could you use for building a settlement on the planet/moon?

ACTIVITY 7 - Route (traverse) planning: Visualizing distance and measuring travel time

A tool built into the application can measure geodesic distances (great circle sections) of a polyline feature drawn by the user (Fig. 5). This tool can be used for traverse planning (from local to global scale), and shows the distance not only in km or mile, but also in practical units: travel time at walking speed (4 km/h), at the maximum speed of Martian rovers (0.1 km/h), the Lunar Roving Vehicle driven by the Apollo astronauts (15 km/h) and for comparison, regular cars on freeways (104 km/h or 65 mph). This gives a realistic view of how fast a place can be reached in surface operations. (The tool does not take topography, slopes, boulders or other obstacles, or surface material properties (sand, dust etc.) into consideration – this should be evaluated by the user). This route planning tool is a counterpart of the Directions tool in Google Maps, however, there are no pre-defined routes (blacktop roads) on other planetary bodies – all routes are cross-country.

Cities and roads activity

STUDENT ACTIVITY ON HANDOUT: Select two sites within your country/state for two settlements. These sites should be

- at the meeting point of two or more different terrain types,

- on a safe place (no steep slope, sand dunes. When surface ice is present, build only houses on stilts).

STUDENT ACTIVITY ON HANDOUT:

Connect the two sites with a line or polyline (with several nodes). This is the road between your settlements. The road should also be safe.

Orally describe the trip on this road, following the different terrain types as you move along. Identify the length of the trip in distance and travel time units.

California East of Hellas Basin with two imaginary settlements and a road.

ACTIVITY 8- TOPONYMS (PLACENAMES)

STUDENT ACTIVITY ON HANDOUT 1. Official nomenclature activity. If the features in your selected area have any names displayed, copy these names onto your paper map and say them aloud. What could these words mean? What is the language of these words? (Answer: descriptor terms are in Latin, specifics are from all around the world).

STUDENT ACTIVITY ON HANDOUT 2. Add New names.

Name

- unnamed prominent geographic features,
- your road and
- your cities.

Names may be random or coherently chosen from a pool of similar terms (i.e., names of gods, names of friends, names of flowers, names of poets, cardinal points etc.).

Mixed official (white) and new (informal, pink) placenames.

FINISH MAP - Cartography

STUDENT ACTIVITY ON HANDOUT Ask students to add the following elements:

- title (it may include a new name for the country/state),
- scale bar - Use the measurement tool to prepare the scale bar. (Draw a 100 km polyline)
- grid (a network of evenly spaced horizontal and vertical lines reaching the margin of the map, used to identify locations)
- Grid labels: column and row labels (A, B, C, ... letters for columns and 1, 2, 3.. numbers for rows) on the margin of the grid.
- legend of the used symbols (for terrain types, cities, roads etc.)

HOME WORK ACTIVITY

1. Landing site selection and city planning

Develop a complex city / road network. Make cities specialized to certain tasks that are in connection with their location.

In this task, students can move their countries to a place that they think would be suitable for a human settlement based on a multicriteria analysis/ evaluation of the new environment (Asking if they wanted to move the entire country to that planet, what would be the ideal site for that). They can argue why that geographic environment was preferred and draw imaginary settlements and roads between them and argue why cities/roads were placed at certain locations thus practice city and road network planning. For example, a city is placed next to a channel, where it is the narrowest and roads follow valleys and avoid large craters or scarps.

Students may explore particular details like how and where power will be generated, how food will be produced, processed and transported, how communication media will operate, what jobs will be required etc. Students may name unnamed features or the features they create (cities, roads). Names may be random or they can develop a name or designation system, learning about the significance and origins of place names. A coherent designation system may use pools of similar terms. Place names can make the project very personal and motivated. For example roads may be numbered in clockwise direction on the map and cities may be named after the students' friends or the teachers of the school or can be names of flowers, names of poets etc.) or students can develop any other set of rules for the nomenclature which might evolve into another project that is more arts or humanities than science, bringing the concept of STEAM (Science, technology, engineering, arts and math) into this activity.

2. One day exploration trip activity

Use high resolution background map (Google). Plan a one-day trip. Participants can choose vehicle and target and determine the distance of the trip from the measurement tool. They should consider travel time with the selected vehicle to the target, back to the habitat, time spent on foot, time spent with documentation (photography)/taking samples and time lost in potential accidents. They should leave after sunrise and return by sunset. For this task, they should learn the local length of day that depends on rotation, season and latitude. Students may place facilities along the roads preferably within one day travel distance.

TEACHER ASSISTED ACTIVITY: Gamification and presentation

Ask students or student groups to further develop and clarify their works and organize an exhibit of the best works.

These works can be also exhibited in the school or a contest can be designed to fully incorporate the concept of gamification. Student can also show their final works by drawing them and explaining the concepts behind at the blackboard, also practicing cartographic generalization.



CURRICULUM



ADDITIONAL INFORMATION

Website: <http://countrymovers.elte.hu>

Planetary nomenclature details can be found at <http://planetarynames.wr.usgs.gov/>

Mátyás Gede and Henrik Hargitai, An Online Planetary Exploration Tool: "Country Movers", Acta Astronautica, <http://dx.doi.org/10.1016/j.actaastro.2017.04.028>



CONCLUSION

Students learn about local and planetary physical geography / geology, toponymy, planetary landing site selection and cartography. The students learn a complex process of landscape evaluation and city planning, based on the interpretation of photomaps or digital terrain models.

ATTACHMENTS

- [Handout](#)

CITATION

Henrik Hargitai; Gede, M., 2017, *Country Movers – Visualizing Spatial Scales in Planetary and Earth Sciences*, [astroEDU](#), , [doi:10.14586/astroedu/1643](https://doi.org/10.14586/astroedu/1643)

ACKNOWLEDGEMENT

Eotvos Lorand University, Europlanet
