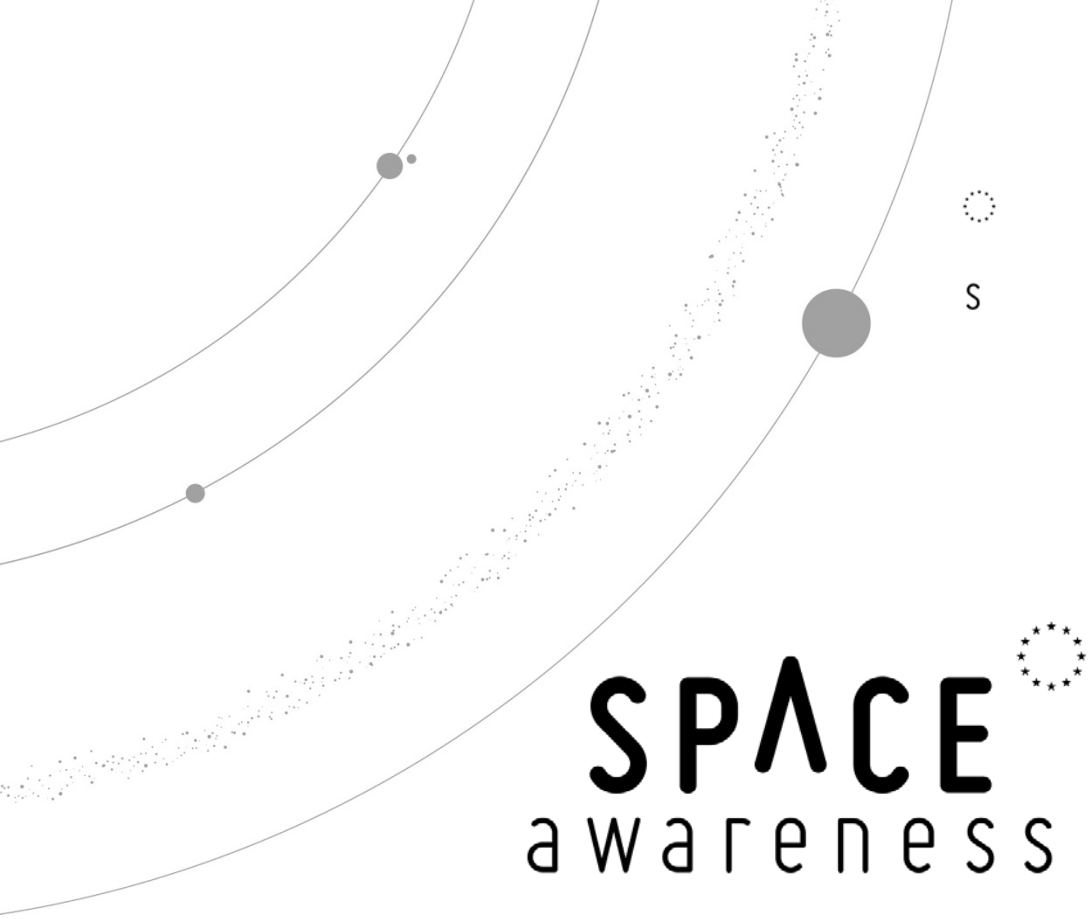

SPACE awareness

NAVIGATION THROUGH THE AGES

TOOLS AND TERMS

HOW TO NOT GET LOST IN THE DARK

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Information about the course

Curriculum topic: Tools and terms on navigation

Category: Navigation through the Ages

Keywords: latitude, longitude, height, position, navigation, precession, zenith, quadrant, theodolite, constellations satellite, GPS, GNSS, EGNOS, Galileo

Didactical hours: 2 didactical hours

Age range: 12–14 years

Education level: Secondary

Language: English

BRIEF DESCRIPTION

After watching the introductory videos, the students engage in an activity that helps them identify the concepts, tools, and terms that are essential for the determination of location. They learn about the basics of how satellite navigation works and about GNSSs, that is, global navigation satellite systems, and their uses and purposes, focusing on Galileo.

EDUCATIONAL OBJECTIVES

- To use space and the Universe to broaden children's minds, develop a sense of European and global citizenship, and foster tolerance for diverse cultures
- To attract the interest of students, mainly European, for space exploration, science, and technology
- To trace the history of navigation, from ancient Greek and fifteenth century European explorers and their missions of global discovery to Europe's Galileo program and the current needs of citizens (mobile devices, increased mobility, safety and security, etc.).

Cognitive Objectives: Types of Knowledge	Cognitive Objectives: Processes	Affective Objectives	Psychomotor Objectives
Factual	To remember	To pay attention	To imitate and try
Conceptual	To understand	To respond and participate	To perform confidently following instructions
Procedural	To apply	To recognise values	To perform independently, skilfully, and precisely
Meta-cognitive	To think critically and creatively	To form and follow a system of values	To adapt and perform creatively

Please briefly explain how each educational objective is achieved by the activity.

STEPS

ORIENTATION

Start the activity by showing a video and then discussing the theme of the video.

(Select one or several videos to show to your pupils)

'See the following video:

How did early sailors navigate the oceans?

https://youtu.be/4DlNhbkPiYY'

Ask them what the video is about.

Make them consider the instruments people in ancient times used to find their way home when travelling by night or day.

Make them imagine that they had a friend in another continent of the same hemisphere, say America, for instance. When it was night-time in both continents, they called him and asked what stars/constellations he could see. Would they name the same stars and, if so, would they see these starts in the same part of the sky?

How easy is to find the North Star?

'What is the video about?

How can you find your location if you don't have access to technology? How did the early travellers, especially navigators, travel?'

Start a discussion until they state (perhaps with your help) that there would be some stars/constellations they would see at the same time, more or less, in the same place in the sky and one, in particular, would seem unmoving, that is, the North Star.

- How can we find the North Star in the sky?
- What if their friend was in the Southern Hemisphere?
- What if he lived on the Equator?

Accompanying files

- How did early sailors navigate the Oceans?
  https://youtu.be/4DlNhbkPiYY
- How to find the North Star
  http://www.instructables.com/id/How-to-find-Polaris-the-North-Star/

'How can we determine our position without the technology of today?

-Why is there a fixed star in the Northern Hemisphere?

-Is it the same in both hemispheres?'

EXTRA GUIDELINES

Tips for a diverse classroom

- Invite all students to contribute to the class discussion

Main skills involved

- Active listening - Paying complete attention to the video
- Active learning
- Time management
- Social perceptiveness

CONCEPTUALISATION

Questions

Based on students' responses to questions about the video, you can determine how much they know.

Now, make them ask questions about the problem/s they have identified.

"How can we determine our position by day?

And by night?

How can I use the stars?

Is it always possible to use the stars?

What instruments (not including modern technology) can I use?

What do they measure?"

After you finish with this part of the discussion, it is time to introduce the research activity to the students.

"Let's set some goals and decide what we want to learn.

This list of goals is what we will call scientific questions. We will try to investigate them and find answers."

Make sure the questions address latitude, constellations, altitude, and position on Earth:

- How can I know my position by day/night?
- Do we have to know how far the stars are?
- Why can I use some stars/constellations?
- How can I use them?

What happens in different hemispheres?

- Can we use the stars in the city?

- What instruments can I use?
- How does the angle of elevation of the North Star relate with the latitude?
- How do we measure angles?
- In ancient times, was there some kind of device that could measure angles?
- Was the Northern star always the guiding star for humans? And will it remain so in the future?
- Is it dark enough in a city to see stars? And around it?
- What is light pollution?

EXTRA GUIDELINES

Tips for a diverse classroom

- Encourage everyone to expresses view and concerns.
- If you have students with special needs, try to adapt the activity so everyone can be included.

Suggested ICT tools

For this part of the activity, you can use the Padlet (http://padlet.com/) tool as an online blackboard to write down the students' research questions. You can also use a projector and type the questions the students mention.

Hypothesis

"Do you have an idea about the answer(s) to your question(s)?

Let's share ideas.

A scientific question or problem can be solved by trying to make a rational guess about the answer: this is known as a hypothesis. This guess should be tested through experimentation. If the hypothesis is wrong, then we should try another 'guess' after doing an experiment or some research. Now let's see if there is any hypothesis to test."

Ask students to make a hypothesis for their questions. You may write the hypothesis in Padlet.

Encourage students to speak their mind even if they are hesitant. Explain to them that everyone make mistakes.

EXTRA GUIDELINES

Tips for a diverse classroom

- Make sure that there are no gender monopolies. Make sure that all students are given time and space to present their hypotheses.
- Treat all questions and hypotheses seriously.

Main skills involved

- Critical thinking – Using logic and reasoning to identify the key points of the game.
- Use of science – Referring to previous knowledge and scientific rules related to the activity.

INVESTIGATION

Exploration

"In order to solve our questions and test our hypotheses, we will need to plan research. We will form groups to conduct our research and do some activities.

Activity N1:

- Investigate using Stellarium:

- What stars/constellations can be used in the Northern and Southern Hemispheres and at the Equator?

- Making the clock go forward, what star seems unmoving in the Northern Hemisphere?

- If we lived on the Moon, could we also use the North Star to determine position?

- Was the North Star always our guiding star and will it remain so?"

At this point in the activity, students will design their research. You can suggest that they do the following activity.

Students should realise that the North Star seems still because it is more or less aligned with the Earth's axis.

In Stellarium (http://www.stellarium.org/), students should place themselves in the Northern Hemisphere, make the clock go forward a few hours and relate what they see.

Using Stellarium

Students can verify their hypothesis by placing themselves in different places:

- in the North Pole;
- in different longitudes with the same latitude
- in the Southern Hemisphere;
- in the northern hemisphere of the Moon

Students can identify some constellations like Ursa Minor and Drago.

They should go back to the times of Plato to see if the North Star was also the best guiding star at that time.

Students should also change the year to 4000, for instance, to see where Polaris will be in the future.

Then they can watch the video Precession of the Earth and try to explain in their own words the change in the position of Polaris with time.

- http://www.space.com/15567-north-star-polaris.html
- http://www.badastronomy.com/bad/misc/badpole.html

Precession of the Earth

- https://youtu.be/qlVqEoZDjok

Activity N. 2:

- How do we measure the altitude of a star?

- What instruments can measure angles?

- How does the altitude of a star relate to the latitude of the place where it is being measured from?

Students will look for different measuring instruments used in ancient navigation.

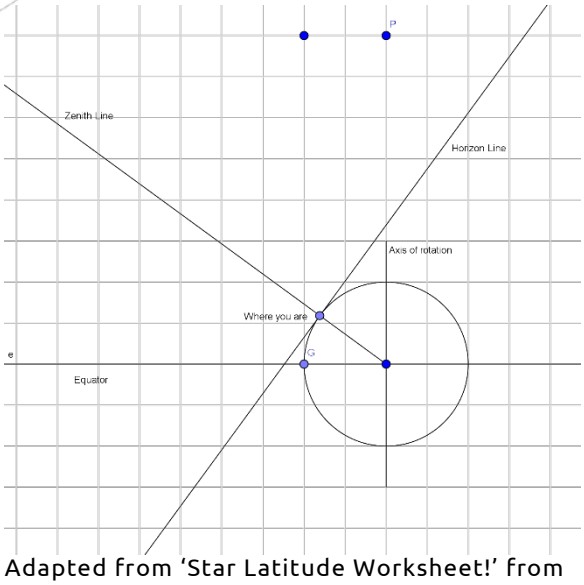
- http://www.thepirateking.com/historical/navigation.htm

With Geogebra, students will learn how to measure the altitude of a star.

The drawing can be made by the students themselves or provided by the teacher. The students must only relate the angle between the horizon line and the position of the North Star and the angle between the zenith line and the Equator (latitude). In this case, there's a time gain:

- Draw a circle to represent Earth and its rotation axis in a vertical position;
- Draw the Equator;
- Above the axis, plot a point representing Polaris
- In the circumference, plot a point representing the place on Earth where you are;
- Draw the tangent line to the circumference on that point; this is the horizon line;
- Draw the perpendicular to the tangent on the point of tangency; this is the zenith line (point in the sky straight above your head).
- Draw a line from your position on Earth to the star;
- Measure the angle between your horizon line and Polaris:_____;
- Measure the angle between your zenith line and the Equator:____; do these two angles match?
- Polaris is not really above the Earth's axis;
- Try to find the approximate real position.
- Plot a point on that new position and draw a line from your position on Earth and this new point;
- Measure the angle between your horizon line and this more accurate line:____

- Students must note that this is not a scale model. Polaris is a long, long way from Earth (they can search how far).



Adapted from 'Star Latitude Worksheet!' from https://www.ion.org/outreach/upload/lesson2.pdf

Activity N. 3

(This activity can be a practical alternative to activity number two)

In this activity, students are supposed to understand that the angle measured when determining the altitude of a star depends on the position you are at (the latitude).

- How can we actually measure the altitude of a star?

- Can we use a protractor?

- Can we build our own measurement instrument?

Can you measure the altitude of a star with your small protractor?

Let's build something similar, that is, a quadrant.

For each quadrant, you will need

- A straw;
- A piece of string of about 30 cm;
- A small weight;
- A piece of card to glue the quadrant template to;

The quadrant template

- http://www.jorgeneto.eprofes.net/images/atividades/quadrante/gabarito.pdf

The students can use previous built quadrants or a protractor, a string with a weight, tape, and a straw. With a previous built quadrant, there's a time gain.

Let's measure something outside. Suppose that lamp is a star.

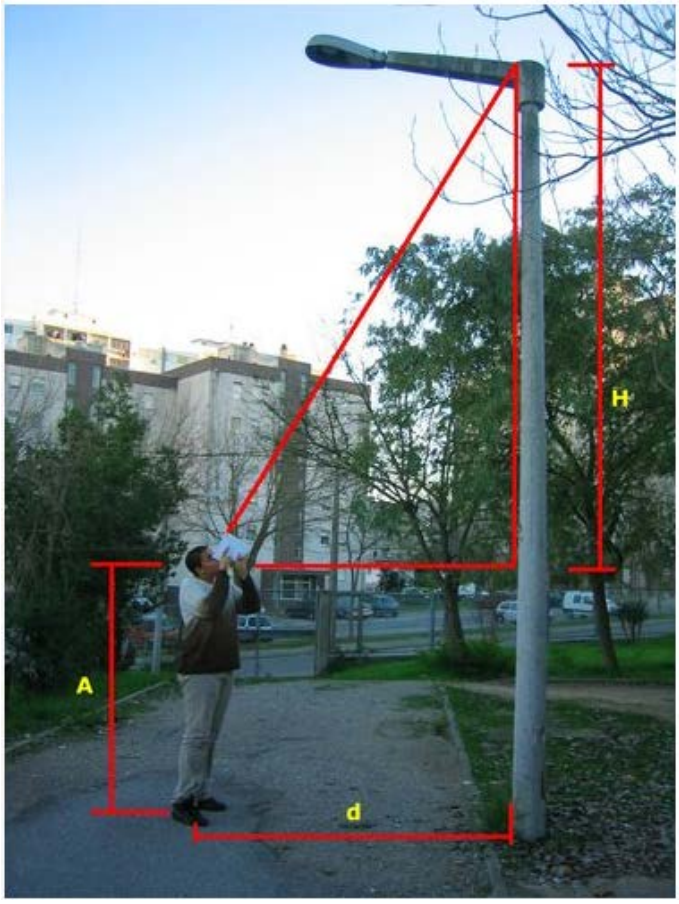
Place students at different distances from the lamp.

Make them measure the observation angle.

It will not be the same for all the students.

This can also be the departing point for some later activities like

- Determining the similarity between triangles
- Spherical geometry
- Measuring the Earth's radius



Let's measure the altitude of the Sun

EXTRA GUIDELINES

Tips for a diverse classroom

- Develop a positive atmosphere in the classroom that promotes excellence and cooperation.
- Encourage your students (as a group or individually) to consult you if they have problems during the activity.

- Encourage the formation of heterogeneous groups across certain characteristics such as gender, race, and level of achievement. You may choose to assign students randomly or ask them to form their own groups.
- Pay attention to the length of time students remain in a group
- Make sure that boys and girls are equally engaged with the theme. You may encourage this by using examples from daily life that are common for both genders.
- Be sure to repeat the instructions if you think someone still has doubts. Be very clear in your instructions so everyone knows what to do next and feels part of the task.

Main skills involved

- Complex problem solving – Understanding the research questions
- Critical thinking – Using logic and reasoning to understand the investigation plan and its implementation. Proposing modifications if needed and assessing the validity of data received and of the final results of data interpretation.
- Judgment and decision making – Considering possible pathways for recognising errors in the experimentation and data manipulation processes. Assessing teammates' proposals and opinions.
- Active listening – Paying full attention to the opinions of teammates.
- Reading and comprehension – Understanding instructions and the relevant theory.
- Monitoring – Assessing self-performance and team performance and taking corrective actions if needed.
- Active learning – Understanding the implementation process and its relation to the problem at hand. Relating information derived from experimentation and data interpretation to knowledge acquired previously and to the problem at hand.
- Time management – Managing experimentation time and not letting the team spend more time than foreseen on the task at hand.
- Systems analysis – Understanding the experimental set-up and how each variable affects the experiment. Manipulating and interpreting the data received.
- Coordination – Cooperation within teams, ensuring harmonious and balanced collaboration.
- Social perceptiveness – Being aware of teammates' reactions and understanding why they react as they do.
- Use of science – Using scientific rules and methods effectively to perform experiments and data interpretation.
- Systems evaluation – Assessing the experimentation process and understanding whether the experiment has been carried out correctly or not. Being able to take the actions needed to improve or correct performance.
- Use of mathematics – Using mathematics to manipulate data and produce final results.
- Quality control analysis – Assessing the results obtained as well as the quality of the gathered data. Being able to estimate the source of errors in the experiment.

Suggested ICT tools

- Research tools (Wikipedia)
- Video:
    - How did early sailors navigate the oceans
        - https://youtu.be/4DlNhbkPiYY
    - How to find the North Star
        - http://www.instructables.com/id/How-to-find-Polaris-the-North-Star/Wiggio
        - http://www.stellarium.org/
        - http://www.space.com/15567-north-star-polaris.html
        - http://www.badastronomy.com/bad/misc/badpole.html
        - http://www.thepirateking.com/historical/navigation.htm
        - Precession of the Earth: https://youtu.be/qlVgEoZDjok
        - https://www.ion.org/outreach/upload/lesson2.pdf
        - http://www.jorgeneto.eprofes.net/images/atividades/quadrante/gabarito.pdf
- Dropbox or Google Docs (for storing their investigation sheets)
- Geogebra

Related careers

Each stage of the development of GNSSs involves several scientists, engineers, and technicians.

CONCLUSION

"Prepare a report about the activity you have done."

Encourage students to share their conclusions via a report.

EXTRA GUIDELINES

Suggested ICT tools

Tools that could be useful in the conclusion phase are:

- Research tools (Wikipedia)
- Online collaboration documents for sharing inputs and ideas (Google Docs)
- Shared space (Dropbox)
- Virtual classroom walls (Padlet, Popplet) (for reflecting on the conceptualisation phase)
- Study cards (Studyblue) (for reflecting on the conceptualisation phase)
- - Geogebra
- - Stellarium

Tips for a diverse classroom and ensuring gender balance

- Encourage students to include multiple perspectives and consider alternative explanations.
- Don't allow students to be interrupted or intimidated.
- Encourage hesitant students to speak their mind and show them you are especially interested in what they have to say.
- Give students time to draw their conclusions and be sure that you are paying attention to all of them equally.
- Refer to a silent student's work in an affirming way.
- Credit a quiet student by making her or him the expert for a task.
- Ask all students to take turns in drawing conclusions.

Main skills involved

- Active listening
- Reading and comprehension
- Speaking
- Active learning
- Time management
- Writing
- Social perceptiveness

DISCUSSION

Communication

'Use the data from the report to describe and explain the steps you have been through and the discoveries you have made to other pupils and to other people outside school (your friends or relatives, for instance)'.

At this time, the entire class presents its findings and each group comments on the work of other groups.

Reflection

"Even if we didn't have today's technology, we wouldn't be lost. However, we do things quite differently nowadays.

See the following videos and think about the uses of satellite navigation in your daily life.

The many uses of Galileo and EGNOS today and tomorrow

http://www.gsc-europa.eu/the-many-uses-of-galileo-and-egnos-today-and-tomorrow

About GSA

The European GNSS Agency: Linking space to user needs

http://www.gsa.europa.eu/gsa/about-gsa"

Show the videos to your students:

- The many uses of Galileo and EGNOS today and tomorrow http://www.gsc-europa.eu/the-many-uses-of-galileo-and-egnos-today-and-tomorrow
- About GSA - The European GNSS Agency: Linking space to user needs http://www.gsa.europa.eu/gsa/about-gsa

Encourage your students to reflect on how despite the instruments being different earlier and now, the underlying concepts are the same.

Discuss with them what they have learnt and the importance of this investigation to know more about navigation systems.

Help them identify how they can share their findings with others (share information on social media, write a blog, build an exhibit, make a video, organise an event for the entire community including relatives and friends, etc.).

EXTRA GUIDELINES

Suggested ICT tools

Different presentation tools can help the students make creative and inspiring presentations. Depending on the timeframe of the activity, students may prepare a simple presentation using tools like Powerpoint or ones that require the use of complex tools like movie-making tools.

- Presentation tools (MS PowerPoint, Open Office Impress, Prezi)
- Story-making tools (Storybird)
- Word clouds (Wordle)
- Movie- and animation-making tools (Windows Movie Maker, Animoto)
- Blogging tools (Blogger, Wordpress, Tumblr)
- Photo-sharing and editing tools (Picasa, Instagram, Snapchat, Flickr, Photobucket)

Tips for a diverse classroom and ensuring gender balance

- Allow the presentation of multiple opinions and perspectives.
- Use examples from multiple backgrounds and perspectives.
- Be sensitive to cultural differences in writing styles, recognising that many standards apply to the evaluation of good writing and presenting.

- Be explicit about what is expected and show examples of good writing done by other students.
- Respect the different opinions of students.
- Be sensitive to the experiences of visibly underrepresented students in your class.

Main skills involved

- Active listening
- Reading and comprehension
- Speaking
- Active learning
- Time management
- Writing
- Social perceptiveness

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