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Learn GREEN - Outdoor STEM

Toolkit GREEN&STEM

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About the GREEN&STEM project

The Learn Green -Outdoor STEM project was launched in February 2022, supported by the European Commission Strategic Partnerships Framework.

GREEN&STEM project is a part of outdoor education. It is about authentic tasks, physical activity, new technologies, and teamwork. It is about a better connection between the environment and STEM subjects. In this project, we developed outdoor trails where students can discover and solve problems on real objects. This type of education makes big popularisation in a STEM subject, and it can be used in the school context to offer a real-life experience besides textbooks.

Nevertheless, it requires good preparation and solid post-processing in the classroom. The project is about bringing outdoor activity together with the possibility modern mobile devices are offering. We can use students' smartphones as a tool for learning and not only as a tool for social interaction as it is most of the time. This quality teaching and learning style has proven to improve behaviour, increase student creativity, and even increase progression. These benefits are particularly apparent and can be most impactful to those students who find it challenging to sit still in a chair, often causing distractions and disruption. When you take learning outside, these students no longer have the boundaries that there are in the classroom, giving them the freedom to relax and enjoy their learning.

This booklet is published within the project result 1: GREEN&STEM toolkit. The toolkit is an easy-to-use and ready digital collection for outdoor science and STEM activities. This toolkit contains ten developed trails by all partner organisations. We developed four trails in Ljubljana, four in Skopje, and two in Burgos.

The toolkit is based on visual, peer-to-peer, and collaborative learning. Every trail has its description, goals, and objectives. It was planned step by step, from choosing the route, finding a place to make the activities, and preparing the supporting documentation.

All STEM trails consist of a minimum of three stops; typically, the stops are independent of each other, so there is no required sequence. A stop is centred on an element in the natural or built environment, artwork, or everyday objects. The target groups are students aged 8-16. Different tasks are developed depending on the age of the participants and the places that will be visited.

The main innovation is that we combine outdoor activities with STEM activities. Moving the classroom outdoors should significantly impact the student's motivation for learning. Students explore the world with their teachers and classmates outside the classroom. It is fun, interesting and healthy.

These activities have high transferability potential as the local community may use the developed STEM trails. The activity will encourage and help other schools or informal groups of learners to bring together students, families, and STEM professionals and engage them with the wonders of STEM.

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1. Introduction

One common definition of STEM education is that it is an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and STEM in contexts that make connections between school, community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy.

Lots have been written about the benefits of STEM education, among which most significant are that it promotes equality in education (gender, racial, religious…), teaches independent innovation, allows students to explore subjects at greater depth, helps students develop critical and creative thinking skills, allows for an integrated curriculum, and lastly, gifted students have high interest in these areas. So, overall, a STEM curriculum or initiative is meant to engage all students in learning by allowing investigative and hands-on activities.

Firstly, we would like to focus on the obstacles that STEM education faces since, over decades of educational initiatives, most haven't survived failing to overcome similar difficulties. Follows a list of five main concerns about STEM that current education policies and programs do not adequately address.

1. **Resources.** Hands-on materials for STEM often cost money. For example, simple circuits, boards and connecting wires are needed in the electricity topic. Most classes in the research shared materials, which could mean building a circuit and then pulling it apart for the next class to reuse the same equipment. This might be a good scientific exercise, but it wastes time and causes frustration.
2. **Equity.** There is a rising STEM equity gap. Most schools had very old hardware – so the "T" in STEM was left hanging. Technology was not well connected, and the software needed urgent upgrading. I have researched school sectors in different states, rural and urban, and the gaps between who has and who has not in STEM are stark. This brings into focus the necessity for needs-based funding.
3. **Teacher professional development.** Teacher learning in STEM education must continue to be supported with targeted funds for teachers to plan units of work together for their continuous professional development is necessary. The default of hiring outside organisations to teach coding and conduct experiments often means teachers stand back while others work with their students. This does little to build personal and professional capacity and confidence.

4. **Literacy and numeracy levels.** Students need literacy and numeracy proficiency for effective primary school education STEM learning. Low literacy and numeracy levels of students made STEM hard. A smaller fraction of students can read the content of lessons without help, and the majority can't successfully make meaning from instructions or video footage they are given. How do these students access the language they need for STEM?

We need to address these obstacles before it is too late.

So how do we do this for the STEM Initiative to survive?

Here are the main ideas that appear in the studies.

1. Schools, school systems, and state and federal education departments need to create a template for teachers to design an integrated unit of study.
2. Units of study need to be clear.
3. Well-developed and useful teacher in-services need to be conducted to teach educators how to:
   - Design an integrated curriculum
   - Classroom management techniques for providing a hands-on activity
4. Individual schools need to provide the following:
   - resources and materials
   - collaborative planning time for educators to share and develop units
   - A lab and/or storage area for equipment and materials

1. 1 How can teachers help overcome challenges in STEM education?

Teachers and educators can be instrumental in a student's decision to pursue the academic disciplines they end up studying. The decision taken by a student to study STEM can be directly influenced by classroom instruction and the advice given directly by a teacher. It can, however, be challenging for teachers to engage their students in certain subject areas.

Here is some advice on how to encourage students to pursue STEM.

Teach them, Young

Student engagement can be a huge challenge for teachers. Between the pervasive use of smartphones and gadgets, common misconceptions about STEM subjects being hard and inaccessible, and boring learning materials, it can be incredibly hard to hold the attention of students for a long. Most students tend to lose interest in science between the ages of 12 and

13—the same age when their perceived self-efficacy starts to change. Implementing robust science education from an early age would help to combat this change at this impressionable age, where they begin to lose confidence and doubt their abilities. Young children often already engage with science without realising it. For example, when children stack building blocks together, they essentially learn fundamental physics laws. Similarly, they observe the biological world when they run off on nature walks to explore a fallen nest or flower. Teachers can use this curiosity to direct their students more purposefully without making their play feel like work.

Innovative Teaching

Science can seem boring when it isn't contextualised in the real world. When not illustrated effectively, concepts can seem abstract and pointless. Most students see the curriculum as boring and irrelevant to life outside school. When concepts are explained in hands-on activities, students can more easily establish a link between their observations and theories. Practical project work also enables group discussions, teamwork, communication and peer-to-peer interaction, all considered important 21st-century skills.

Topical Science

Most children struggle to understand the importance of science because they cannot see the connection between what they learn in the classroom and the happenings of the real world. Students also have a perception of science subjects being either too difficult or too boring. Introducing topical science in class can help students understand the relevance of science in everyday life. A typical STEM lesson usually involves four basic steps:

- Identifying a real-world problem.
- Asking questions to explore the problem (and hopefully solving it)
- Developing potential solutions
- Exploring a hands-on activity

Going Digital

Most teachers and educators have an unpredictable and heavy workload, which doesn't always allow much time to plan intricate and engaging STEM lessons. This is where technology comes in. The EPI found that teachers who make their pupils use technology for class projects in all or most lessons have four to five more hours free each week than those who only occasionally use educational films and quizzes. Educational films are a quick and fun way to capture students' attention and can often be used to initiate teaching techniques like flipping the classroom.

Erasing the Gender Divide

The ratio of men and women working in STEM remains largely disproportionate, with men significantly outnumbering women. While things have improved significantly since the days of the male-breadwinner model, there are still greater barriers to entry for any young girls hoping to study STEM. While we have more women in STEM than ever—and thus a plethora of fantastic role models—inequality still exists in the opportunities offered to those who successfully break into STEM careers and academia. For young girls and women in STEM, dominated classrooms and labs can lead to isolation, ostracisation, and even outright marginalisation. If you were the only girl in a science classroom full of boys, would you be intimidated?

1. 2. STEM trails can help overcome most of the above

Another way to tackle the obstacles in STEM education is through the concept of so-called STEM trails introduced in this project. Namely, STEM trails fit very nicely into the ideas of the popularisation of STEM and informal STEM education that has been increasingly recognised as valuable adjuncts to improving STEM education in schools.

Namely, all broad characteristics of STEM: communication, connections, reasoning, and problem-solving are experienced in all their dimensions through STEM trails. They also popularise STEM subjects through out-of-school activities. By providing opportunities for STEM out of school, the trails extend the time spent thinking about STEM and STEM problems. They also tend to connect back to school. All of this makes for a stronger STEM education program in general.

Background and history

The earliest STEM (math) trails appeared in England and Australia. In 1985, Dudley Blane and his colleagues blazed a trail (Blane and Clarke, 1985; Blane and Jaworski, 1989, 114–116) around the centre of Melbourne as a holiday-week activity for families. The trail's mathematical ideas included investigating a circular pattern of bricks in the pavement (to discover the invariance of pi), studying the timetables in a train station, looking at the reflection of a cathedral in a pond (to estimate its height), trying to estimate the speed of water rushing down a spillway, counting the number of windows in a wall of a skyscraper, and looking for patterns in the numbers of post office boxes.

Australian STEM educators constructed many more trails based on various themes and venues, including preparing for prospecting in a gold rush town, acting as an apprentice keeper in a local zoo, and working on the ship works and sailing boats in a historical nautical village. Each Australian trail had a brochure containing thought-provoking, mathematically oriented questions. In many cases, the questions had no single correct answers as such. The tens of thousands of Australians who walked these trails attested to their popularity. Many walkers returned for a second round accompanied by their families. Because of the strong demand for Blane's Melbourne trail, the organisers maintained it for several months longer than the planned week.

Like any good idea, the idea of a STEM trail has spread, and people have adopted it. Carole Greenes of Boston University (Massachusetts) created a historical STEM trail in Boston centred on the Common and the Public Garden. Unlike Blane's Melbourne trail, walkers on Greenes' trail followed a human guide who knew the trail's historical and mathematical aspects and could give hints and suggestions to walkers who got stuck on a task or idea. Kay Toliver, an award-winning New York City schoolteacher, leads her students on walks while guiding them to discover STEM in their school neighbourhood. Student walkers do not write their ideas and solutions on paper but informally discuss their discoveries on the spot and then take the discussion back to the classroom. Florence Fasanelli, Fred Rickey, and Richard Torrington developed an elaborate STEM (math) trail that takes advantage of The Mall in Washington. It provides an opportunity for the thousands of people who visit The Mall every year to include a STEM (mathematical) dimension to their sightseeing. These successful trails show that the idea is robust and malleable enough to meet the needs and imagination of trailblazers in many different situations.

Characteristics of a STEM trail

Follows a basic description of a model for a STEM trail. It can be adapted to match different interests and needs.

- STEM trails are for everyone. Everyone studies (or studied) STEM in school. Everyone uses STEM. STEM trail problems should be interesting and accessible to people at all levels of age and experience. The aim should be for the widest possible participation. Trail walkers discuss how to approach a problem and compare their thinking. Talking about STEM helps to bring it to life and to build confidence in one's abilities. STEM trails respond to the variety of walkers with various STEM problems, both in the level of difficulty and in type. Easier and harder problems blend or alternate.
- STEM trails are cooperative, not competitive. The emphasis is on talking about and doing STEM. The STEM trail problems aim to bring attention to the processes for

formulating and solving problems, not to find single correct solutions. While an individual might walk a trail with pleasure and profit, the orientation of trails is toward families and other groups.

- STEM trails are self-directed. Such trails are ready when a walker is ready. There is no time limit.
- STEM trails are voluntary. An important characteristic of the model is that walking a STEM trail is entirely voluntary. This idea is in keeping with the general principles of the popularisation of STEM. A popular presentation of STEM must first attract and keep its participants. If a particular bit of STEM or the setting is not attractive or interesting, it won't work for a STEM trail. STEM trails are not made for specialists. What works for a person who already likes STEM a lot may not work for someone who doesn't like it or for someone who is not confident about doing it.
- STEM trails are opportunistic. STEM is everywhere. Trailblazers can prove the assertion by taking advantage of their locale: neighbourhood street, business district, parking lot, college campus, shopping mall, park, zoo, library, grocery store, clothing store, and more. Any public place that allows safe walking is ripe with STEM problems for an imaginative trailblazer.

- STEM trails are temporary. Places change. Permanent trails require maintenance, continuing time, and energy and, perhaps, miss new opportunities. Rather than maintain this year's trail, blaze a new trail next summer as a way to bring back satisfied walkers and use the novelty to attract new walkers.

Creating a trail

Creating a trail is straightforward and lots of fun in itself. It can take as much time and energy as you have available. The project should be fun for you and the trail walkers.

- Location. Where do you want to locate a trail: neighbourhood street, business district, parking lot, college campus, park, zoo, grocery store, or other interesting place? Walk the venue looking for STEM problems from which to choose. Collect many more than you will use so that you can pick and choose for good balance among the final lot. Snapshots and sketches will be useful in your planning, although you will probably make several visits to the site. Keep notes on your ideas so you can sort out the pictures when they come back from the developer. Be alert for problems involving elements of local culture or history, as well as the site's physical attributes. Work with a scale map of the venue, noting the specific location of each problem. Your stops on the final trail route will probably occur in a different sequence or route then you used in collecting the ideas.

- Length. Walking distance, walking time, and the number of problems all affect the length of a STEM trail. One mile will do for many people, although you might design a two-part trail to give a longer option. Two hours limit most people's attention for problem-solving, even in the most attractive locale. Consider including a sit-down break midway in distance and time. This is a chance for the group to talk about what they've been doing, as well as to catch their collective breath. The spacing of consecutive trail stops more than 10 minutes apart risks losing a walker's attention. The time required at each trail stop depends on the walkers and the problem.
- Trail guide. Prepare a scale map of the trail, including all appropriate landmarks and features and clear notations of the trail stops. Describe the problems for each stop, leaving room for trail walkers to write, sketch, and record their thinking and solutions. Make a note of the tools that a trail walker might need for each problem. Keep the overall list simple. Paper, a pencil, an eraser, a watch, and a hand calculator are what you can expect most people to have readily available. Include an address to encourage trail walkers to send comments about the trail. This will be helpful to you in thinking about the success of the trail.
- STEM. Sketch out the STEM problems that you discover. Organise them on your site map. Including two or three problems at a trail stop helps to hold a walker's interest and increases the ratio of STEM time to walking time. Posing the problems at different levels and with different focuses will help to achieve a good variety in the overall trail. Make the problems independent so that trail walkers will be encouraged by a fresh problem at each stop, regardless of how well they understand earlier problems. Aim for problems that are not like students' current problems in school. Novel STEM will help demonstrate the value of studying mathematics. Problems that arise naturally from the situation are best, although incidental problems are also fun. You will find that blazing a STEM trail is itself a good STEM challenge.

1. 3 Girls and underprivileged children in STEM

With this project, we aim to increase the motivation of girls and underprivileged children to style STEM subjects and contribute to more women and students from underprivileged communities graduating from STEM subject studies at universities in Europe.

We have identified the problem of the underrepresentation of girls and underprivileged children. This is a deeply rooted and complex social problem. According to the latest data from the euro stat, in 2019, there were more than 6.3 million female scientists and engineers in the EU, accounting for 41% of total employment in science and engineering. By sector, women were underrepresented in manufacturing (where only 21% of scientists and engineers were

female), while there was more of a gender balance in the services sector (46%). Among the EU Member States, the proportion of female scientists and engineers varied widely in 2019, ranging from 55% in Lithuania to 28% in Luxembourg.

Recent research and real-world initiatives have shown ways to reduce gender bias, increase the perceived and actual social relevance of STEM, and ultimately increase women's sense of belonging in these fields. In the report on Women and STEM in Europe and Central Asia, released in 2021 by the Word Bank Group, the authors systematically reviewed 21 articles. They concluded that there are several answers to the question: What works? Mostly, it is:

- the education domain of female teachers;
- exposing girls to nontraditional or gender-neutral roles in the learning environment; and
- female peer mentoring.

We are using the second item of this research to make a unique approach to our project, i.e. GREEN&STEM project exposes girls and underprivileged children to nontraditional and gender-neutral roles in the learning environment. The final goal of the project and our motivation is to have more girls/women in the STEM subject studies and more underprivileged students in the STEM subject studies, using the activities and results within this project.

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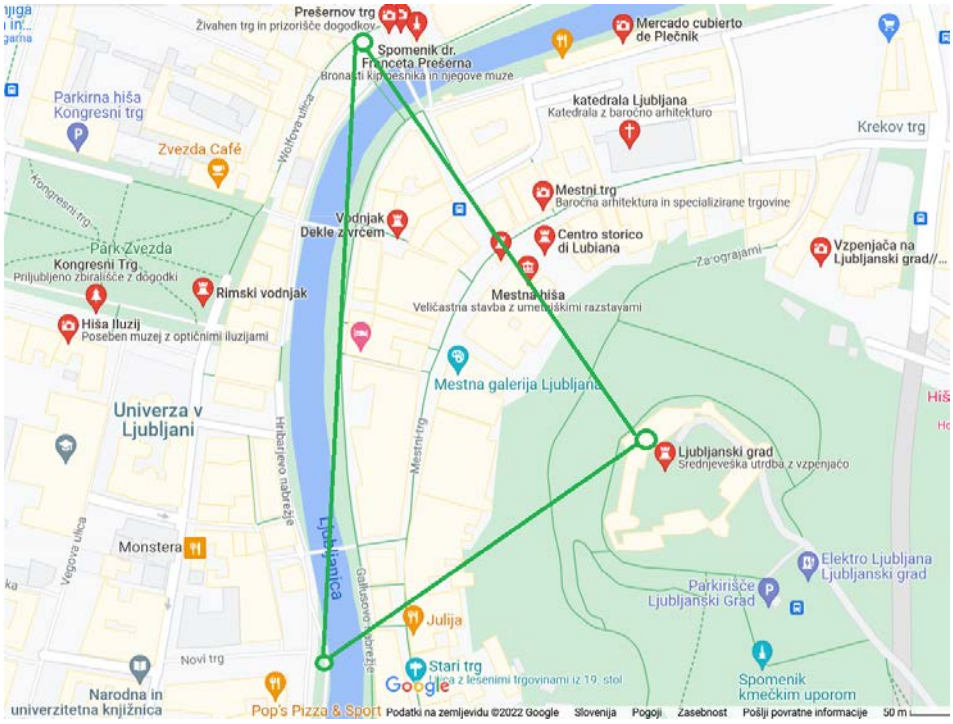
2. Four GREEN&STEM trails around the city of Ljubljana

2.1 Green&STEM trail Number 1 in Ljubljana

Author: Katarina Rojko

General notes



1st stop (the order is arbitrary):

Location

A viewing platform on Castle Hill next to the Ljubljana Castle

Paths to Ljubljana Castle:
https://www.ljubljanskigrad.si/en/plan-your-visit/how-to-get-to-the-castle-en-us/

Overview and Purpose

The purpose is to solve geometric tasks looking down from Castle Hill at the well-visible and important buildings/places in Ljubljana.

Objectives

Students will:

- learn about the different figures formed by famous Ljubljana buildings and surroundings in nature, using concrete examples
- study the congruence of geometric figures and bodies
- look for symmetries
- calculate the area of the geometric figures and the volume of the geometric bodies based on the estimated lengths
- use the Pythagorean theorem to calculate your distance from the chosen building
- use angular functions to understand their position on the viewing platform of Ljubljana Castle compared to a chosen building in the City of Ljubljana

The learning will take place in a location that is one of the most attractive to tourists in Slovenia.

Materials Needed

- Mobile application
- Phone calculator

Activities

5 minutes: Start the lesson with an introduction:

> The Ljubljana Castle is a medieval architectural landmark in Ljubljana, situated on the north-western part of Castle Hill at an altitude of 376 meters above sea level (https://sl.wikipedia.org/wiki/Ljubljanski_grad). Ljubljana's altitude is 295 meters above sea level (https://sl.wikipedia.org/wiki/Ljubljana).
>
> From the viewing platform on Castle Hill next to Ljubljana Castle, you can see many important buildings in Ljubljana. The buildings are very different from each other in appearance and shape. You can recognise different geometric figures and bodies.

10 minutes: Introduce (or repeat) the following notions:

- Geometric figures: all ages
- Congruence and symmetry: all ages
- Area of geometric figure: ages 11 - 13 and 14 - 16
- Volume, Pythagorean Theorem, angular functions: ages 14 - 16

15 minutes: Explain and demonstrate the notations mentioned above with an object. Then put students in groups of two or three per age group if possible. Tell them to cooperate within their group to provide answers to the questions in each of the 3 tasks per age group below. After providing the answers, they should also open the mobile app and answer the question for their age group of this stop (A viewing platform on Castle Hill next to the Ljubljana Castle).

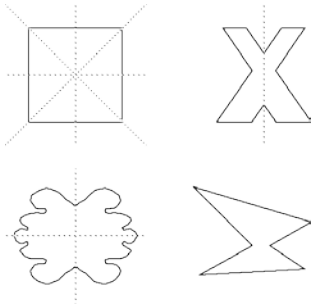
- Tasks, age 8-10:

Task 1: From the viewing platform, observe the buildings you can see in the attached pictures and others. Of what geometric shapes are they? What are all the figures you can see?

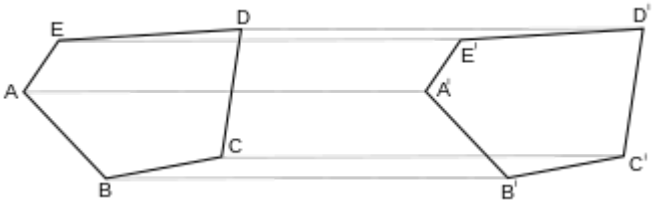
Task 2: Choose a building that you can see clearly and try to determine the correspondence of the individual surfaces of the geometric body with the rest of the surfaces. Then consider whether these surfaces have symmetries.

Task 3: For the following figures: deltoid, rectangle, square, equilateral triangle and circle, explain the properties:

- number of sides,
- characteristics of sides,
- characteristics of angles,
- number of symmetries.



* Image 1: Symmetry of some figures



* Image 2: Congruent figures

*__The symmetric__ (also coordinate) of a given set of points is the line if the set maps into itself when mirrored over the line. A figure has symmetry if it can be divided by a line so that the two halves of the figure are congruent. Some figures have multiple symmetries, and some have zero.

*__Congruence of figures__: two figures of the same shape and size are congruent. If two congruent figures are placed one on top of the other, they overlap completely.

- Tasks, age 11-13:

Task 1: Which geometric figures (rectangle, square, circle, triangle) does each selected building (e.g., NUK or Ljubljana skyscraper - see pictures below) look like it is made of?

Task 2: Area of geometric figure: Estimate the length of the sides of the figures of the outer walls of the selected building (e.g., NUK or Ljubljana Skyscraper) in meters and calculate the area of the figures of the exterior walls of the building.

TIP 1: To better understand the size of the building you have chosen, first measure the area of the figure of the viewing platform. Measure it by measuring the length and width of the viewing platform in steps (approximately 1 meter) and then calculate its area.

Task 3: Now, look at your chosen building as a geometric body (cube, rectangular prism, sphere, pyramid, cone). Does the building look like it is made up of one or more geometric bodies? What are the properties of this or these geometric bodies?

- **Task, age 14-16:**

Task 1: Volume: Estimate the lengths of the edges of the selected building (e.g. the NUK or the Ljubljana Skyscraper) in meters and calculate its volume.

TIP 1: To get a better idea of the size of the building, first look at the Ljubljana Castle Viewing Tower. How tall do you think it is? Answer: 24 m. Do you think the building you have chosen is taller or shorter?

TIP 2: Now, look at the NUK and consider how it is built. Does it look like it is built up of several geometric bodies or one? Answer: NUK looks like it is made up of 4 rectangular prisms*, two and two rectangular prisms with the same volume. Many other buildings also look like they are built up of several geometric bodies.

*The formula for the volume of a rectangular prism is: $\mathbf{V = a \cdot b \cdot c}$

Task 2: From the height of Ljubljana Hill (376 m - 295 m = 81 m) and the estimated distance of the chosen building from Ljubljana Hill (in metres), calculate the distance between you and the building.

Pythagorean theorem: Distances in space can be calculated using the Pythagorean theorem. The Pythagorean theorem is a theorem in plane geometry named after Pythagoras, although it was known before him. The sum of the areas of the squares of the legs of a right triangle is equal to the area of the square above the hypotenuse (https://sl.wikipedia.org/wiki/Pitagorov_izrek). The theorem is written as:

$\text{hypotenuse}^2 = \text{opposite leg}^2 + \text{adjacent leg}^2$

or

$\mathbf{c^2 = a^2 + b^2}$

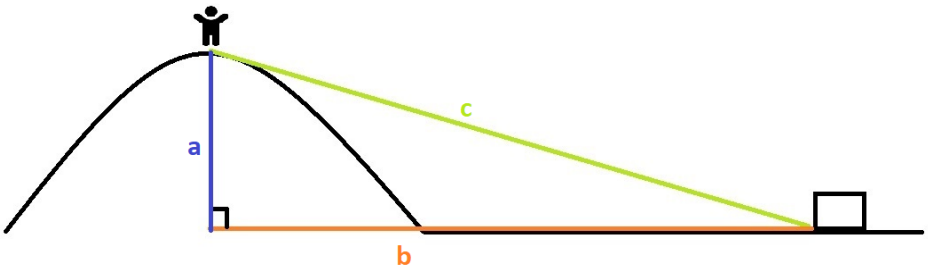


Image 3: The green side (c) of a right triangle is the hypotenuse.

Task 3: Calculate the size of the angle at which you observe the building with the sine (sin)* or cosine (cos) or tangent (tan) or cotangent (cotan) function.

*sin α = opposite leg : hypotenuse (sin α = a : c)

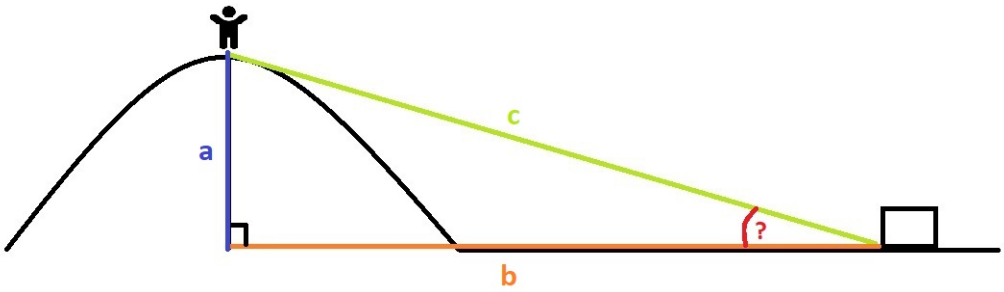


Image 4: The angle of interest is the right angle.

Image 5: National and University Library (NUK)

Image 6: Ljubljana's skyscraper

Image 7: Ljubljana Castle Viewing Tower

Idea: If you have the opportunity, you can also see Ljubljana from the Ljubljana Castle Viewing Tower (this is possible at certain times and for a fee).

2nd stop (the order is arbitrary)**:**

Location

Along the Ljubljanica River: the riverside area of the Ljubljanica River, located next to the New Market Square, between the Shoemakers' Bridge (Slovene: Šuštarski most) and the St. James's *Bridge* (Slovene: Šentjakobski most).

Overview and Purpose

Find out what makes some bodies sink in water and others not.

What influences it?

How do the laws of physics (formulas) explain this?

Objectives

Students will:

- Learn why some bodies float in water
- Understand that buoyancy is the reason why some bodies can float in water
- Recognise that buoyancy is a force acting on a floating body and in which direction this force is directed as a vector
- Know what buoyancy depends on
- Know how buoyancy is calculated

Materials Needed

- Find a floating body in the Ljubljanica River. This could be a tourist boat (as in the pictures) or something else floating by, such as a piece of wood, fallen leaves from trees, etc.

- Mobile application
- Phone calculator

Activities

5 minutes: Start the lesson with an introduction:

Why do some bodies float on water and some sink?

We have special sensations in water. We feel to be lighter. We feel a force pushing us upwards. This force is called buoyancy, and we will explore it in more detail later (Physics 8, Buoyancy and swimming, http://iucbeniki.si/fizika8/164/index.html).

Interesting fact

The magnitude of buoyancy was determined by Archimedes. Anecdotally, while bathing in a tub, he found that the amount of water displaced was equal to the volume of the submerged body. He was thus able to determine whether the crown made for the king by the goldsmith was made of pure gold. He compared the crown's volume with an equally sized piece of gold and found the goldsmith's deception.

In honour of Archimedes, the realisation that buoyancy is equal in magnitude to the weight of the displaced liquid is called Archimedes' law.

10 minutes: Introduce (or repeat) the following notions:

- Forces acting on the floating body: all ages
- Weight: all ages
- Buoyancy - the force that pushes a body upwards in a liquid: all ages
- Balance of forces: all ages
- Surface area, density: ages 11 - 13 and 14 - 16
- Specific gravity, volume: ages 14 - 16

15 minutes: Explain and demonstrate the notations mentioned above with an object. Then put students in groups of two or three per age group if possible. Tell them to cooperate within their group to provide answers to the questions in each of the 3 tasks per age group below. After providing the answers, they should also open the mobile app and answer the question for their age group of this stop (Along the Ljubljanica River)

- **Tasks: age 8-10:**

  Task 1: What kind of water is the Ljubljanica River (Learning about the environment 3 - different waters, lakes, rivers, sea, fresh, salt)?

  Task 2: Observe what floats on the Ljubljanica. Do you think the water is clean? Do you see the bottom of Ljubljanica as you might see it in a swimming pool or the sea? Why doesn't anyone swim in the Ljubljanica River (Learning about the environment 3 - Environmental protection, pollution)?

Task 3: What are the ships made of? What materials are they made of? Why don't even huge and heavy objects like ships sink? Can ships sink anyway? When? (too heavy loading, e.g. too many passengers, damage to the vessel, storms...)

- **Tasks: age 11-13:**

Task 1: Can you swim well? Why do we need to swing our arms and/or legs when swimming? Do you know that it is easier to stay afloat in the sea than in a swimming pool or a river like the Ljubljanica? Why?

In salt water, because the density of the water is higher, it takes less energy to swim (Water Density - Science and Technology 5

https://eucbeniki.sio.si/nit5/1326/index2.html).

Task 2: Buoyancy makes bodies float. What would happen if the force of gravity would be greater than the force of buoyancy (e.g., what happens if someone throws a pebble into a river)?

Task 3: Bodies that are less dense than water float. Bodies that have a higher density than water sink in water (Science and Technology Buoyancy https://eucbeniki.sio.si/nit5/1326/index3.html). Why some bodies that look very heavy still don't sink, e.g. a ship made of metal? How does the surface area of a body affect buoyancy?

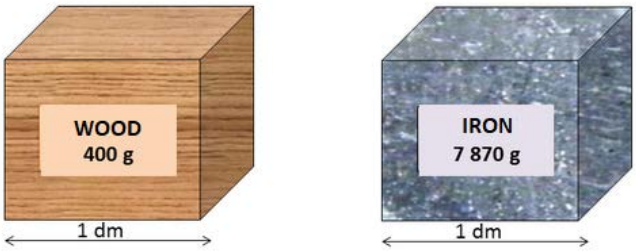


Image 1: Bodies with more mass (heavier bodies) and the same volume as lighter bodies have a higher density.

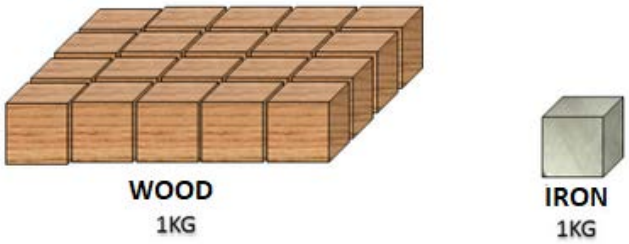


Image 2: Bodies with a larger volume and the same mass as the ones with a smaller volume have a lower density.

The density of a body depends on its volume and mass (weight). It is calculated by dividing the mass of the body by the volume of the body.

density = mass : volume

What is the density of normal water?

Water density is: 1 kg/dm^3 or 1 kg/l

Bodies with a lower density than the water in the Ljubljanica float in the river. Bodies that have a higher density than the water in the river sink.

- **Tasks: age 14-16:**

The floating body is in balance. The weight of the body is opposed by the force of the water, buoyancy:

Fg = B (buoyancy)

> **Task 1:** Why does a body float in the Ljubljanica River? Try to explain the formula **Fg = B** using the example of a floating body.
>
> **Task 2:** Given the size of a floating body, estimate its volume. Use your feeling* for the size of **1 cm^3, 1 dm^3, and 1 m^3.**

*Teacher or facilitator demonstrates with examples in the surroundings the size of 1 cm^3, 1 dm^3, 1 m^3.

Then estimate how much of the body is under the water and how much is above water, e.g., **1/4 (25%) or 1/2 (50%) or 3/4 (75%)** or the **whole (100%)** volume of the body is under the water.

Finally, multiply the estimated volume (V) by the percentage of submerged volume to get the volume of the submerged part of the body.

V of the body · x % = V of the submerged part of the body

> **Task 3:** What is the buoyancy of the selected floating body?

HINT 1: We know that the buoyancy is equal in magnitude to the weight of the displaced liquid. The weight of the liquid depends on its density or specific gravity. Let us assume that the Ljubljanica River has the normal gravity of water:

1 litre = 1 dm^3 = 1 kg = 9.8 N (approx. 10 N)

N = Newton is a derived unit of the International System of Units for Force. It is named after Isaac Newton.

So, what is the weight of water in 1 cm^3 or 1 m^3?

Convert and note that 1 dm^3 = 1000 cm^3 and 1 m^3 = 1000 dm^3.

HINT 2: If a body is floating in or on the surface of the water, the weight of the displaced water is equal to the weight of the body. Since we know that buoyancy is equal in magnitude to weight in this case, we can conclude that buoyancy is equal in magnitude to the weight of the displaced water.
We, therefore, calculate buoyancy as follows:
$B = \rho \cdot V$, where
ρ is the liquid's specific gravity, and V is the volume of the submerged part of the body.
Therefore, when you apply the formula

$B = \rho \cdot V$, you can calculate the buoyant force (B).

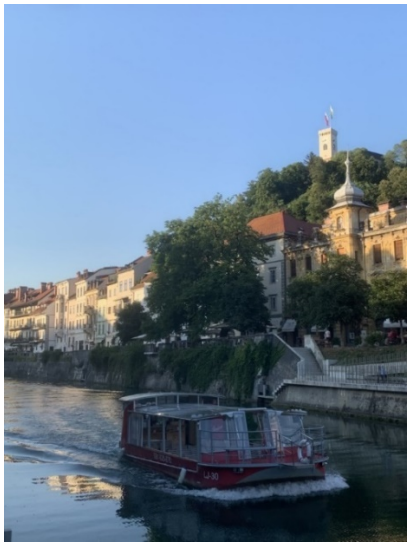


Image 3: Ljubljana raft - tourist boat

4: Ljubljana raft - tourist boat Barjanka Emonca Image

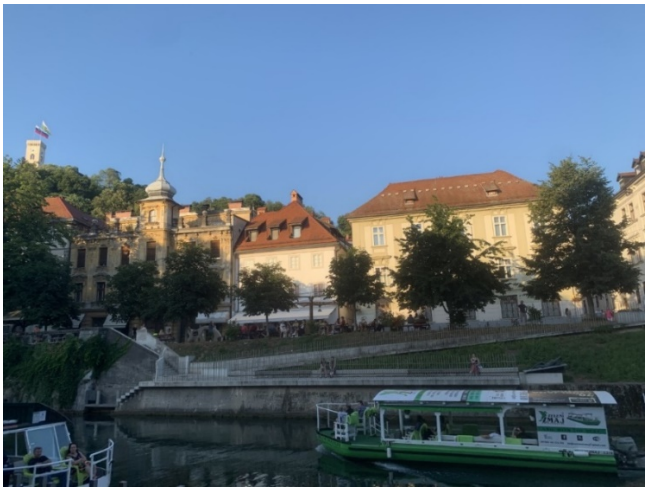


Image 5: meeting of two Ljubljana's rafts

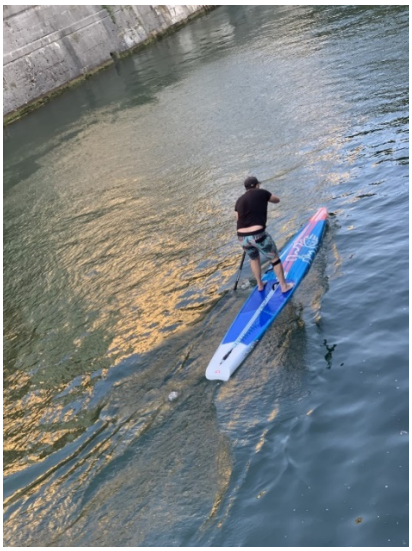


Image 6: occasionally, something else floats down the Ljubljanica river😊

3rd stop (the order is arbitrary):

Location

Prešeren's Square

Overview and Purpose

Understanding that weather phenomena and time cause chemical reactions reflected in changes in materials (colour, shape, functionality).

Objectives

Students will:

- Understand that time and weather phenomena affect the way materials change
- Recognise that a chemical reaction is a process in which the chemical and physical properties of a substance are permanently changed
- Recognise that some materials are more affected by time and weathering than others and that there are ways of protecting them
- Analyse chemical changes in concrete examples (monuments and buildings) in a site which is one of the most attractive tourist attractions in Slovenia

Materials Needed

- Visit Prešeren's Monument and the surrounding buildings (Franciscan Church of the Annunciation, Hauptmann House, the dome of Ljubljana Cathedral in the background of Prešeren's Monument, the dome of the Kresija, which houses the Ljubljana Tourist Information Centre (pictures below)
- Mobile application
- Phone calculator

Activities

5 minutes: Start the lesson with an introduction.

When you look at Prešeren’s Monument and the surrounding buildings, consider whether they are new, restored or need renovation. How do we distinguish between new and old buildings? Why do we notice the difference just by looking at them? Have you ever heard of the expression "the tooth of time"?

Tooth of time = Meaning: destruction over time. Origin: The phrase Tooth of Time is probably derived from an expression in Shakespeare's tragicomedy, Soap Opera, in which it reads Tooth of time. The expression has become a metaphor for the destructive action of time.

The "tooth of time" is more noticeable on some materials.
10 minutes: Introduce (or repeat) the following notions:

- "The tooth of time": all ages
- Impact of weather phenomena: all ages
- Chemical reaction: ages 11 - 13 and 14 - 16
- Chemical symbols, chemical compounds, chemical equations: ages 14 - 16

15 minutes: Explain and demonstrate the notations mentioned above with an object. Then put students in groups of two or three per age group if possible. Tell them to cooperate within their group to provide answers to the questions in each of the 3 tasks per age group below. After providing the answers, they should also open the mobile app and answer the question for their age group of this stop (Prešeren’s Square).

- **Tasks: age 8-10:**

  Task 1: The "tooth of time" also affects living beings. How does it affect people, animals and plants?

  Task 2: What weather phenomena are you familiar with? Do you think these weather phenomena (rain, heat, cold, sun, wind) also affect the surrounding buildings?

  Task 3: What are the surrounding buildings made of, and what materials? Why and how are these buildings also affected by weather phenomena and the "tooth of time"?

- **Tasks: age 11-13:**

A chemical reaction is a process in which a substance's chemical and physical properties are permanently changed.

Chemical kinetics studies the rates of chemical reactions.

The rate of a chemical reaction measures how the concentrations or pressures of reactants and products change over time during a chemical reaction. The rate of a chemical reaction is very important for designing industrial chemical processes and calculating chemical equilibrium.

Task 1: Do you know which materials are more and less affected by the "tooth of time"? How can we protect them?

Task 2: What about weather phenomena? How do you think weather events affect the surrounding buildings? Take a look at Prešeren's Monument - do you think its appearance has changed over time? Why? Do you see any other buildings in the area that show such a change? Answer: the dome of Ljubljana Cathedral, the dome of the Kresija.

Task 3: Now turn towards the Franciscan Church of the Annunciation and the Hauptmann House. How old do you think they are?

Answer: The church was built between 1646 and 1660 on the site of an older church, and Hauptmann's house was built in 1873.

Why do both buildings look well-preserved despite their age?

What changes (chemical reactions) have taken place over time concerning the different colours of the facade (Fact 1) or its decoration (the Hauptman House also has tiles - Fact 2)?

The most noticeable is the colour or painting of their facade.

HINT 1: Although the best pigments are used to produce facade paints, we cannot ignore that intense colours in certain parts of the colour spectrum fade faster than "traditional" earthy or pastel shades. In other words: intense shades need to be freshened earlier than less striking colours.

Organic pigments are neither UV-resistant nor alkaline-stable, so an intense shade will fade unevenly if the substrate is different due to UV rays.

Dark tones also soon show any structural defects, dirty marks left by water running down the facade along ledges, balconies, on buildings without canopies, etc. In addition, a surface painted in dark shades can heat up to 70 degrees Celsius. This means extreme conditions for expansion joints in thermal insulation systems, which can lead to cracks in the plaster. https://deloindom.delo.si/enostanovanjske-hise/ne-kricecim-barvam-na-fasadah

HINT 2: The house was renovated in 1904. The owner decorated the facade with ornaments and coloured ceramic tiles (more durable) in a geometric pattern which thickens towards the top and is in green-blue-red colour tones. https://sl.wikipedia.org/wiki/Hauptmannova_hi%C5%A1a,_Ljubljana

Tasks: age 14-16:

A chemical equation is a record of a chemical reaction. The following rules apply:

- On the left side of the equation are the reactants - the substances that enter the chemical reaction,
- On the right-hand side are the products - the substances that are formed during the reaction.

- The reactants and products are written with their symbols (elements) or chemical formulae (compounds). They may be followed by information about their aggregate state in brackets (s (solid) - solid, l (liquid) - liquid, g (gas) - gas).
- The coefficients preceding the element symbols and the compound formulae tell how many atoms or molecules of each substance enter or are formed in the reaction.
- The left and right sides of the equation are separated by an arrow (→), symbolising a chemical change and indicating the direction in which the reaction is proceeding.
- Jean Beguin wrote the first chemical equation as a scheme in 1615.
- The equations must be balanced, according to the law of conservation of mass, so that the number of atoms of each element on either side of the equation is the same.

Task 1: Look at Prešeren's monument. What material is it made of?

Bronze is the name given to alloys of copper with tin, aluminium, lead, beryllium, silicon, manganese, iron and nickel. It was forged in the Middle East around 3300 BC. During this period, called the Bronze Age, arsenic was also added to the alloy to strengthen the metal.

The bronze statue of Prešeren is made from a traditional quaternary alloy and contains copper (88%), tin (5%), zinc (4%) and lead (3%).

How do we use chemical symbols to denote the chemical elements that make up Prešeren's monument, and how do we denote the bronze alloy?

Copper is a chemical element with the symbol Cu (from the Latin cuprum) and atomic number 29. It is a soft, malleable and kneadable metal with very high thermal and electrical conductivity. When freshly exposed, the surface of pure copper has a pinkish-orange colour.

Tin or tin is a chemical element with the symbol Sn (from the Latin Stannum stannum) and atomic number 50. Tin is a silver metal which has a characteristic yellowish tint. The tin is soft enough to be cut without much force.

Zinc (Latin: zincum) is a chemical element with the symbol Zn in the periodic table and atomic number 30. It is the fourth most widely used metal globally, after iron, aluminium and copper.

Lead is a chemical element with the symbol Pb (from the Latin plumbum) and an order number of 82. It is a soft, toxic, metallic metal with a relatively low melting point, bluish-white in fresh cross-section, quickly darkens to a dark grey colour in the air. Lead is the last stable element in the periodic table.

Image 1: Copper

Image 2: Tin

Image 3: Zinc

Image 4: Lead

Task 2: Take another look at the Prešeren's Monument. How has the appearance of the monument changed over time? Why? Do you see any other buildings in the area that show this chemical reaction? Answer: the dome of Ljubljana Cathedral, the dome of the Kresija.

The monument was unveiled in 1905 to commemorate the poet France Prešeren. Over time, the appearance of the monument has changed. Every now and then, most recently in 2005, the monument was restored, but only the stone plinth was renovated; the bronze figures were not restored at that time because it was not the right time of year to restore them in good quality. In 2022, the restoration centre of the Institute for the Protection of Cultural Heritage prepared a conservation plan for the restoration.

Today, Prešeren's Monument is brown to black in colour, but in the exposed parts, i.e., the shoulders of the jacket, the hair, the front of the face, and the shoes, it is predominantly green. Both the brown and the green areas on the bronze are oxide layers and corrosion products of the copper, formed under specific atmospheric conditions. The oxide layers and corrosion products on the bronze form what is known as a patina.

Image 5: Various patinations for studies in a laboratory environment (https://www.alternator.science/sl/daljse/kako-se-stara-bron-lepota-staranja/)

Task 3: First, read the information below and then, looking at the Prešeren's Monument and the other surrounding buildings with bronze domes, answer the questions below.

A patina is a thin layer on the surface of some metals formed due to oxidation of the surface or some other chemical process.

Thus, patina is formed on some metals as a result of the reaction of the surface with oxides, carbonates, sulphides or sulphates during exposure to atmospheric conditions. However, atmospheric conditions are not the only factors affecting the formation of a patina; artificial patina is also known.

Patina forms on the surface of copper, bronze, brass, and similar metals such as silver or a specific type of steel. The term is also used in connection with stone and wood to indicate a permanent change in the material's surface.

Patina may be removed by sanding, grinding or similar processes.

Depending on where the bronze surface is exposed and how aggressive the atmosphere is, secondary corrosion products can form on the patinated surface of the bronze. These are usually green in colour and consist mainly of copper species. Bronze is an alloy of copper and

alloying elements, and the corrosion products are predominantly copper compounds or minerals, which can be identified by their green to blue hues. (https://www.alternator.science/sl/daljse/kako-se-stara-bron-lepota-staranja/)

The statues are mostly made of bronze, which is protected from the weather by microcrystalline wax. But even this protection slowly evaporates and wears off. Then the weather works; the statue begins to oxidise and change its original patina. Acid rain also adds its effect, accelerating the oxidation of the bronze, and light-greenish spots appear on the statue - "GREEN WOLF" the dirt accumulated over the years (smog, pollen, etc.) is baked onto the surface, and the monument in some cases becomes unrecognisable. (https://www.livartis.si/obnova-spomenikov)

Questions:

So, what is patina, and how can it be removed?

What is oxidation?

Can it be seen elsewhere? E.g., on other surrounding buildings?

What changes have the atmospheric conditions left on the facade of the Franciscan Church and the Hauptmann House?

Image 6: The memorial to the poet Dr France Prešeren and his muse (Prešeren's monument), with the dome of Ljubljana Cathedral in the background.

Image 7: The dome of the Kresija, which also houses the Ljubljana Tourist Information Centre

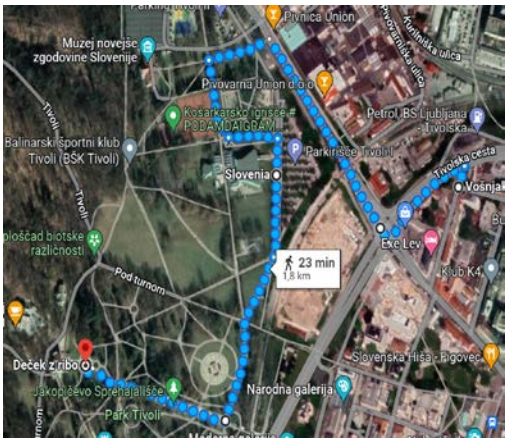
Image 8: Franciscan Church of the Annunciation

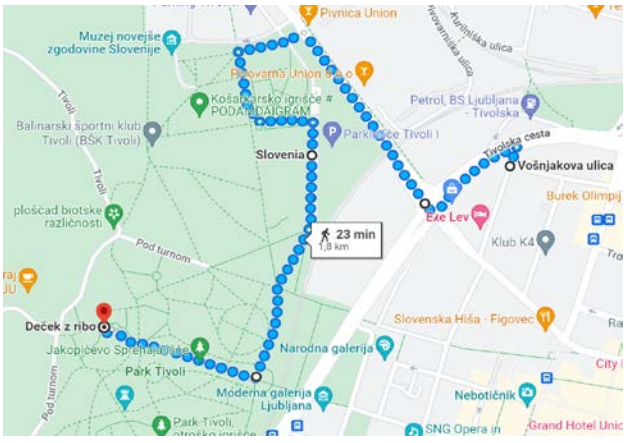
Image 9: Hauptmann House

2.2 Green&STEM trail Number 2 in Ljubljana

Author: Biljana Mileva Boshkoska

This trail consists of three stops. The recommended first stop is at Tivolska cesta and Vošnjakova street. The final stop is at the Ljubljana castle, where you may continue to the next trail in Ljubljana. The following maps show the trail. This trail consists of three stops within a 27 minutes walking distance, as shown on the map.





Stop 1: the Air pollution

- **Location**

The location of the 1. stop is at the air monitoring station located at the intersection of Tivolska cesta and Vošnjakova street (https://www.ljubljana.si/sl/moja-ljubljana/varstvo-okolja/stanje-okolja/zrak/).

- **Overview and Purpose**

To understand the different air pollutants and their multiple sources and impacts.

- **Education Standards**

The student will learn to:

1. Human impact on nature and the environment (biology) [4]..
2. Know that transport pollutes air, water and soil (if not necessary, choose a less polluting means of transportation, walk, cycle, train) (environment) [4].
3. Know the air pollutants, emphasising transport (environment), [4].
4. Identify and describe the main contributors to air pollution and local air pollutants - identify particulate matter pollution in the air (science and technology) [5].
5. Propose possible solutions for cleaner air (air filters), (science and technology) [5].
6. Evaluate people's behaviour or attitudes towards air pollution, explaining what is meant by a responsible attitude towards the environment (Science and Technology) [5].

7. Describes the composition and explains the significance of air (Science and Technology) [5].
8. Lists some measures for cleaner air (Science and Technology) [5].

- **Objectives**

Students will:

- To name air pollutants and their sources.
- To describe how to improve air quality locally.
- To convince others to help improve air quality.

- **Materials Needed**
  - Mobile application.
  - Access to the internet of printed web resources.
  - Phone calculator.

- **Activity**

5 minutes: Start the lesson with a historical note.

Pollutants come from many sources: humans make some, and others are natural. The main pollutants of concern are nitrogen dioxide (NO2) and particulates (PM10 and PM2.5). Traffic pollutants are generally the biggest problem for cities like Ljubljana [1].

Air is an essential biotic and environmental factor today and has always been. Various writers mention Ljubljana's air in the seventeenth century, even Valvasor in his Slava Vojvodina Kranjska. Ljubljana's basin location is the cause of the city's marked lack of air, which is also reflected in the air quality. In the past, this led to severe air pollution, especially during long-lasting winter inversions in the winter part of the year. That is why air protection was one of Ljubljana's first big environmental topics.

Air quality in Ljubljana has been monitored with continuous measurements since 1968. Today, at this measuring point, we monitor air quality, the impact of traffic pollution, and noise and meteorological parameters [1].

5 minutes: Introduce (or repeat) the main compounds of air pollution:

- SO_2 = Sulphur dioxide
- NO_2 = nitrogen dioxide
- PM_{10} = particle matters that may be obtained with filters of 10 micrometres
- What other compounds pollute the air? Possible Answers: NO_X, $PM_{2.5}$, dust, CO (carbon monoxide), O_3 (ozone)

15 minutes: Put students in groups of two or three, and give them the tasks.

Explain to students that they must work with their group to identify different pollutants at the stop. Complete the table for the major pollutants.

The task for age group 1 (age 8-10)

T1: Count the number of cars passing near the monitoring station in 5 minutes. Count how many are electric cars.

T2: Ask which activities we may incorporate in our daily lives to help improve the air quality. Help students with discussing the following [2]:

1. Encourage recycling
2. Leave the car at home – walk, cycle or scoot to school
3. Use public transport
4. Don't use single-use plastic
5. Save energy – switch lights off
6. Hold an anti-idling campaign, and switch off your engines when the car isn't moving.
7. Choose a route to school that avoids busy roads
8. Park and stride

T3: Fulfill the following sentences [3].

Air is polluted when there is too much _____and _____ .
In _____, _____ is polluted, in rural areas _____ is polluted.
Pollutants can be _____: volcano, forest fire and _____: traffic, thermal power plants, industry, heating plants.
To keep the air clean, we need to install _____ in chimneys.
These will catch _____.
We need to put _____ in cars. This is a device that catches _____ gases.
We will also need to look at installations in iron and steel works, oil refineries, spray factories and artificial fertiliser plants, where _____.
Winds can _____ _____ far away.
If we don't take care of the consequences, we will face weather changes and the risk of our _____

The task for age group 2 (age 11-13**)**

T1: Count the number of cars passing near the monitoring station in 5 minutes.

T2: Estimate the pollution of SO2 and CO2 released by cars in 5 minutes if the average amount of CO2 emissions by a car driving at the speed of 40-60 km/hour is 252 grams of CO2.

T3: What are the latest hourly measured emissions of CO2 and SO2 at this monitoring station? Help yourself by visiting the webpage of the monitoring station and discussing the proportion of pollution that comes from the nearby cars.

The task for age group 3 (age 14-16**)**

Aim: Demonstrate accurate and less accurate ways of measuring, and ask best students.

T1: Tell students to open the mobile app and find the Pollutant worksheet. Demonstrate Nitrogen dioxide as an air pollution compound. Ask students to choose one parameter and fill in the Pollutant worksheet for the selected pollutant. Provide students with the internet web pages given in

5 minutes: Discussion and conclusions.

Ask students to sit with their groups and look over their data.

10 minutes: Assessment. Steps to check for student understanding.

- Which objects are polluting the air nearby the monitoring station?
- Think of ways to decrease air pollution for a specific air pollutant.
- Which parameters are measured by the monitoring station?

Planning activity

1. Choose ONE way that your school can improve air quality.
2. Decide what change/s you want to make.
3. Decide the messages you want to share.
4. Create a poster or plan an activity to share your thoughts.
5. Share your findings by making a campaign in your school. Show students your poster(s).

Extension/Homework

One of the biggest pollution problems is traffic in cities. Imagine if every car that came into Ljubljana city had to pay 5EUR.

- What would you spend this money on?
- Explain your strategy.
- What would be the benefits and problems of your plan?

References:

1. https://www.ljubljana.si/sl/moja-ljubljana/varstvo-okolja/stanje-okolja/zrak/
2. Understanding air pollutants. https://schools.leicester.gov.uk/services/environment-health-and-well-being/air-quality-education/air-quality-education-resources/
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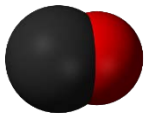
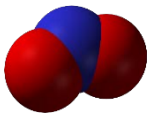
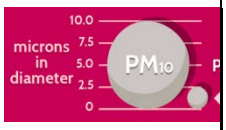
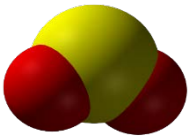
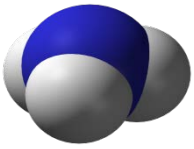
5. https://www.gov.si/assets/ministrstva/MIZS/Dokumenti/Osnovna-sola/Ucni-nacrti/obvezni/UN_naravoslovje_in_tehnika.pdf

References for future planning and teaching

1. https://schools.leicester.gov.uk/services/environment-health-and-well-being/air-quality-education/air-quality-education-resources/
2. Mocnik_Papez_Pavlin_Onesnazenost.pdf (uni-lj.si)

Table 1 Filled in pollutant worksheet with examples (source: https://schools.leicester.gov.uk/services/environment-health-and-well-being/air-quality-education/air-quality-education-resources/)

Name (and symbol)	Diagram	Sources	How to reduce	Interesting fact
Carbon dioxide (CO)		• Road transport • Smoking	• A good supply of oxygen for burning	• Produced instead of carbon dioxide in low oxygen levels
Nitrogen dioxide (NO_2)		• Burning fossil fuels (heating) • Lightening	• Using fewer cars, vans and lorries on the roads	• Lightening production makes a tiny amount
Ozone (O_3)		• Industrial sources • Nitrogen dioxide in sunlight	• Reduce the number of other pollutants, e.g. burning fossil fuels	• Found in the atmosphere to reduce UV
Particulates		• Transport • Solid fuel burning and BBQs	• Using fewer cars and vehicles	• It can be man-made and natural
Sulphur dioxide (SO_2)		• Power stations • Solid fuel burning	• Reducing the number of fuels being burned	• Volcanoes produce large amounts of sulphur dioxide
Ammonia (NH_3)		• Fertilisers • Waste disposal	• Reduce the amount of fertiliser and use it at the correct time of year	• Limited exposure for most people
VOCs (volatile Organic Compounds)	Lots of diagrams	• Household products • Fuels	• Reduce the amount of VOCs being used as solvents	• It can last in the air for a long time!

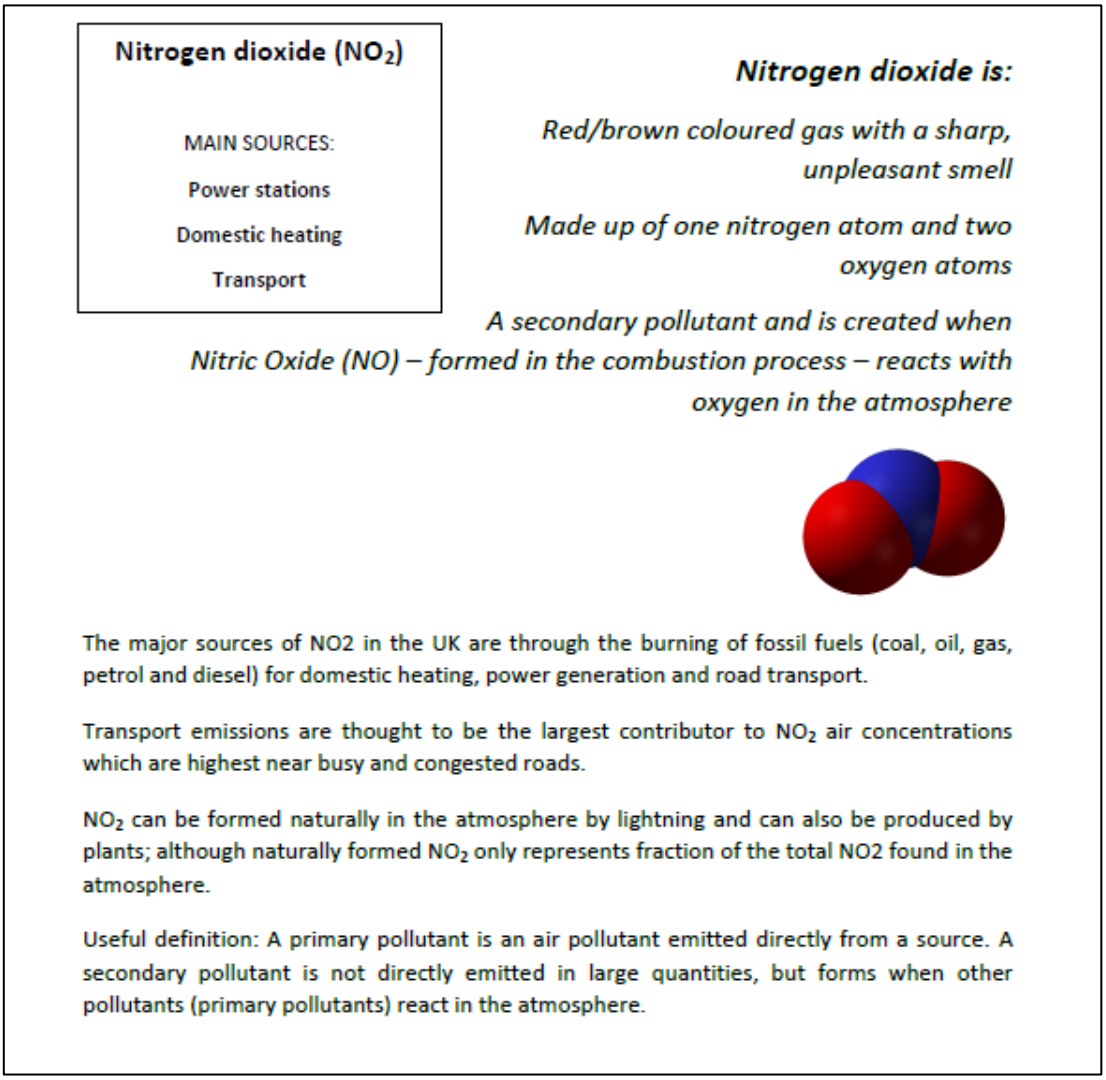


Figure 2 Pollutant factsheets: nitrogen dioxide (source: https://schools.leicester.gov.uk/services/environment-health-and-well-being/air-quality-education/air-quality-education-resources/)

Table 2 Web resources for task 1, age group 3

Basic information about NO2	*https://www.epa.gov/no2-pollution/basic-information-about-no2*
Basic information about SO2	*https://www.epa.gov/so2-pollution/sulfur-dioxide-basics*
Basic information about CO2	*https://www.epa.gov/co-pollution/basic-information-about-carbon-monoxide-co-outdoor-air-pollution*
Basic information about O3	*https://www.epa.gov/ground-level-ozone-pollution/ground-level-ozone-basics*
Basic information about Particulates	*https://www.epa.gov/pmcourse/what-particle-pollution*
Basic information about Ammonia	*https://www.epa.gov/wqc/aquatic-life-criteria-ammonia*
Basic information about VOC	*https://www.epa.gov/indoor-air-quality-iaq/volatile-organic-compounds-impact-indoor-air-quality*

ANSWERS TO T3 FOR AGE GROUP 1

Air is polluted when it contains too many other gases and dust.
It is more polluted in cities and less polluted in rural areas.

Pollutants can be natural: a volcano, a forest fire, or man-made: traffic, thermal power plants, industry, heating plants.

To keep the air clean, we need to install filters in chimneys.
These will trap the ash.

Cars need to be fitted with a catalytic converter. This is a device that traps toxic gases.

We will also need to take care of installations in iron and steel works, oil refineries, spray factories and artificial fertiliser plants where toxic gas is produced.

Winds can carry the smoke far away.

If we don't take care of the consequences, we will face weather changes and the risk of our health.

Stop 2: the Fibonacci sequence

- **Location**

The second stop is in Tivoli, in front ot the Tivoli swimming pool.

- **Overview and Purpose**

To understand the Fibonacci sequence's mathematics, to learn how to construct it and to recognize it in nature.

- **Education Standards**

The student will learn:
1. Relation of quantities [3].
2. Irrational numbers [3].
3. Sequences and types; samples [3, 4].
4. Recognize, continue and form sequences of numbers [5].
5. Form and continue sequences of numbers [5].
6. They form a sequence and continue a given sequence of natural numbers [5].
7. They recognise the rule in the numerical sequence, continue it and predict it (e.g. 20. Article of the sequence) [5].
8. They observe and recognise the rule in the numerical sequence and continue the sequence [5].

- **Objectives**

Students will:
1. Learn the origins of the golden ratio.
2. Learn to construct the Fibonacci sequences.
3. Be able to demonstrate the occurrences of the number phi in nature.
4. Explain Fibonacci numbers and their origin.

5. Identify Fibonacci numbers in nature and art.
6. Generate the following numbers in the Fibonacci sequence.
7. Create an original sequence of numbers and explain the pattern in which the numbers occur.
8. Create a Fibonacci rectangle and spiral.

- Materials Needed
- Mobile application.
- Phone calculator.
- Printed one-page material from mobile applications or chalks in different colours.

- Activities

5 minutes: Start the lesson with a historical note.

As young children, we played games with flowers: pulling the petals off a daisy (Figure 3), or wreath of flowers. Even at young age we observed that the yellow centre of a daisy comprises spirals that go out from the centre. This kind of pattern often occurs in nature [2].

Figure 1. Daisy (source:https://www.istockphoto.com/photos/daisy-petals)

The pattern can be represented mathematically as a sequence of numbers that, represent many relationships in nature. They may determine shapes, which connected in a certain manner, form the circles in the daisy. The mathematical sequence has a spatial name, and it is called a Fibonacci series. Some of the shapes that may be obtained from the Fibonacci sequence are shown in Table 1. For example, you may see pictures of sunflowers, flowers, and so many more [1]!

Figure 4 presents an example of numbers, also called the Fibonacci numbers, that follow the Fibonacci sequence. In this series, to determine the next number, you simply use the Fibonacci rule: add the previous two numbers together. The Fibonacci sequence is also called the *Golden Ratio*: the ratio of two quantities in a series is equal to the ratio of the later two quantities, which repeats for the whole series.

Figure 2. Fibonacci numbers sequence

5 minutes: Introduce (or repeat) the meaning of the gold ratio

Mathematically, for two quantities and , such that , are in the golden ratio if their ratio is the same as the ratio of their sum to the larger of the two quantities :

In the last formula, the Greek letter denotes the golden ratio. Let us calculate the golden ratio from the Fibonacci sequence given in Figure 4:

3/2 = 1.5
5/3 =1.6667
8/5 = 1.6
13/8 = 1.625
21/13 = 1.6154
34/21 = 1.6191
55/34 = 1.6176
89/55 = 1.6182
144/89 = 1.618

The Golden Ratio is Phi, 1.618….

15 minutes: Divide the students in groups of two or three and aks them to solve the following tasks.

Print out the Guidelines of Fibonacci art template. Ask them to draw the Fibonacci sequence using chalks according to the following guidelines. For younger students, teach up to number 13. For older students, suggest adding additional numbers in the image.

Guidelines for drawing Fibonacci rectangles:

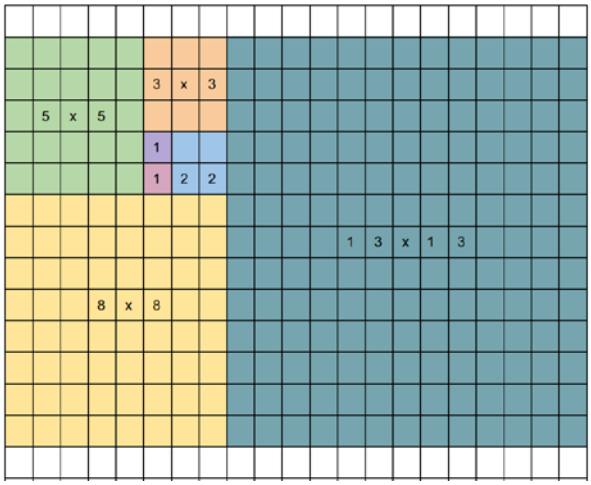


Figure 3 Step 1

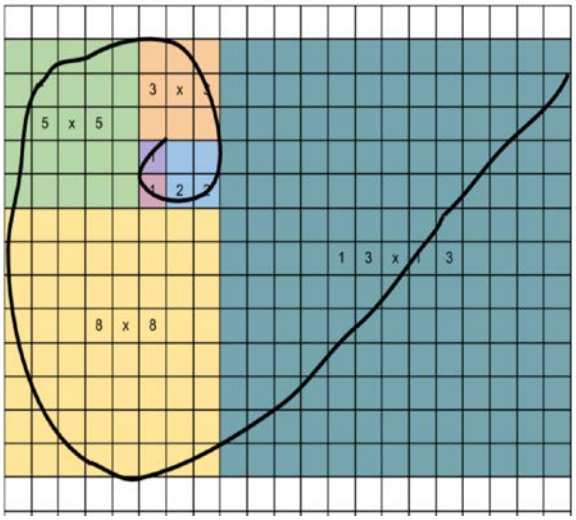


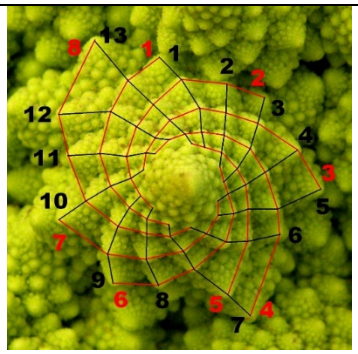
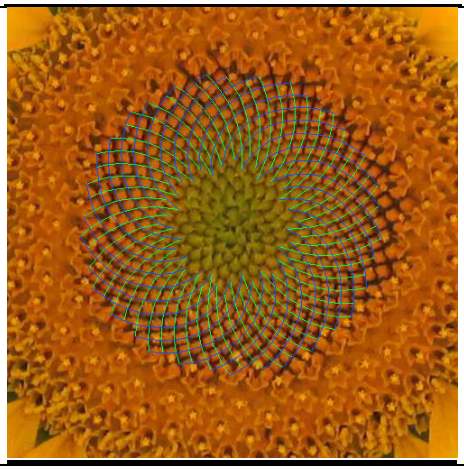
Figure 4 Step 2

The task for age group 1 (age 8-10**)**

Engineering – Observe the surrounding environment, both nature and architecture. Try to identify the spiral of the Fibonacci sequence in the objects that surround you.

Science – Go on a Golden Ratio nature walk and try to find the Fibonacci sequence in nature!
Now that you know what Fibonacci numbers are, you're ready to go on a Fibonacci hunt. Look at the photos of plants and objects in Table 1 and try to identify the Fibonacci pattern.

Table 3 Fibonacci shapes

The task for age group 2 (age 11-13**)**
Engineering – Look at local architecture (nature) that surrounds you and try to find the spiral of the Fibonacci sequence in buildings and structures (plants, trees, leaves).

Technology – Try to write the first ten numbers of the Fibonacci sequence in binary code.

The task for age group 3 (age 14-16**)**

Math – Try the **Threebinacci** sequence where you get the following number in the series by adding the past three numbers:

0, 1, 2, 3, 6, 11, ___, ___, ___, ___, ___, ___, ___, ___, ___, ___

Now, create your original pattern of numbers, explain and then write down the rule that you used to obtain the following number in the sequence.

Technology – Discuss how computer programmers utilise patterns to write code. Write the first six numbers of the Fibonacci sequence in binary, octave and hexadecimal code.

5 minutes: Discussion and conclusions.

Ask students to sit with their groups and look over their data.

10 minutes: Assessment. Steps to check for student understanding.

- Which objects in nature exhibit the golden ratio?
- Check the youtube link: Fibonacci square for kids - Google Search.

References:

1. https://ourfamilycode.com/fibonacci-artwork-steam-activity/ (Make Fibonacci Art: Hands-on Math Art Activity! - Our Family Code | Teach Kids to Code | STEAM & STEM Activities)
2. https://www.mensaforkids.org/teach/lesson-plans/fabulous-fibonacci/
3. https://www.gov.si/assets/ministrstva/MIZS/Dokumenti/Osnovna-sola/Ucni-nacrti/obvezni/UN_naravoslovje_in_tehnika.pdf

4. http://eportal.mss.edus.si/msswww/programi2018/programi/media/pdf/un_gimnazija/un_matematika_gimn.pdf
5. https://www.gov.si/assets/ministrstva/MIZS/Dokumenti/Osnovna-sola/Ucni-nacrti/obvezni/UN_matematika.pdf

Resources for learning in the classroom or at home:

1. https://ourfamilycode.com/fibonacci-artwork-steam-activity/
2. https://ourfamilycode.com/fibonacci-artwork-steam-activity/
3. https://www.mensaforkids.org/teach/lesson-plans/fabulous-fibonacci/
4. https://static.americanmensa.org/Assets/MFK2/assets/File/Teach/LessonPlans/Lesson_Fibonacci.pdf
5. https://www.mensaforkids.org/teach/lesson-plans/fabulous-fibonacci/
6. https://www.mensaforkids.org/teach/lesson-plans/

Stop 3: the geometry

- **Location**

The **location** of the **3. stop** is in front of the mansion in the city's Tivoli Park northwest the city centre, at the foot of Rožnik Hill. An alpine-style building called the Švicarija (the Swiss House) stands behind the mansion [6]. This stop is located in front of the Tivoli caste.

Figure 5 Tivoli castle

- **Overview and Purpose**

To understand the mathematics behind the estimation of the area of geometric figures, to recognise them in nature, and construct them by themselves.

- **Education Standards**

The student will learn to:

1. Understand estimation techniques (science and technology) [5]
3. Learn about symmetry (mathematics) [3, 4]
4. Identify and describe different construction materials (science and technology) [5]
5. Learn orientation (science and technology) [5]

- **Objectives**

Students will:

1. Learn to estimate height and distance.

2. Students find, recognise and count rectangular objects regularly arranged (age group 1).
3. To identify and differentiate rectangular shapes in nature and urban environments.
4. To calculate actual dimensions of length measurements.
5. Recognising similar triangles and using the Thales theorem for indirect length calculation in the urban environment (age groups 2, 3).

- **Materials Needed**

- Mobile application
- Phone calculator
- A meter, pencil or any object with known height. A mobile phone with a meter application is preferable. A foot measure is 30.48 cm. Use your feet length (for example, 35cm – 42cm).

- **Activity**

5 minutes: Start the lesson with a historical note.

“Tivoli Castle is a mansion located in the Ljubljana's Tivoli Park. In the early 15th century, a tower stood in the woods above the site; it was owned by Georg Apfalterer, an ally of Duke Frederick (later Holy Roman Emperor Frederick III). The tower was destroyed by Frederick II, Count of Celje in 1440.

The current structure was built in the 17th century atop the ruins of a previous Renaissance-period castle, the mansion was initially owned by the Jesuits, but came into the possession of the Diocese of Ljubljana following the 1773 suppression of the Jesuit order. Used as the bishop's summer residence, it was surrounded with orchards.

In the mid-19th century, it was bought by the Austrian emperor Francis Joseph I, who in 1852 presented it as a gift to the veteran Habsburg marshal Joseph Radetzky. Radetzky renovated the mansion in the Neoclassical style, giving it its present appearance, and spent much of his retirement in it with his wife Francisca von Strassoldo Grafenberg, a local Carniolan noblewoman.

The field marshal Joseph Radetzky von Radetz (1766–1858) contributed a lot to the arrangement of Tivoli Park. There was a full-size cast iron statue of Radetzky on display in Ljubljana on the steps in front of Tivoli Castle from 1882 till 1918. In 1851, it won a prize at the Great Exhibition in London. Today, it is preserved by the City Museum of Ljubljana. The statue's pedestal, however, remains at its original place.

In 1863, the mansion was bought by the Municipality of Ljubljana, who used it as (among other things) a poorhouse, later subdividing it into condominiums. In 1967, it was again renovated and became the venue for the International Centre of Graphic Arts.

In 1864, the Austrian sculptor Anton Dominik Fernkorn created four cast iron dogs, still on display in Tivoli Park in front of Tivoli Castle." (source:

https://en.wikipedia.org/wiki/Tivoli_Castle).

5 minutes: Introduce (or repeat) the meaning of estimation

Imagine if you could easily estimate:

- How many trees are in Tivoli park?
- How many litters of water is in the fountain?
- How many stones were used to build the Tivoli castle?

Also, it would be great if you could quickly guess how many stairs are to the top of the Tivoli castle, how many windows has the castle, or even how many birds are on the roof.

When we estimate quantities with numbers, we are not looking for exact answers, but for answers that are good enough for the given situation, or close enough to the real solution [7].

"Estimation is finding a number that is close enough to the correct answer."

15 minutes: Divide students in groups of two or three and ask them to provide solutions to the following tasks.

The task for age group 1 (age 8-10**)**

Count the number of windows in the front wall of the Tivoli castle. Measure the width of one window. Measure the width of the house. Estimate how many windows may fit on the Tivoli castle (use only the width of the window and the Tivoli castle).

To estimate, compare, measure, and record lengths, encourage students to use different non-standard units of measurement: giant steps, jumps or toe-to-heel steps. A sample template for this is provided below [1, 2].

	From ___ to ___	From ___ to ___	From ___ to ___
Giant steps	Estimate: Result:	Estimate: Result:	Estimate: Result:
Jumps	Estimate: Result:	Estimate: Result:	Estimate: Result:
Toe-to-heel steps	Estimate: Result:	Estimate: Result:	Estimate: Result:

Additional questions for discussion

- What shapes can you see?
- How many different colours can you see? Is there a pattern? Explain your answer.
- Estimate how many windows there are in the school building. Check your answer.
- Can you find any examples of symmetry?
- Are there any windows that are longer/shorter than the rest?
- What materials can you see on the building? Do the materials feel cold or warm? Rough/smooth? Soft/hard?
- Are the materials waterproof? How do you know?

- Are any of the materials recyclable?
- Can you see any pipes or drains? Count and record how many drains and pipes you can see.
- What materials are the drains and pipes made from? What are they used for?
- What kind of workers were needed to construct this building?
- If you were to make any changes to the building, what would they be? Why?

The task for age group 2 (age 11-13**)**

Estimate the number of blocks/bricks that were used to construct the wall at the front of the Tivoli castle? What strategies could you use to figure out your answer?
Using your hands, measure the width/height of the window. Note your answer. Did you get the same answer as your partner? Why do you think this is? How could you verify your measurements using measuring equipment?

What materials can you identify in the building? Which are man-made, and which are natural?

The task for age group 3 (age 14-16**)**

Turn and face the Tivoli castle and try to guess the correct answers on the following questions:

- What direction are you facing? How do you know? How could you check?
- Estimate the area/perimeter of the wall of the Tivoli castle you are facing? Explain your reasoning for this estimate. How could you perform the measurement?
- Can you see any doors/windows? Could you measure their area/perimeter?
- Are the doors/windows environmentally friendly? Give reasons for your answer.
- Whilst facing the Tivoli castle, rotate 45º/ 90º /180º etc. What direction are you now facing? How do you know?
- What examples of lines/ angles/ shapes/ symmetry can you now identify? Draw some examples and label the diagrams.

5 minutes: Discussion and conclusions.

Ask students to sit with their groups and look at and discuss their data.

10 minutes: Assessment. Steps to check for student understanding.

Planning activity

Extension/Homework
Use 1-2 more pipe cleaners to complete your spiral. Poke the ends into the paper to make the spiral sturdy.

References:

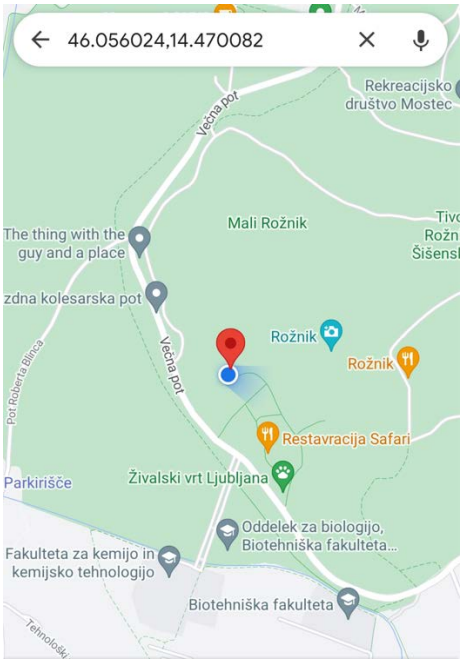
1. https://www.scoilnet.ie/uploads/resources/34622/34373.pdf
2. https://www.scoilnet.ie/uploads/resources/34623/34374.pdf
3. https://www.gov.si/assets/ministrstva/MIZS/Dokumenti/Osnovna-sola/Ucni-nacrti/obvezni/UN_naravoslovje_in_tehnika.pdf
4. http://eportal.mss.edus.si/msswww/programi2018/programi/media/pdf/un_gimnazija/un_matematika_gimn.pdf
5. https://www.gov.si/assets/ministrstva/MIZS/Dokumenti/Osnovna-sola/Ucni-nacrti/obvezni/UN_matematika.pdf
6. https://en.wikipedia.org/wiki/Tivoli_Castle
7. https://www.mathsisfun.com/numbers/estimation.html

2.3 Green&STEM trail Number 3 in Ljubljana

Authors: Nina Cvek Bijelič, Marina Ristova Firer, Anja Šuštar

FIRST STOP: BUILDING/ CONSTRUCTING

Location: the path to Rožnik



- **Education Standards**

Objectives from UN-Fine Arts, Natural Sciences and Engineering, Engineering and Technology: Objectives from UN-Fine Arts, Natural Sciences and Engineering, Engineering and Technology:

- create spatial formations using different materials,
- develop a sense of product stability,
- they know how to make a model of a hanging swing and balance it here
- develop motor skills and feel when working with different materials and aids for expression in three-dimensional space,
- develop a sense of the stability of the structure in the room,
- present the advantages and disadvantages of using wood compared to others materials.

- **Objectives**

Students will:

- *build* models using different materials;
- develop a sense of the stability of their model.
- be able to make a model of a seesaw and balance it;
- present the advantages and disadvantages of using wood compared to other materials.
- develop motor skills and a sense of working with different materials and tools to express themselves in three-dimensional space;
- develop a sense *of structural stability in space.*

- **Materials Needed**
  - stones of different shapes
  - sticks
  - rocks

- **Activity**

TASK (30 min):

Gather at least ten stones of different shapes and sizes from your surroundings. Place one on top of another so the structure does not collapse (Figure 1). This stack of stones is called a CAIRN and was sometimes used as a trail marker.
When stacking the stones, you had to ensure they were balanced. Make some seesaws (Figure 2) from the materials you find on the ground (rocks, sticks, etc.).
Try to build as solid a shelter/bridge/imaginary structure as possible from natural materials (Figure 3).

ANALYSIS (5 min):
What natural materials did you use? Are they better than synthetic ones? Explain.

FOLLOW-UP TASK (10 min):

Age Group 1 (8-10y): Try to make a mobile from the materials you find on the ground (Figure 4). You need different things like stones, rocks, sticks, …etc. Use them to construct a mobile.

Age Group 2 (11-13y): Look at photos of knots (Figure 5). Find a natural material that could be used to tie twigs. How did the prehistoric people do it?

Age Group 3(14-16y): Build a small bridge and see how much weight it can hold (you do this by placing progressively heavier stones on it). Think about how you could improve the structure to handle more weight.

Figure 1 – Gather at least ten stones of different shapes and sizes from your surroundings and place them one on top of another

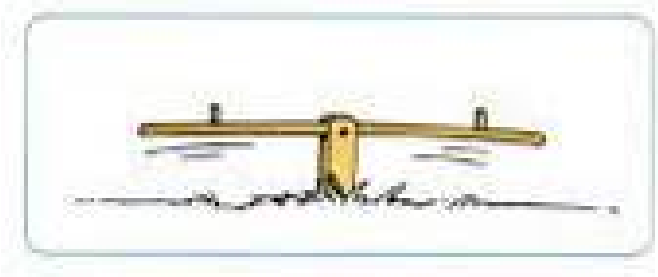


Figure 2 - make some seesaws.

Figure 3 – Try to build as solid a shelter/bridge/imaginary structure as possible from natural materials.

Figure 4 – Try to make a mobile from the materials you find on the ground.

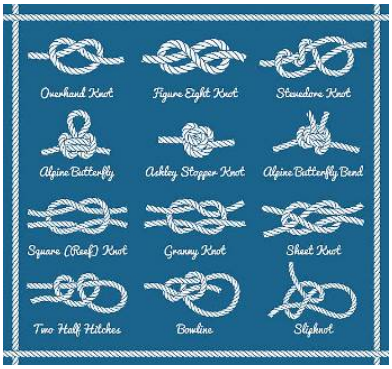


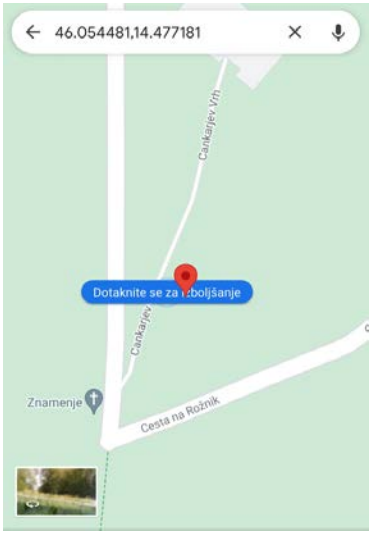
Figure 5 –

References

- https://www.gov.si/assets/ministrstva/MIZS/Dokumenti/Osnovna-sola/Ucni-nacrti/obvezni/UN_naravoslovje_in_tehnika.pdf
- https://www.gov.si/assets/ministrstva/MIZS/Dokumenti/Osnovna-sola/Ucni-nacrti/obvezni/UN_tehnika_tehnologija.pdf
- https://www.gov.si/assets/ministrstva/MIZS/Dokumenti/Osnovna-sola/Ucni-nacrti/obvezni/UN_likovna_vzgoja.pdf

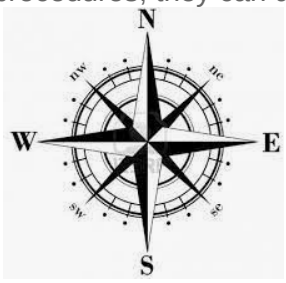
SECOND STOP: ORIENTATION

Location: near the church on top of Rožnik



- **Overview and Purpose**

At this task, children will find their cardinal directions in different ways. They will find that with various tools and procedures, they can determine the exact sides of the sky.



Cardinal directions – Figure 1

Compass – Figure 2

- **Education Standards**

The student will learn to:

1. Correctly use a compass and analogue watch and observe the Sun and shadow to determine the side of the sky
2. Solve various tasks for determining the side of the sky.
3. To say what is located in a particular area (note in the north, south, east and west).
4. Determine the cardinal directions

- **Objectives**

Students will:

1. know the cardinal directions (east, west, north, south)
2. can determine the cardinal directions using the Sun, shadows, a watch, and a compass.
3. learn that the Sun is the primary source of energy on Earth,
4. know how to explain why the amount of energy received from the Sun depends on the season.

- **Materials Needed**

1. Compass
2. Analogue watch
3. Mobile application
4. Sticks

- **Activity**

  - **5 minutes: Start the lesson with a historical note.**

The word orientation comes from the Latin word orient, which means east. Orientation means determining the celestial direction according to the rising Sun, i.e. the eastern side. According to the international agreement, we know the four main directions of the sky, which are denoted by letters: N - north, S - south, E - east, and W - west. In addition to these main sides of the sky, we know several auxiliary ones.

If we know one of the celestial directions, we can quickly and easily determine all the others. Thus, orientation means determining at least one direction in the sky, with which we then find ourselves on land or in space. The most general orientation is the determination of our place of observation (location) in relation to certain points, objects and signs.

Even primitive man knew how to orient himself in nature to move from place to place or go somewhere further to hunt and return safely. The skill of orientation was their life necessity and one of the survival skills. Of course, primitive man did not use special devices for orientation but oriented himself by various natural signs and probably had a much more developed sense of orientation. They helped themselves to orient themselves by observing nature and space bodies. They discovered certain regularities that they used usefully when orienting themselves in nature.

(Vir: http://www.szsms.si/wp-content/uploads/2018/03/orientacija-gradivo.pdf)

- **5 minutes: Introduce (or repeat) the following notions:**
- compass - a device that shows us exactly where north is. When we know where the north is, we know all the other sides of the sky. We know several models of compasses, which differ in shape, material, construction, basic markings and price.
- Analogue watch - a mechanical device that measures and displays time, usually on a dial or in digital notation with numbers.
- Shadow - We need a light source and an obstacle to create a shadow. Light spreads or travels through space. However, when light encounters an obstacle, it cannot pass through. A shadow forms behind the obstacle.

- **15 minutes: work in groups**

Divide students into groups of three or four. Each group should have a student who wears a wristwatch with their hands. If they don't have one, they should look for a wristwatch on their phone. Also, have them open the mobile app and find the orientation to the Sides of the Sky worksheet.
Did you know that you can find the cardinal directions without a compass?

1. If you get lost, you can use the shadow stick method. Place a stick into the ground so it does not cast any shadow. Wait a couple of minutes. Eventually, a shadow will appear, pointing eastwards.

2. Orientation (in sunny weather) using an analogue watch:
Hold the watch horizontally in your hand with the hour hand in the direction of the Sun and the twelve o'clock marker facing left. The middle point between the two marks SOUTH. What time is it?

What time of the day is the Sun highest in the sky?

- **5 minutes: Discussion and conclusions.**

Students present their work in groups. Each group presents the same task they solved. We compare the results.

With the help of which fact did you determine the cardinal directions?
Explain your finding.

- **10 minutes: Assessment. Steps to check for student understanding.**

Did you know we can also orient ourselves by looking at the Sun?

Age Group 1 (8-10y): Observing nature can also determine Cardinal directions. Take a walk in the woods above the school playground and try to identify the cardinal directions. Use the following facts to help you:

- Moss mainly grows on the north side of trees and rocks.
- Trees will have more branches on the south-facing side.

Age Group 2 (11-13y):

Figure 3: Push the one-metre-high stick you brought with you into the ground.

Figure 4: Place a small stick on the tip of the shadow of the first stick.

Figure 5: Wait about 15 minutes for the shadow to move. After 15 minutes have elapsed, mark the location of the tip of the shadow with another small stick.

Figure 6: Place the third stick between the other two.

Figure 7: Then, place another stick perpendicular to the third stick.

Figure 8: The first point marked by the stick points WEST; the second point is EAST. The upper part of the fourth stick points NORTH, and the lower part points SOUTH.

Age Group 3 (14-16y):

Solar energy, emitted by the Sun to Earth in the form of sunlight, is the most important non-living factor in the environment. That is why we say that the Sun is the primary energy source on Earth.

Plants need water, minerals and carbon dioxide for their growth. Solar energy allows plants to carry out photosynthesis. The energy of the Sun is also necessary for other processes in nature, such as the growth of plants, the creation of wind, the formation of rocks, and the change of aggregate states of matter...

- Does the Earth receive the same amount of solar energy throughout the year? Explain.
- There is a church on the top of Rožnik. In addition, they would like to build three houses. Where would you put them to get enough sunlight? Pay attention to the direction of the sky and the height of existing buildings.

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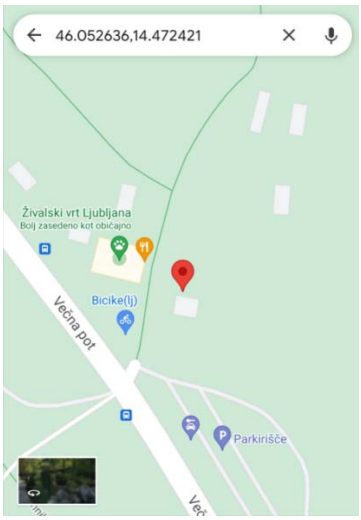
THIRD STOP: SYMMETRY



- **Overview and Purpose**

Symmetry in everyday language refers to a sense of harmonious and beautiful proportion and balance. In mathematics, "symmetry" has a more precise definition and is usually used to refer to an invariant object under some transformations,

including translation, reflection, rotation or scaling. Although these two meanings of "symmetry" can sometimes be told apart, they are intricately related and hence are discussed together in this article.
Mathematical symmetry may be observed with respect to the passage of time; as a spatial relationship; through geometric transformations; through other kinds of functional transformations; and as an aspect of abstract objects, including theoretical models, language, and music.
This article describes symmetry from three perspectives: in mathematics, including geometry, the most familiar type of symmetry for many people; in science and nature; and in the arts, covering architecture, art and music.
The opposite of symmetry is asymmetry, which refers to the absence or violation of symmetry.

- **Education Standards**

Goals from UN-mathematics:

- recognize and show symmetry in objects and figures,
- draw symmetrical shapes,
- recognize and design symmetrical shapes,
- form patterns with movements, rotations and mirroring.
- form patterns with rotations and mirroring.

- **Objectives**

Students will:

- identify and show symmetry in objects and images,
- draw symmetrical shapes.
- identify and form symmetrical shapes,
- form patterns by moving, rotating and mirroring.
- form patterns by rotating and mirroring.

- **Materials Needed**

1. natural materials found in your surroundings

- **Activity**

TASK (30 min):

Have you ever been to a formal French garden? There's one in Slovenia in Volčji Potok (Figure 1). But what's so unique about them? That's right! Symmetry. Everything on one side of the garden must be mirrored exactly on the other to give a consistent and clear picture.
Look at the photos (Figures 2-6) showing symmetry. Then look around and find symmetrical shapes. How many can you find?
Create a symmetrical image using natural materials found in your surroundings. Look at the photos for a hint (Figures 7-8).

ANALYSIS (5 min):

Find the bisector (the line that divides the image into two congruent parts) on the symmetrical images you have made. Is it possible to find any other symmetry in your product?

FOLLOW-UP TASK (10 min):

- ***Age Group 1 (8-10y):*** Choose a part of your masterpiece and turn it into a pattern.
- ***Age Group 2 (11-13y):*** Place a stick next to your masterpiece. Mirror your masterpiece over the stick (line).
- ***Age Group 3 (14-16y):*** Place a stone next to your masterpiece. Mirror your masterpiece over the stone (point).

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Figure 1 – Volčji Potok (place in Slovenia)

Figure 2 – symmetry

Figure 3 – symmetry in butterfly

Figure 4 – symmetry in flower

Figure 5 – symmetry in spider

Figure 6 – symmetry in snowflake

Figure 7 – symmetry in mandals

Figure 8 – symmetry in mandal

2.4 Green&STEM trail Number 4 in Ljubljana

Authors: Nina Cvek Bijelič, Marina Ristova Firer, Anja Šuštar

FIRST STOP: SLIDE

Location: school playground

46°02'42.0"N 14°27'13.2"E

Osnovna šola Vrhovci, Cesta na Bokalce 1, Ljubljana, Slovenija

- **Overview and Purpose**

At this station, the children will go down the slide and use a stopwatch to measure how long it takes them to go down once and return to the original position. They will compare their results and (try to) determine what the time of one descent depends on.

Figure 1

Figure 2

- **Education Standards**

The student will learn to:

- Use the stopwatch correctly and carefully observe your friend's descent and movement.
- Solve a task that contains time units (conversion of units)
- Calculate how many descents an individual can make in a certain time frame.
- Generalizes from a sample of observations in individual cases and makes an assumption (problem-solving).

- **Objectives**
  Students will:
  - calculate using identical units of measure (MATH)
  - use elementary operations to solve problems (MATH),
  - convert units of measurement and calculate with them (smaller units to larger ones) (MATH),
  - use unit conversion to solve word problems (MATH),
  - independently carry out a measurement of length or time, calculate the average value and roughly estimate the measurement error (e-experimentation) (PHYS).

- **Materials Needed**
  - Slide
  - Notes from student's phones
  - Mobile application
  - App from student's phones

- **Activity**

5 minutes: Start the lesson with a historical note.

Playground slides are found in parks, playgrounds and backyards. A roller coaster is an example of a simple machine known as an inclined plane that makes moving objects up and down easier or, in our case, more fun. The slide can be flat, half or tubular to prevent falls. The user, usually a child, climbs a ladder or stairs to the top of the slide, sits on top, and slides down the chute.

The earliest known playground slide was installed at the "Neighbour House" playground in Washington, D.C., in early 1902. The first bamboo slide at Coney Island opened in May 1903, so it is unclear which slide came first - the playground slides or the amusement park.

We know spiral, wave, flat, downhill, water and toboggan slides in amusement parks.

Slides can also be divided into independent slides, slides that stand alone, or compound slides, which are slides connected to one or more pieces of playground equipment.

5 minutes: Introduce (or repeat) the following notions:

- Descent = On average, a child needs 10 seconds to climb the stairs, walk to the slide and go down it. It takes an additional 5 seconds to return to the starting position - to the stairs.
- Stopwatch = a clock designed to measure the time that elapses between switching it on and off.

It is necessary to pay attention to safety. There is only one person on the slide. Before going down, check that your laces are tied and that the surface of the slide is dry and clean.

15 minutes: Group work

You have been on the school playground many times. What is on it? Take a good look at all the items. List them. How do we use them correctly? What skills do we teach them?

Divide the students into groups of two or three and give them stopwatches. Tell them to open the mobile app and find the Toboggan worksheet. Demonstrate one descent down the slide and measure with a stopwatch. Record the result.

Explain to the students that together with their group, they have to time one descent down the slide.

Subtasks:

- Age Group 1 (8-10y): Pick a student and start the stopwatch. How many times in one minute can the child go down the slide?
- Age Group 2 (11-13y): One child needs 15 seconds to go down the slide and return to the starting position. How long would it take for 20 students to slide down? Record the result in minutes.
- Age Group 3 (14-16y): Choose five students to go down the slide. Have them form a queue in front of the stairs. Important: Record the students' times and the total time. On your signal, the first student starts the task. When they return to the starting position, they touch the other student so that they can begin the task. Stop the watch when the last student comes back. How long did it take, on average, for one student to slide down? Why were the measurement results different?

5 minutes: Discussion and conclusions.

Students present their work in groups. Each group presents the same task they solved. We compare the results and discuss why the deviation occurred.

We guide the students to the answers with questions. Possible questions: Why do you think the time is different if you got a different time? What does the time of going down the slide depend on?

10 minutes: Assessment. Steps to check for student understanding.

1. Have two children of different weights go down the slide. How long did it take for them to slide down? What does the time of descent depend on?
2. Have the two students go down the slide twice: the first time with their legs bent and raised, the second with their legs bent and lowered. Which descent took longer and why?
3. How could the incline of the slide be changed? Does the angle affect the speed and time of the descent?

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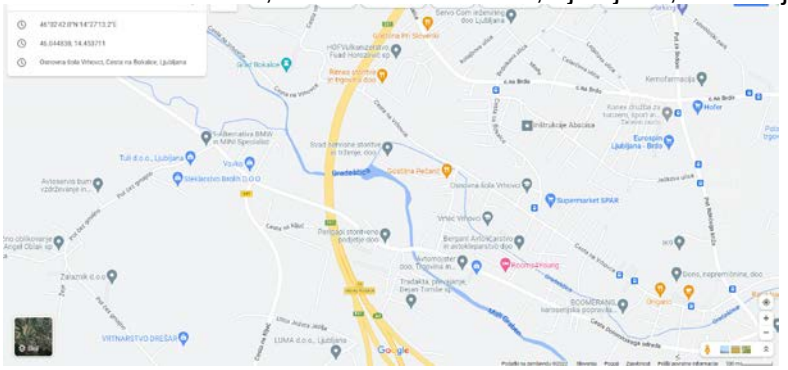
SECOND STOP: SWING

Location: school playground

46°02'42.0"N 14°27'13.2"E

Osnovna šola Vrhovci, Cesta na Bokalce 1, Ljubljana, Slovenija



- **Overview and Purpose**

  At the second station, children will swing and measure the time of one swing with a stopwatch. One swing is the path of the swing from the first extreme position to the second extreme position and back. They will compare their results and find out how we can swing or what to do to make the swing.

- **Education Standards**

  The student will learn to:

  1. Use the stopwatch correctly and observe the swing.
  2. Solve a task that contains time units (unit conversion)1. Solve a task containing time units (unit conversion)
  3. To find out what the time of one oscillation depends on.

- **Objectives**

  Students will:

  - learn that we can influence motion (ENVIR),
  - prove that a push is needed to start swinging (NSE),
  - identify the difference between the motion and the rest of an observed body in relation to its surroundings (PHYS),
  - learn by experiment that forces cause a change in the motion or shape of a body and name the types of forces after the bodies that cause them (E-experimentation); (PHYS),
  - represent the force with a directed line segment in the given ratio; (PHYS),
  - are familiar with the concept of the centre of gravity (PHYS).

- **Materials Needed**

  - Swing
  - Notes from student's phones
  - Mobile application
  - App from student's phones

- **Activity**

5 minutes: Start the lesson with a historical note.

A swing is a seat often found in playgrounds, courtyards, circuses for acrobats or on verandas for relaxation. The swing seat can be hung on chains or ropes. Once the swing is in motion, it continues until it comes to rest or doesn't stop.

The earliest swings were found in Greece, 1450 – 1300 BC. n. no.
Playgrounds have several swings, often suspended from the same metal or wooden frame, allowing more than one child to play simultaneously. You can swing low or high on the swing. We know swings of various shapes and sizes:

Figure 1: swing for the youngest children

Figure 2: nest

Figure 3: children's

Figure 4: bench

Figure 5: support

Figure 6: garden

Figure 7: indoor

Figure 8: swing

5 minutes: Introduce (or repeat) the following notions:

- Movement = changing the position of the body in relation to the surroundings.
- Rest = a body is at rest when it does not change its position in relation to another body or a group of bodies in the surroundings.
- Swing = the path of the swing from the first extreme position to the second extreme position and back.
- A push = change in motion of a moving body.
- Centre of gravity = in physics, the point on a body on which the torque of the force of gravity is zero.

We must be careful not to fall and to walk too close to the swing when someone is swinging.

15 minutes: works in groups

Sit on a swing in the school playground and try to swing without the help of your legs. Can you start swinging without legs? In what way could you swing without using your legs? Have someone help you and start. Swing low and swing high. What affects the height of the swing?

Divide the students into groups of two or three, and I will give them stopwatches. Tell them to open the mobile app and find the Swing worksheet.

Explain to the students that they have to solve the task together: the child makes one swing in 1 s. How long does it take for ten swings? How many swings does it make in half a minute/ one, a quarter/ third of a minute?

5 minutes: Discussion and conclusions.

Students present their work in groups. Each group presents the same task they solved. We compare the results and discuss why the deviation occurred.

The teacher helps to understand the differences in measurements and leads a discussion about why this happens.

10 minutes: Assessment. Steps to check for student understanding.

Sit on the swing. Ask a classmate to use a stopwatch to measure the time it takes you to do one swing. Did you both measure at the same time? What does the time of one swing depend on?

Age Group 1 (8-10y): What do you need to make a swing? Find the materials on the playground and make one.

Age Group 2 (11-13y): Swing on the swing for 30 seconds, then stop. Count the swings until the swing stops.

Age Group 3 (14-16y): Is the oscillation of the swing driven by force? What forces are acting on the swing during the period of movement?

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THIRD STOP: TEMPERATURE

Location: school playground

46°02'42.0"N 14°27'13.2"E

Osnovna šola Vrhovci, Cesta na Bokalce 1, Ljubljana, Slovenija

- **Objectives**

Students will:

- know how to measure temperature (ENVIR)
- can distinguish between temperature and heat (NSE)
- be able to describe different thermometers and measure temperature (NS)
- learn that luminous energy can cause matter to warm differently (NS)
- develop practical skills and methods of investigation (NS)

- **Materials Needed**

- thermometer app

- **Activity**

TASK (30 min):

Did you know that there's a difference between temperature and heat? Heat is energy, while the temperature is a measurement of that energy. Do you know any devices that measure temperature? Of course, you do. They're called thermometers. Look at the different thermometers in the photos (digital thermometer – Figure 1; kitchen thermometer – Figure 2; infrared thermometer – Figure 3; alcohol thermometer – Figure 4).

To start your task, you'll need a thermometer, which you can download for free on your phone. You can also use your fingertips to take measurements.

Measure the temperature at different points (see Figures 5 and 6 for some help):
* in the shade of a grassy area (e.g., next to a tree),
* in the shade on an artificial surface (e.g., under the playground equipment),
* in the Sun on a grassy area (e.g., the lawn next to the playground),
* in the Sun on an artificial surface (e.g., on the playground or the playing field).

If you measure with a thermometer, record the temperatures in the spreadsheet. Using your fingers, you can use terms such as cold, warm, hot, colder, warmer, hotter, etc.

	GRASS SURFACE	ARTIFICIAL SURFACE
IN THE SHADE		
IN THE SUN		

Figure 1 – digital thermometer

Figure 2 – kitchen thermometer

Figure 3 – infrared thermometer

Figure 4 – alcohol thermometer

Figure 5 – Measure the temperature at different points

Figure 6 – Measure the temperature at different points.

Analysis (5 min):

Observe (compare) the temperature of the grass surface in the shade and the Sun and the temperatures of the artificial surface in the shade and the Sun.

Assessment. Steps to check for student understanding.

Age Group 1 (8-10y): Where would you prefer to play on hot summer days and why?

Age Group 2 (11-13y): Why are areas covered in plants cooler than artificial surfaces? How else could we check if plants are natural coolants?

(SOLUTION: https://eucbeniki.sio.si/nar6/1559/index2.html)

Age Group 3 (14-16y): Have you ever heard of green roofs? What are the benefits of such roofs? Why do they work? (**Energy efficiency:** Green roofs in densely populated areas prevent the overheating of buildings, reducing the need for cooling. As a result, buildings with green roofs consume less electricity. Such roofs prevent “heat islands.” Ljubljana stands out as a distinct heat island in our country.)

SOURCE: https://www.obenauf.si/strehe/zelene-strehe

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3. Two GREEN&STEM trails around the city of Burgos

3.1. Green&STEM trail Number 1 in Burgos

Authors: Andrés González, Raquel Martínez, Sara Fernández, Ana Mugarra

General notes

This Green&STEM takes place in the centre of Burgos near the Arlanzón river.

Activity gamification:

A) Characters

The group will consist of 5 students with the following roles:
Captain – squire, the student who organizes the work to be done by the group.
Scribe, the student who is in charge of keeping track of the activity that is being carried out.
The alchemist is the student who has the necessary technological means to carry out the activity.
Porter, the pupil in charge of collecting the instruments needed to carry out the activity.
Jester is the pupil who will act as the spokesperson for the group in front of the other groups and who will be responsible for asking for the corresponding clues.
Punctuation:
Teams will have to pass each trial to score 45 points (15 x 3). Two clues may be used in each test. The use of each clue subtracts 2 points.
The game ends when the three tests are completed, and the Cid's chest is opened. To open the chest, at least 39 points must be scored. This means that only half of the clues can be used to obtain the combination of the final lock.
You can get 2 points each time you help a partner group.

Development

Groups of pupils dressed in period costumes will have the task of opening the Cid's chest. In the first of the tests (stop), they will find the chest; in the second, the key and in the third, the combination of the second padlock. There is no winning or losing team; it is just a matter of ingeniously finding all the clues to open the chest and earn their wages, which had been kidnapped by the Cid's enemies.

- **Location**

This stem track is located in La Quinta Promenade. It starts at Diego Porcelos statue and ends at the Human Evolution Museum.

- **Length**

There are no more than 0.6 kilometres between the start and the end of the stem walk in a landscaped area so that, at any given moment, our pupils can rest briefly in the shade of the trees, if necessary.

- **Problems to be solved**

On this walk, pupils will face challenges in Mathematics, Natural Sciences and Physics.

Stop 1

- **Overview and Purpose**

At this stop you will learn how algebraic language can help to encrypt a message.

Before you can encrypt, you will need to find the solution to the equations you are given to obtain the decryption key.

To carry out the activity, gamification will be used as a methodology. Groups of students will be created and group roles will be assigned. Each challenge will have a score that they will get if they solve the challenge according to the rules of the challenge. Each challenge will have some clues, which will subtract points from the group if they need them to overcome the challenge.

- **Education Standards**

The student will learn to:

1. Use of algebraic language in real contexts.
2. Use of numerical calculation to solve problems.
3. Equation solving.
4. Identify the mathematics involved in other subjects and in real situations that can be approached in mathematical terms, interrelating concepts and procedures to apply them in different situations.

5. Represent, individually and collectively, mathematical concepts, procedures, information and results using different technologies in order to visualize ideas and structure mathematical processes.

References:

- https://www.educa.jcyl.es/es/informacion/sistema-educativo/educacion-secundaria-obligatoria/educacion-secundaria-obligatoria-borrador-curriculo/anexo-iii-materias-educacion-secundaria-obligatoria

- **Objectives**

Students will:

1. Apply knowledge of algebra to solve real problems.
2. Use algebraic variables in different environments.
3. Solve linear equations with one or several variables.

- **Materials Needed**
  - Mobile application
  - Phone calculator
  - Book for the notes

- **Activity 1 High level**

1. 5 minutes: Start the lesson with a historical note.

   Good morning squires. For today's mission, you will have to use reasoning to find the combination of the lock to get the treasure from the Cid's chest. The knight needs the money to buy food for his soldiers, who are exhausted from fighting against injustice. You have to solve the system of equations. Once you have solved the system of equations, in each coloured circle, you have to add the results of each partial equation. This way, you will find four numbers which are the combination of the safe (which you will find on the side of the statue) in which the chest is.

2. 5 minutes: Introduce (or repeat) the following notions:

   We begin the stop with an explanation of the following concepts:

   - Concept of a variable.
   - Concept of linear equation.
   - Problem-solving protocol.

3. 15 minutes:

Students arranged in groups are faced with the mathematical challenge of finding the algebraic solution to the following challenge.

To do so, they will have to find the following location, see Illustration 1.

Here, once the augmented reality application Aurasma is installed, it will show you the graphic in Figure 1.

Illustration 1: Statue at the Trail start. Google 2022.

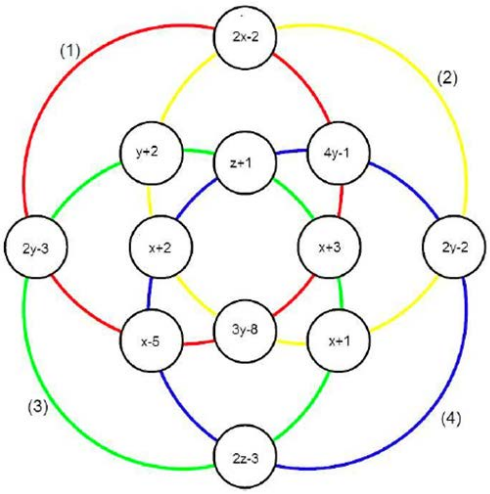


Figure 1: Sistema de ecuaciones circulares. Fuente : https://anagarciaazcarate.wordpress.com/2020/04/14/cuatro-circunferencias-magicas-algebraicas/

The circles you see are special circles. The sum of the numbers that represent these expressions is 39. Find the numbers in each circle, knowing that you have to solve the system of equations to find the value of each letter.
Hint: start with the circle with one unknown. To find the order of the numbers, you will need to decrypt the message of the inscription. The inscription reads: "Life has its order, and order will lead you to a good life".

1. 5 minutes: Discussion and conclusions.
   At this point, students have found different strategies to solve equations with three, two or one unknown and can share their strategies with their classmates.
   The exercise will be more enriching the more ways the students find.
2. 10 minutes: Assessment. Steps to check for student understanding.
   Define two or three (at most) tasks or problems for students to solve.
   · What paths have they taken to solve the equation?
   Have they arrived at the solution of the system of linear equations?

- **Activity 2 medium level**

1. 5 minutes: Start the lesson with a historical note.

Good morning squires. For today's mission, you will have to use reasoning to find the combination of the lock to get the treasure from the Cid's chest. The knight needs the money to buy food for his soldiers, who are exhausted from fighting against injustice. You have to solve the system of equations. Once you have solved the system of equations, in each coloured circle, you have to add the results of each partial equation. This way, you will find four numbers which are the combination of the safe (which you will find on the side of the statue) in which the chest is.

2. 5 minutes: Introduce (or repeat) the following notions:

- Concept of a variable.
- Concept of the equation.
- Problem-solving protocol.

3. 15 minutes:

The students, arranged in groups, are faced with the mathematical challenge of finding the algebraic solution to the following challenge:
To do this, they will have to find the following location, see Illustration 2.

Illustration 2. Path's start statue. Google 2022

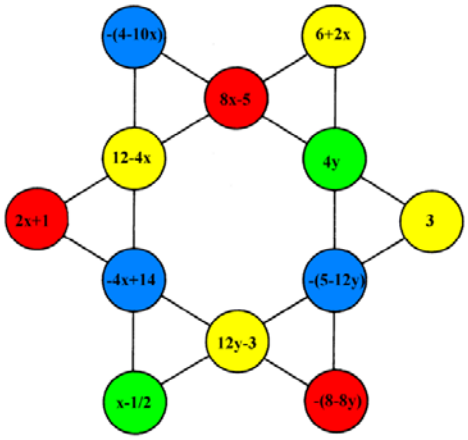


Illustration 3: System of polygonal equations. Source https://anagarciaazcarate.wordpress.com

Here, once the augmented reality application Aurasma is installed, it will show you the graphic, see Illustration 3.

You face a magic star. This means that all the rows are the same. The Cid's enemies wanted to hide the combination in the safe where the chest with x and y expressions is. Find the values of the letters so that you can open the safe and return the chest to the Cid.
To find the order of the numbers, you just have to order them according to their importance.

1. 5 minutes: Discussion and conclusions.
   At this point, students have found different strategies to solve equations with three, two or one unknown and can share their strategies with their classmates.
   The exercise will be more enriching the more ways the students find.

2. 10 minutes: Assessment. Steps to check for student understanding.
   Define two or three (at most) tasks or problems for students to solve. For example:
   - Find the solutions to the system.
   - Describe the method of solving the system.

- **Activity 3 low level**

1. 5 minutes: Start the lesson with a historical note.

Good morning squires, for today's mission, you will have to use reasoning to find the combination of the lock to get the treasure from the Cid's chest. The knight needs the money to buy food for his soldiers, who are exhausted from fighting against injustice. You have to solve the system of equations. Once you have solved the system of equations, in each coloured circle, you have to add the results of each partial equation. This way, you will find four numbers which are the combination of the safe (which you will find on the side of the statue) in which the chest is.

2. 5 minutes: Introduce (or repeat) the following notions:
   - Concept of a variable.
   - Concept of the equation.
   - Problem-solving protocol.

3. 15 minutes:
   The students, arranged in groups, are faced with the mathematical challenge of finding the algebraic solution to the following challenge:
   To do this, they will have to find the following location, see illustration 4.

Illustration 4: Trail start. Google 2022

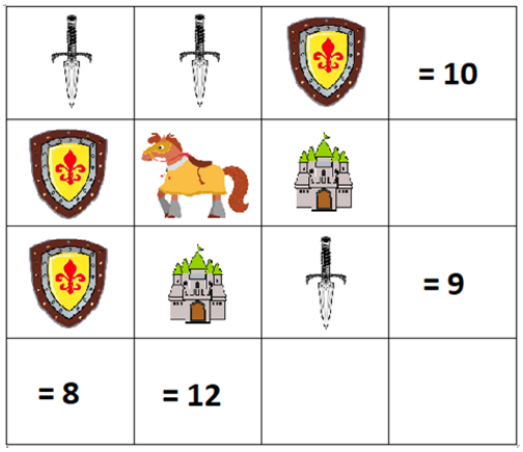


Illustration 5: Square on the square. Fuente https://anagarciaazcarate.wordpress.com

Here, once the augmented reality application Aurasma is installed, it will show you the graphic, see illustration 5.
You face a magic star. This means that all the rows are the same. The Cid's enemies wanted to hide the combination in the safe where the chest with x and y expressions is. Find the values of the letters so that you can open the safe and return the chest to Cid.

To find the order of the numbers, you only need to order them according to their importance.

1. 5 minutes: Discussion and conclusions.
   At this point, students have found different strategies to solve equations with three, two or one unknown and can share their strategies with their classmates.
   The exercise will be more enriching the more ways the students find.
2. 10 minutes: Assessment. Steps to check for student understanding.
   Define two or three (at most) tasks or problems for students to solve. For example:
   - Calculation of the solutions.

- Description of the solution method.

References:

- https://anagarciaazcarate.wordpress.com/2020/04/14/cuatro-circunferencias-magicas-algebraicas/
- https://anagarciaazcarate.files.wordpress.com/2022/02/10actividadesludicasdealgebrayfigurasmagicas.pdf

Stop 2

- **Overview and Purpose**

At this stop, you will measure angles to measure distances and areas. The three levels you can try are as follows:
1st, You will have to calculate the height of the MEH door with respect to the street. From that height, an arrow will be launched to light the cauldron of the celebrations for the reception of El Cid in the city. We will have to find the speed and the angle with which the arrow will have to be shot so that the arrow reaches the cauldron that will be placed 100 m above the river.
2nd We will have to calculate the area of the fabric to cover each of the rhombuses on the side of the MEH to decorate it.
3rd We will create a clinometer to calculate the angles.
To carry out the activity, gamification will be used as a methodology. Groups of students will be created, and group roles will be assigned. Each challenge will have a score that they will get if they solve the challenge according to the rules of the challenge. Each challenge will have some clues, which will subtract points from the group if they need them to overcome the challenge.

- **Activity 1 High level**

Education Standards
The student will learn to:

1. Application of the sine theorem.
2. Application of the equations of the parabolic shot.
3. Calculation of the initial conditions for reaching a given distance.
4. Application of the Pythagorean theorem to calculate distances.
5. Construction of angle measuring apparatus.
6. Application of criteria of equality of angles.
7. Determination of angles by means of equality criteria.
8. Measurement of angles.

Referencias:

- https://www.educa.jcyl.es/es/informacion/sistema-educativo/educacion-secundaria-obligatoria/educacion-secundaria-obligatoria-borrador-curriculo/anexo-iii-materias-educacion-secundaria-obligatoria

- **Objectives**

Students will:

1. Learn to measure distances indirectly by determining angles.
2. Design and create angle measuring devices.

3. Apply different theorems for the determination of angles.

- **Materials Needed**
  1. Tape measure
  2. Protractor
  3. Mobile application
  4. Phone calculator
  5. Clinometer
  6. Laser meter

- **Activity 1 High level**

1. 5 minutes: Start the lesson with a historical note.
   Good morning squires; in today's mission, you will have to use your ingenuity and your knowledge of Mathematics and Physics to organise the festivities to welcome the Cid to Burgos.
   The mayor wants to spruce up the area around the museum to make it the central venue for the festivities.
   You, squires, have to determine the initial conditions for the archer to shoot the arrow of fire to the cauldron that is floating over the Arlanzón river.

2. 5 minutes: Introduce (or repeat) the following notions:
   - Concept of angle.
   - Sine Theorem
   - Pythagorean Theorem
   - Parabolic Launch.
   - Criteria of equality of angles.

3. 15 minutes:
   The students, arranged in groups, are faced with the challenge of finding an interdisciplinary solution to find the distance of a parabolic shot.
   They will have to determine the initial conditions for shooting the arrow that will light the cauldron from the door of the MEH to its position above the river.

Illustration 6: MEH entrance. Self-creation

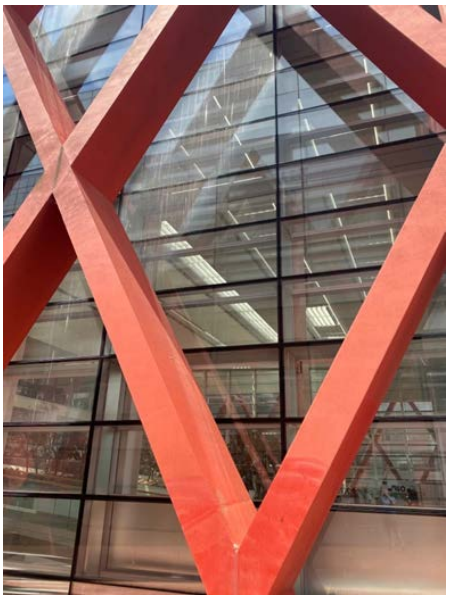


Illustration 7: MEH façade. Self-creation

Hints: You will need to determine the height of the gate above the river level and determine the angle of the throw above the horizontal to substitute into the equations for the parabolic throw.

1. 5 minutes: Discussion and conclusions.
   At this point, students will be able to describe the processes they have gone through to determine the initial conditions.
   The discussion on how the angle has been calculated to find the height of the MEH gate over the river will be of particular interest.
2. 10 minutes: Assessment. Steps to check for student understanding.
   Define two or three (at most) tasks or problems for students to solve. For example:
   1. Determination of angles and distances.
   2. Finding the height of the launching point over the river by means of the sine theorem.
   3. Determination of the angle and initial velocity of the arrow.

- **Activity 2 medium level**

1. 5 minutes: Start the lesson with a historical note.
   Good morning squires; in today's mission, you will have to use your ingenuity and your knowledge of Mathematics and Physics to organise the festivities to welcome the Cid to Burgos.
   The mayor wants to spruce up the area around the museum to make it the central venue for the festivities.
   You, squires, have to decorate the surroundings of the MEH as this historical reunion deserves.
   You will be in charge of covering the façade of the museum.
   Bearing in mind that the coats of arms of the Cid have to be painted on canvas, and the canvas has to cover each figure that can be seen on the sides of the museum.
2. 5 minutes: Introduce (or repeat) the following notions:
   - Concept of angle
   - Sine Theorem
   - Pythagorean Theorem

3. 15 minutes:
   The students, arranged in groups, are challenged to find the area of the figure on the sides of the museum. To do this, they will have to determine which figure it is by demonstrating it mathematically.
   They will have to determine the diagonals of the rhombus in order to find the total area.
   To find the diagonals, they will use a measuring device and will have to calculate the largest diagonal indirectly by means of the Pythagorean theorem.

Illustration 8: MEH facade. Self-creation.

Hints: you will notice that the rhombuses coming out of the ground are half rhombuses, making it easier to measure and use the Pythagorean Theorem.

1. 5 minutes: Discussion and conclusions.
   At this point, students will be able to describe the processes they have gone through to determine the surface area of each rhombus.
   A discussion of how the angle has been calculated to determine the type of figure and how the direct and indirect measurement of the diagonals of the rhombus has been carried out will be of particular interest.
2. 10 minutes: Assessment. Steps to check for student understanding.
   Define two or three (at most) tasks or problems for students to solve. For example:
   1. Determine the interior angles of a figure.
   2. Identify the type of figure.
   3. Find the diagonals.
   4. Calculate the area of the rhombus.

- **Activity 3 Low level**

1. 5 minutes: Start the lesson with a historical note.
   Good morning squires; in today's mission, you will have to use your ingenuity and your knowledge of mathematics and technology to organise the festivities to welcome the Cid to Burgos.
   The mayor wants to spruce up the area around the museum to make it the central site for the festivities.
   Your squires will be the most important ones because you will have to build a device to measure angles. You will be able to help your companions to measure distances.
2. 5 minutes: Introduce (or repeat) the following notions:
   - Concept of angles.
   - Criteria for equality of angles.
3. 15 minutes:
   The students, arranged in groups, are faced with the challenge of finding an interdisciplinary solution to build a clinometer.
   For this, they have a protractor and a tube, a string and a nut.
   They will have to be able to measure angles with the apparatus and be able to arrive at the measurement of other angles by the criteria of equality of angles alone.

Hints:

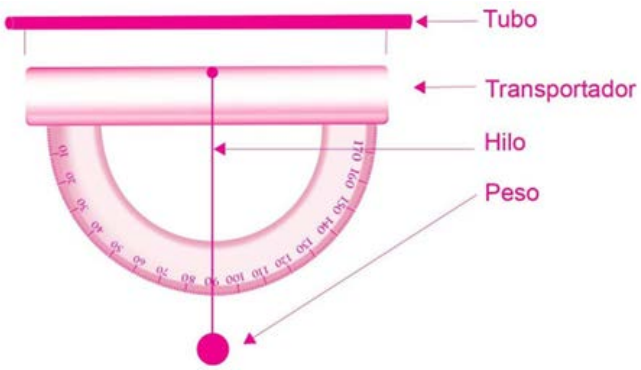


Illustration 9. Clinometer. Source: WikiHow, 2005

1. 5 minutes: Discussion and conclusions.
   At this point, students will be able to describe the processes they have used to determine the shape of the clinometer.
   The discussion on how the angles have been calculated to find the height of the MEH gate over the river, having made use of the criteria of equality of angles, will be of particular interest.
2. 10 minutes: Assessment. Steps to check for student understanding.
   Define two or three (at most) tasks or problems for students to solve. For example:
   1. How did you design and create the clinometer?
   2. How did you measure the angle of the ramp using the clinometer?

Stop 3

LOCATION:

The stop is located at the statue of the woman in front of the Arlanzón river, at the height of the emblematic building of the Teatro Principal de Burgos, and takes place within a radius of about 500 metres.

Illustration 8: Arlanzón River Shore. Self-creation

Illustration 7: Arlanzón shore. Self-creation.

- **Overview and Purpose**

The main mission is to locate medicinal plants to treat soldiers' illnesses and pains. In addition, a study will be made of the riverbank vegetation and fauna of the Arlanzón riverbed and river. Use of different applications to identify plants and animals.
Study of the following medicinal plant species: Willow (Salix sp) - Aspirin (Acetylsalicylic Acid), equisetum arvense (Equisetum arvense)-natural anti-inflammatory, Birch (Betula Pubescens), Dandelion (Taraxacum officinale), Yew (Taxus baccata), mullein (Verbascum thapsus)–painkiller, diuretic, expectorant, beggar's weed (Clematis vitalba), wild rose (dog rose)-a natural antioxidant, black poplar (Populus nigra)-antiseptic properties, diuretic, antirheumatic…

Reference:

- https://ecoinventos.com/corteza-de-sauce/

To carry out the activity, gamification will be used as a methodology. Groups of students will be created, and group roles will be assigned. Each challenge will have a score they will get if they solve the challenge according to the rules. Each challenge will have clues, subtracting points from the group if they need them to overcome the challenge.

- **Education Standards**

The students will learn to:

1. Main characteristics of riverside ecosystems.
2. Importance of medicinal plants and sustainable habits (responsible consumption, respect for the environment...).
3. Strategies for the recognition and identification of the most common species of riverbank ecosystems.
4. Use scientific resources such as manuals, field guides, dichotomous keys and digital sources of information.
5. Relationship between the health of the environment, humans and other living beings.

Referencias:

- https://www.educa.jcyl.es/es/informacion/sistema-educativo/educacion-secundaria-obligatoria/educacion-secundaria-obligatoria-borrador-curriculo/anexo-iii-materias-educacion-secundaria-obligatoria
- https://www.educa.jcyl.es/es/informacion/sistema-educativo/educacion-primaria/educacion-primaria-borrador-curriculo/anexo-iii-areas-educacion-primaria

- **Objectives**

Students will:

1. Identity employing different methods (dichotomous keys, mobile phone applications, etc.) of the main living beings in the riverside ecosystem, specifically in the Arlanzón river, an important watercourse in the city of Burgos.
2. Distinguish some of the medicinal plants present in the city and learn about their curative properties.
3. Value the importance of taking care of the environment and acquiring sustainable habits (2030 Agenda, sustainable development goals, 3, 6, 11 and 12 mainly).

- **Materials Needed**
  - Mobile application (Species identification Apps; plantnet, birdnet, arbolapp, inaturalist, google lens, compass, pic collage..)

- Notebook (field notebook), pencils and coloured pencils, glue, scissors…
- Field guides
- Binoculars, magnifying glasses, ruler or tape measure for measurements.

- **Activity 1 High level**

  - 5 minutes: Start the lesson with a historical note.

    The main challenge of this stop is to make as complete a study as possible of the "Arlanzón River" ecosystem, especially its main plant species. We will identify some of the medicinal plants that will be used to solve the illnesses and pains of the soldiers of El Cid. In addition, an in-situ observation of all the environmental elements of the river will be made.
    https://www.miradorescatedraldeburgos.es/blog/rio-arlanzon/

  - 10 minutes: Introduce (or repeat) the following notions:
    · Concept of riverbank ecosystem:
    https://www.fbbva.es/microsites/ecologia_fluvial/pdf/cap_02.pdf
    · Review of the classification systems of living organisms.
    · Main characteristics of the plant kingdom (nutrition, reproduction, relationship).
    · Concept of biodiversity, sustainability and environmental health.

  - 15 minutes:
    The students, divided into groups of 5, are challenged to identify the main animal and plant species they find in a certain area of the stop site.
    To do so, they have some tools at their disposal (binoculars, magnifying glasses, field guides), as well as the help of mobile phones with species identification apps (hint).
    In each group, there will be one or two people in charge of drawing a picture of the parts of the plant, writing down its scientific name and finding out if it has healing properties. They will also write down other species they find and their main characteristics, as well as the coordinates of the exact place where they have found each species (using google maps).

· 5 minutes: Assessment. Steps to check for student understanding.
  Define two or three (at most) tasks or problems for students to solve. For example:
  - Identification and description of species and the scientific method used.
  - Draw up a summary table in each working group containing as much information as possible about each species found. For those plants that are medicinal, highlight their main curative properties. The table should include the coordinates of where the species have been found.
  - Answer a question about the degree of conservation of the section of the river observed: what behaviour or habits should citizens have to conserve the river? What environmental problems have they observed, etc.?

Illustration 9: Arlanzón river riverbed. Self-creation

- **Activity 1 medium level**

1. 5 minutes: Start the lesson with a historical note.

   The main challenge of this stop is to study the "Río Arlanzón" ecosystem, especially its main plant species. We will identify some of the medicinal plants that will be used to solve the illnesses and pains of the soldiers of El Cid. We will also make an in situ observation of the plants' characteristics.
   Reference:
   https://www.miradorescatedraldeburgos.es/blog/rio-arlanzon/

   1. 10 minutes: Introduce (or repeat) the following notions:
      - Concept of riverbank ecosystem: https://www.fbbva.es/microsites/ecologia_fluvial/pdf/cap_02.pdf
      - Review of the classification systems of living organisms.
      - Main plant kingdom characteristics (nutrition, reproduction, relationship).
      - Environmental factors of the river (climate, humidity, light, temperature...) and conditioning species growth.

3. 15 minutes:
   The students, divided into groups of 5, are challenged to identify the main animal and plant species they find in a certain area of the stop site.
   To do so, they have some tools at their disposal (binoculars, magnifying glasses, field guides), as well as the help of mobile phones with species identification apps (hint).
   In each group, there will be one or two people in charge of drawing a picture of the parts of the plant, writing down its scientific name and finding out if it has healing properties. They will also write down other species they find and their main characteristics, the coordinates of the exact place where they have found each species (using google maps) and the environmental factors they observe in the river that determine the type of species they are going to find.

4. 5 minutes: Assessment. Steps to check for student understanding.
   Define two or three (at most) tasks or problems for students to solve. For example:
   - Identification and description of species and the scientific method used.
   - Draw up a summary table in each working group containing as much information as possible about each species found. For those plants that are medicinal, highlight their main curative properties. The table should include the coordinates of where the species have been found.
   - Study the environmental factors of the river that condition the existence of the type of plants that grow there (climate, humidity, light, temperature, etc.).

Illustration 10: dandelion plant (Taraxacum officinale) in river Arlanzón riverbank. Self-creation.

- **Activity 1 low level**

1. 5 minutes: Start the lesson with a historical note.

   The main challenge of this stop is to observe the "Arlanzón River", especially its main plant species. We will identify some of the medicinal plants that will be used to solve the illnesses and pains of the soldiers of El Cid. In addition, an in situ observation of all the characteristics will be made. Reference: https://www.miradorescatedraldeburgos.es/blog/rio-arlanzon/

2. 10 minutes: Introduce (or repeat) the following notions:
   - Review of the classification systems of living things in the 5 kingdoms.
   - Relationships established between species. Trophic chain, ecosystem.
   - Main characteristics of the plant kingdom (nutrition, reproduction, relationship).
   - Soil type, environmental factors (light, humidity, temperature, etc.).

3. 15 minutes:
   The students, divided into groups of 5, are challenged to identify the main animal and plant species they find in a certain area of the stop site.
   To do so, they have some tools at their disposal (binoculars, magnifying glasses, field guides), as well as the help of mobile phones with species identification apps (hint).
   In each group, there will be one or two people in charge of drawing a picture of the parts of the plant, writing down its scientific name and finding out if it has healing properties. They will also write down other species they find and their main characteristics, the coordinates of the exact place where they have found each species (using Google maps) and the environmental factors they observe in the river that determine the type of species they are going to find.

4. 5 minutes: Assessment. Steps to check for student understanding.
   Define two or three (at most) tasks or problems for students to solve. For example:
   - Identification and description of species and the scientific method they have used.
   - Complete a summary table in each working group listing the names of the species found. Of the medicinal plants, highlight their main healing properties.

- In each group is given a D4 sheet where they can make an artistic collage with natural elements from the river (branches, leaves, fruits...) and write an original title, a short poem, haiku, or acrostic that defines the work... (They take a photo with their mobile phone and send it).

There is the possibility of making a pic collage with the mobile phone, adding the poem, title or acrostic, and uploading it to Padlet.

Illustration 11: Riverside vegetation on the banks of the Arlanzón, next to the San Pablo bridge. Self-elaboration.

3.2. Green&STEM trail Number 2 in Burgos

Authors: Andrés González, Raquel Martínez, Sara Fernández, Ana Mugarra

General notes

In this Stem Path, you will learn exciting things about the geology and rock formations that you can find in Burgos. Also, you will learn how the golden ratio marks the architecture of the Cathedral of Burgos, how to measure heights and surfaces indirectly. Finally, you will learn to apply your knowledge to find an unknown volume.
In this activity, the squires of the Cid will have the mission of preparing the wedding festivities of their lord. To do so, they will have to overcome the three challenge-stops.
Gamification of the activity:

A) Characters.
The group will consist of 5 students with the following roles:
Captain - squire, the student who organizes the work to be done by the group.
Scribe, the student in charge of keeping a record of the activity being carried out.
The alchemist is the student who has the necessary technological means to carry out the activity.
Porter, the student in charge of gathering the instruments necessary to carry out the activity.
Jester, the student who will act as the spokesperson for the group in front of the other groups and will be responsible for asking for the corresponding clues.

B) Scoring.
Teams must pass each test to score 45 points (15 x 3). Two clues may be used in each test. The use of each clue subtracts 2 points.
The game ends when the three tests are completed, and the Cid's chest is opened. To open it, teams must score at least 39 points. This means that only half of the clues can be used to obtain the combination of the final lock.
You can get 2 points each time you help a partner group.

C) Development.
Groups of students dressed in period costumes will have the mission to open the CID chest. In the first of the tests (stop), they will find the chest; in the second, the key and the third, the combination of the second lock. There is no winning or losing team; it is only a matter of ingenuity to get all the clues to open the chest and earn their salary, which the enemies of the Cid had kidnaped.

- **Location**

Figure 1. Route map. Source: Google Earth 2022

This Stem path starts at the Rosa de los Vientos de Burgos, located in the surroundings of the Castle of Burgos, passing through the Plaza de San Fernando, in front of the door of the Cathedral, and ends at the Plaza de Santa María on the side of the Cathedral.

Length
There is no more than 1 kilometre between the beginning and the end of the stem walk in a landscaped area so that, at any given time, our students can relax in historical surroundings enjoying the wonderful views.

Problems to be solved
1. On this path, students will be challenged in mathematics, natural science and physics.

Stop 1

LOCATION:
The stop is located at the viewpoint of the Castle of Burgos, where we can enjoy the best views of the old town and its new landmark buildings, such as the Museum of Human Evolution.
On the horizon, la Sierra de la Demanda, the Landa Palace... to complete an extensive list of elements of great interest.

Illustration 1. Panorama of the city of Burgos from the Castle viewpoint. Own elaboration.

Illustration 2. “Rosa de los vientos” with distances to European cities. Castle viewpoint. Own elaboration.

- **Overview and purpose**

The squires of the Cid are watching the city from the castle lookout. They contemplate the panoramic view of the city on the plain of the Arlanzón River and comment on the location of the Cid's house and the Monastery of San Pedro Cardeña, the location of the Museum of Human Evolution and the Atapuerca mountain range (the most important paleontological sites in Europe).
Their main mission is to check the type of soil and rocks in the place to prevent enemies' attack. In addition, they have to investigate the changes that the landscape of Burgos has undergone throughout its geological history.

They have to locate the native oak forest (google lens application to identify the plant species) and the spring where water is to be replenished for the soldiers by using coordinates with the google maps application.
They will also have to observe the possible natural and anthropic risks that may affect the conservation of the city's important historical and natural heritage.
To carry out the activity, gamification will be used as a methodology. Groups of students will be created, and group roles will be assigned. Each challenge will have a score they will get if they solve the challenge according to the rules. Each challenge will have clues, subtracting points from the group if they need them to overcome the challenge.

- **Education standards**

The students will learn to:

1. Analysis of the elements of a landscape and the dynamics of relief.
2. Importance of conserving the natural heritage and identifying natural and anthropic risks to promote a sustainable attitude towards the environment.
3. Strategies of recognition and identification of the main rocks and plant species associated with the different types of soil in a small area in the vicinity of the viewpoint of the castle.
   Use of scientific resources such as manuals, field guides, dichotomous keys and digital sources of information.

References:

- https://www.educa.jcyl.es/es/informacion/sistema-educativo/educacion-secundaria-obligatoria/educacion-secundaria-obligatoria-borrador-curriculo/anexo-iii-materias-educacion-secundaria-obligatoria
- https://www.educa.jcyl.es/es/informacion/sistema-educativo/educacion-primaria/educacion-primaria-borrador-curriculo/anexo-iii-areas-educacion-primaria
- https://asociaciongeocientificadeburgos.com/2013/12/23/geoturismo-en-la-ciudad-de-burgos-una-guia-de-geologia-urbana-para-todos-los-publicos/

- **Objectives**

  Students will:

1. Locate geostrategic places by using coordinates (Google maps).
2. Identify and classify using different methods (dichotomous keys, mobile applications...) the main rocks and plant species present in the environment of the castle.
3. Analyze and observe the human intervention in the landscape of the castle. Example of the area: reforestation with conifers in the surroundings of Cerro San Miguel.
4. Value the importance of taking care of the environment and acquiring sustainable habits (2030 Agenda, sustainable development goals: 6, 11, 12 and 15 mainly).

Illustration 3. Limestone rock and plant of the crassulaceae family (castle wall). Own elaboration.

- **Materials needed**
  - Mobile application (Geology and rock identification apps: rock identifier, naturalist, google lens, google maps, compass, bubble, pic collage…).
  - Notebook (field notebook), pencils, glue, scissors…
  - Field guides and excel table to complete field information.
  - Magnifying glasses, ruler or meter to make measurements.
  - Relive the application to obtain a video of the geological itinerary.

- **Activity 1 High level**

1. 5 minutes: Start the lesson with a historical note.
   After a brief explanation of what can be seen "from a bird's eye view" from the viewpoint of the castle, the main mission of the students is to describe and locate on a map the main elements of the landscape (rocks, type of soil and relief, associated plant species...), with their coordinates using a compass and google maps.
   In addition, the anthropic elements in the landscape around the castle will be observed, and their possible negative impacts will be analyzed.

2. 10 minutes: Introduce (or repeat) the following notions:
   - Soil formation and type:
   https://entreelespacioyeltiempo.wordpress.com/2017/09/30/el-suelo-y-sus-etapas-de-formacion/
   - Cycle of rocks and their classification. Limestones of the moor and their relationship with the cavities of the province of Burgos.
   - Concept of allochthonous and autochthonous vegetation. Differentiation between gymnosperm and angiosperm. Types of fruits and seeds (acorn, samara, cone, pineapple...).
   https://www.diariodeburgos.es/noticia/z5d17dec2-057c-0143-3502da1064286fda/201303/guerra-al-invasor
   - Main landscape modelling agents. Impact of anthropic action.

Illustration 4 Soil in the castle with needles (gymnosperm leaf) and pinecones. Own elaboration.

1. 15 minutes: Students distributed in groups of 5 students face the challenge of locating -by using coordinates (google maps)- places in the surroundings of the

castle viewpoint where they will differentiate the types of soil, rocks and associated plant species.
To do this, they have some work tools (field guides, magnifying glasses...), as well as the help of the cell phone with species identification apps (hint).
In each group, there will be one or two people in charge of writing down all possible observations of the geostrategic points visited to complete a data table and conclude.

In addition, they can take photos of the points visited using the Relive application and thus obtain a video of the route taken.

2. 5 minutes: Assessment. Steps to check for student understanding.
Define two or three (at most) tasks or problems for students to solve. For example:
   - Identification and description of geological points (soil, rock, vegetation) and the scientific method used.
   - Elaboration of a summary table in each working group where all the data of each strategic point are listed: scientific name, type of soil, rock classification, type of vegetation: allochthonous or autochthonous gymnosperm or angiosperm, type of fruit and seed...
   - Answer a question about the influence of human activity on the modelling of the landscape to open a debate on the importance of conserving the natural heritage.

Illustration 5. Cedar in the vicinity of the Castle of Burgos. Own elaboration

Illustration 6. Access door to the interior of the Castle of Burgos. Own elaboration.

Illustration 5. Cedar in the vicinity of the Castle of Burgos. Own elaboration

- **Activity 1 Medium level**

1. 5 minutes: Start the lesson with a historical note.
After a brief explanation of what can be seen "from a bird's eye view" from the viewpoint of the castle, the main mission of the students is to describe and locate on a map the main elements of the landscape (rocks, type of soil and relief, associated plant species...), with their coordinates using a compass and google maps.
In addition, the anthropic elements in the landscape around the castle will be observed, and their possible negative impacts will be analyzed.

2. 10 minutes: Introduce (or repeat) the following notions:
   - Soil formation and type:

https://entreelespacioyeltiempo.wordpress.com/2017/09/30/el-suelo-y-sus-etapas-de-formacion/

- Cycle of rocks and their classification. Limestones of the moor and their relationship with the cavities of the province of Burgos.
- Concept of allochthonous and autochthonous vegetation. Differentiation between gymnosperm and angiosperm. Types of fruits and seeds (acorn, samara, cone, pineapple...). https://www.diariodeburgos.es/noticia/z5d17dec2-057c-0143-3502da1064286fda/201303/guerra-al-invasor
- Main landscape modelling agents. Impact of anthropic action.

1. 15 minutes:

   Students distributed in groups of 5 students face the challenge of locating -by using coordinates (google maps)- places in the surroundings of the castle viewpoint where they will differentiate the types of soil, rocks and associated plant species.
   To do this, they have some work tools (field guides, magnifying glasses...), as well as the help of the cell phone with species identification apps (hint).
   In each group, there will be one or two people responsible for writing down all possible observations of the geostrategic points visited to complete a data table and draw conclusions later.
   In addition, they can take photos of the points visited using the Relive application and thus obtain a video of the route taken.

4. 5 minutes: Assessment. Steps to check for student understanding.
   Define two or three (at most) tasks or problems for students to solve. For example:
   - Identification and description of geological points (soil, rock, vegetation) and their scientific method.
   - Elaboration of a summary table in each working group where all the data of each strategic point are included: scientific name, type of soil, rock classification, type of vegetation: allochthonous or autochthonous.

- **Activity 1 Low level**

1. 5 minutes: Start the lesson with a historical note.
After a brief explanation of what can be seen "from a bird's eye view" from the viewpoint of the castle, the main mission of the students is to describe and locate on a map the main elements of the landscape (rocks, type of soil and relief, associated plant species...), with their coordinates using a compass and google maps.
In addition, the anthropic elements in the landscape around the castle will be observed, and their possible negative impacts will be analyzed.

2. 10 minutes: Introduce (or repeat) the following notions:
   - Cycle of rocks and their classification.
   - Concept of allochthonous and autochthonous vegetation. Differentiation between gymnosperm and angiosperm.
   - Concept of soil and how it is formed.
   - Main agents that shape the landscape. Impact of anthropic action.

3. 15 minutes:
Students distributed in groups of 5 students face the challenge of locating -by using coordinates (google maps)- places in the surroundings of the castle viewpoint where they will differentiate the types of soil, rocks and associated plant species.
To do this, they have some work tools (field guides, magnifying glasses...), as well as the help of the cell phone with species identification apps (hint).

In each group, there will be one or two people responsible for writing down all possible observations of the geostrategic points visited to complete a data table and draw conclusions later.
In addition, they can take photos of the points visited using the Relive application and thus obtain a video of the route taken (optional).

4. 5 minutes: Assessment. Steps to check for student understanding.
   Define two or three (at most) tasks or problems for students to solve. For example:
   - Identification and description of geological points (type of rock and plant species) and scientific method used.
   - Elaboration of a summary table in each work group where some basic data of each of the strategic points are included: type of soil, name of the rock, type of vegetation: allochthonous or autochthonous.
   - Optionally, each group can be asked to make an artistic collage with natural elements from the castle environment (branches, leaves, fruits, stones, sand...) and add an original title, a short poem, haiku, or acrostic that defines the work.
     (They take a picture and send it)
     There is the possibility that they do it with the cell phone using the pic collage and add the poem, title or acrostic and upload it to a padlet.

Illustration 7. Plant collage. Own elaboration.

Stop 2

● Overview and purpose

In this stop, you will learn how proportions mark the geometry of our surroundings. You will identify the Vesica piscis in elements of the Cathedral and then analyze the arithmetic characteristics of the construction. All in all, you will find the interior area of the arch.

To carry out the activity, gamification will be used as a methodology. Groups of students will be created, and group roles will be assigned. Each challenge will have a score they will get if they solve the challenge according to the rules of the challenge. Each challenge will have some clues, subtracting points from the group if they need them to overcome the challenge.

- **Education standards**

  The student will learn to:

  1. Apply Thales' Theorem to calculate the lengths of similar figures.
  2. Apply the Pythagorean Theorem to calculate distances.
  3. Analyze arithmetically the geometry of the Vesica piscica.
  4. Apply the knowledge of volumes in real situations.
  5. Calculation of areas of large surfaces.
  6. Use of numerical calculus to solve problems.
  7. Solve equations involved in real-life processes.
     Identify mathematics involved in other subjects and in real situations susceptible to being approached in mathematical terms, interrelating concepts and procedures to apply in diverse situations.

  References:
  https://www.educa.jcyl.es/es/informacion/sistema-educativo/educacion-secundaria-obligatoria/educacion-secundaria-obligatoria-borrador-curriculo/anexo-iii-materias-educacion-secundaria-obligatoria

- **Objectives**

  Students will:

  1. Apply analytical knowledge to solve different geometries.
  2. Calculate proportions.
  3. Measure distances indirectly.
  4. Measure volumes.

- **Materials needed**

  - Tape measure.
  - Hard cardboard and tripod.
  - Laser meter.
  - Mobile application.
  - Phone calculator.

- **Activity 1 High level**

  1. 5 minutes: Start the lesson with a historical note.

Good morning squires. Today El Cid will celebrate his marriage with Doña Jimena. We are in front of the Cathedral of Burgos. Your mission will be to cover the interior arch of the main door of the Cathedral of Burgos with gold leaf.
The Vesica piscis is a compound geometric form in which, as you can see in the figure, it is constructed from two circles of the same radius so that the other circle passes through the centre of each circle.

  2. 5 minutes: Introduce (or repeat) the following notions:
     - Vesica piscis and its proportions.
     - Golden ratio.
     - Problem-solving protocol.

  3. 15 minutes:

In front of the doorway of the Cathedral, we are asked to find the figure's upper area of the Vesica piscis by first measuring the width of the doorway.

Illustration 8. Sarmental Gate. Google 2022 + own elaboration.

Hint, the inner triangle formed is equilateral.

1. 10 minutes: Assessment. Steps to check for student understanding. Define two or three (at most) tasks or problems for students to solve.

· Description of the formation of the Vesica piscis.
· Determination of the inner area of the VP by indirect measurements.

Activity 2 medium level

1. 5 minutes: Start the lesson with a historical note.
   Good morning squires. Today El Cid will celebrate his marriage with Doña Jimena. We are in front of the Cathedral of Burgos; your mission will be to build the stage to celebrate the ceremony.

2. 5 minutes: Introduce (or repeat) the following notions:
   - Thales' Theorem.
   - Measurement of distances indirectly.
   - Problem-solving protocol.

3. 15 minutes:

Illustration 9. Distant view of the Sarmental gate Google 2022.

In the Plaza del Rey San Fernando, we are asked to calculate the height of the façade of the Cathedral from the ground and from the floor of the entrance by two different means but using the same mathematical principle. The similarity of triangles. Shadow and reflection.

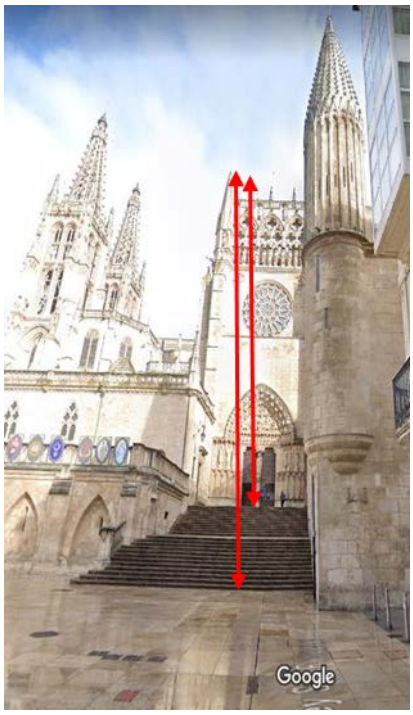


Illustration 9. Distant view of the Sarmental gate Google 2022.

Both methods use the Thales theorem to find similar triangles and thus find distances between points.
Once the height difference has been found, the students will have to build a stage with wood at the height of the door of the Cathedral so that all the people in the San Fernando square can see the wedding ceremony that will take place on that stage.
They will have to calculate the total surface height, as well as the amount of wood needed to build the stage

1. 10 minutes: Assessment. Steps to check for student understanding.
   Define two or three (at most) tasks or problems for students to solve. For example:
   - Determination of the height of the Cathedral by means of Th of Thales.
   - Calculation of the area of the wooden stage needed to build the stage structure.

- **Activity 3 Low level**

1. 5 minutes: Start the lesson with a historical note.
   Good morning squires. Today the Cid will celebrate his marriage with Doña Jimena. We are in front of the Cathedral of Burgos. It is time to calculate the capacity of the Plaza de San Fernando to determine how many people can access the link. We have to be very rigorous to avoid security problems and ensure that there will be water for everyone.

2. 5 minutes: Introduce (or repeat) the following notions:
   - Measurement of distances in an indirect way.
   - Construction of the handmade graphometer.
   - Area of large surfaces.
   - Problem-solving protocol.

3. 15 minutes:

Illustration 10. Aerial view plan of San Fernando square. Google 2022

In the Plaza del Rey San Fernando, you are asked to calculate the square area to know how many people can fit in to watch the festivities.
To do this, you will have to make use of the handmade graphometer that previously had to be built.

1. 10 minutes: Assessment. Steps to check for student understanding.
Define two or three (at most) tasks or problems for students to solve. For example:

- Dynamics of construction of the handmade graphometer.
- Calculation of the area of the square.

Stop 3

Figure 3. Fountain in Santa Maria Square. Google 2022

- **Overview and purpose**

In this stop, you will learn to apply your knowledge of volumes, proportionality and areas.
To carry out the activity, gamification will be used as a methodology. Groups of students will be created, and group roles will be assigned. Each challenge will have a score they will get if

they solve the challenge according to the rules of the challenge. Each challenge will have some clues, subtracting points from the group if they need them to overcome the challenge.

- **Education standards**

  The student will learn to:

  1. Apply the knowledge of volumes in real situations.
  2. Calculate areas.
  3. Use proportionality applied to real situations.
  4. Use of numerical computation to solve problems.
  5. Solve equations involved in real-life processes.
  6. Identify the mathematics involved in other subjects and real situations susceptible to be approached in mathematical terms, interrelating concepts and procedures to apply in diverse situations.

- **References:**

  https://www.educa.jcyl.es/es/informacion/sistema-educativo/educacion-secundaria-obligatoria/educacion-secundaria-obligatoria-borrador-curriculo/anexo-iii-materias-educacion-secundaria-obligatoria

- **Objectives**

  Students will:

  1. Apply analytical knowledge to solve different geometries.
  2. Calculate indirect proportions.
  3. Measure distances directly and indirectly.
  4. Measure volumes.

- **Materials needed**

  - Laser meter.
  - Mobile application.
  - Phone calculator.

- **Activities**

  1. 5 minutes: Start the lesson with a historical note.
     Good morning squires. Today the Cid will celebrate his marriage with Doña Jimena. We are in front of the Cathedral of Burgos on the west side. In Santa María square, you will see a hexagonal fountain. Here is where you will have to develop your ingenuity and apply your knowledge to calculate the capacity of the fountain, the amount of water needed to give drink to the people who will attend the wedding and the capacity of the fountain to supply all the attendees.

  2. 5 minutes: Introduce (or repeat) the following notions:
     - Volume and capacity.
     - Direct and inverse proportionality.
     - Problem-solving protocol.

  3. 15 minutes:
     The tasks will be as follows:

- **Activity 1, High level**

  For the High-level task group, they will have to estimate the amount of litres per minute that has to come out of the fountain spouts to fill the fountain as it empties so that it is always about to overflow. Therefore, they will have to design and organize how many

rows they will approach the fountain and how many litres per second each spout has to pull so the fountain is always full.

- **Activity 2 Medium level**

  Knowing the capacity of San Fernando square, you have to find out how much water is necessary for a person not to dehydrate for 6 hours in the sun. With this data, you have to estimate how many litres of water will be necessary to give to drink to the assistants and how many times it will be necessary to fill the fountain, knowing the data of the capacity of this that will provide us with the group of the youngest squires.

- **Activity 3 Low level**

  You, junior squires, have the task of calculating the capacity of the fountain. You will also have to determine the capacity of the utensils to serve the water so that the necessary amount of water can be served daily per assistant in the minimum number of hunts.

4. 10 minutes: Assessment. Steps to check for student understanding.
   Define two or three (at most) tasks or problems for students to solve.

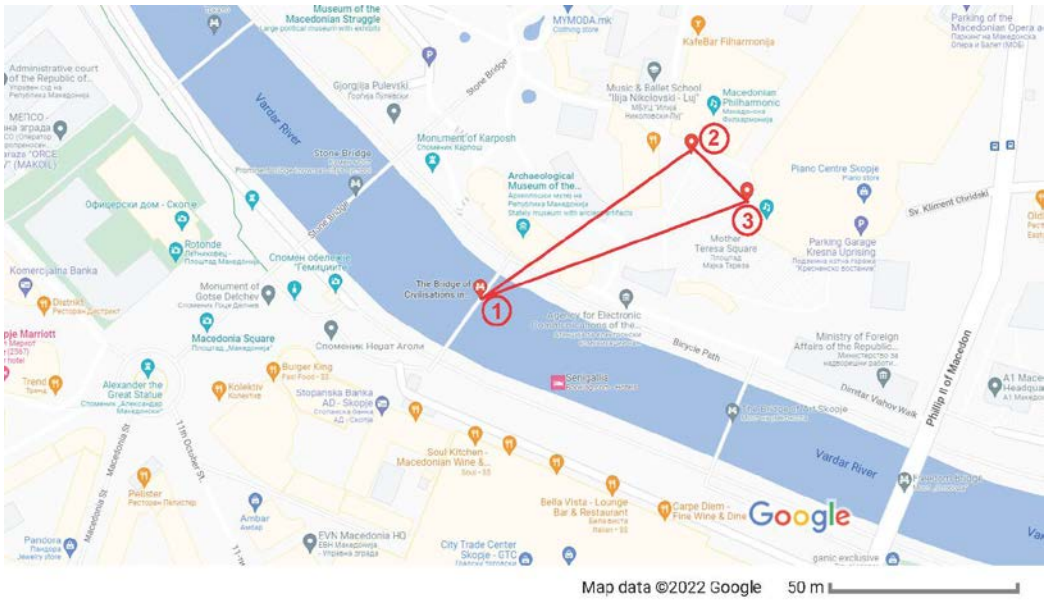
   High level:
   - Description of the estimate made to calculate the flow rate of the pipes.
   - Calculation of the flow rate in proportion to the filling time.
     - Medium level:
   - Research the process to estimate the amount of water needed to avoid dehydration.
   - Determination of the total amount of water needed so that attendees do not run out of water.
   - Determination the number of times the fountain needs to be filled to provide water to all attendees.
     - Low level:
   - Determination of the octagonal source volume.
   - Description of the process.

4. Four GREEN&STEM trails around the city of Skopje

4. 1. Green&STEM trail Number 1 in Skopje

Author: Biljana Jolevska-Tuneska

General notes



This is a trail located in the very center of Skopje city. With this trail, we want to introduce the students to the Skopje city center, stop at a few important locations, and gain some knowledge in STEM.

The trail has three stops, and each stop has a few problems. The problems are adapted to the different ages of the students. The stops are close, so the group of students needs approximately 2 hours to make this trail.

Stop 1: The discovery of Pi

(approx. 40 min)

Location

This stop is located on the bridge on the Vardar River. This bridge is located after the Stone bridge, which is one of the city's main landmarks of Skopje.

Figure 1. Circles on the bridge: stop 1

Overview and Purpose

At this stop, we will investigate circular patterns to discover the invariance of pi. Students will use data on the circumference and diameter of various objects to calculate pi. The exciting aspect of this lesson is that no matter the size or nature of the circular objects measured, the ratio of the circumference to the diameter will come out the same: pi!

Education Standards

The student will learn to:

1. applies techniques and tools to accurately find measurements (measurement).
2. solves problems involving perimeter and diameter (geometry).
3. Generalizes from a pattern of observations made in particular cases and makes a conjecture (problem-solving).
4. Recognizes and applies geometric ideas to everyday life (connections to the world).

References:

1. https://www.bro.gov.mk/wp-content/uploads/2018/02/Nastavna_programa-Matematika-VIII_odd-mkd.pdf (page 45)
2. https://www.bro.gov.mk/wp-content/uploads/2018/02/Nastavna_programa-Matematika-IX_odd-mkd.pdf (page 7, page 73,74)

Objectives

Students will:

1. Measure the perimeter and diameter of a variety of circular objects.
2. Organize the data in a table or chart in the application
3. and calculate pi – the ratio of perimeter to diameter (P/D).
4. Discuss the invariance of pi
5. Analyze and solve further problems involving circles

Materials Needed

Materials are brought to the stop by the teachers. In the case of other parties (for example, parents with children) visiting the trail, measurements can be done using various free mobile applications.

- Variety of strings/ropes for measurement.
  Note: The length of string pieces may vary depending on the circular objects chosen.
- Mobile application
- Phone calculator

Activity

- 5 minutes: Start the lesson with a historical note.

Pi is a magical number and can be found in the world in surprising ways. Somehow, some humans found it important to memorize Pi to hundreds of thousands of digits or to calculate Pi to trillions of digits. The usefulness of so many digits can be debated.

March 14 is Pi Day, but it is also the birthday of famous people such as Albert Einstein, Johann Strauss, Michael Caine, Stephen Curry, Nicolas Anelka, Billy Crystal, and Quincy Jones.

- 5 minutes: Introduce (or repeat) the following notions:
  - perimeter = the distance around a circle
  - diameter = the line segment that goes through the center of the circle and has endpoints on the edge of the circle
  - ratio = a way of comparing two numbers – the ratio of a to b is a/b

- 15 minutes: Put students in groups of two or three, and give them the measurement tools. Tell them to open the mobile app and find the Pi worksheet. Demonstrate the perimeter and diameter of an object.

Explain to students that they are to work with their group to measure the perimeter and diameter of the circular objects at the stop. One of the challenges for students is estimating the center of the circle when they measure the diameter. Demonstrate accurate and less accurate ways of measuring, and ask students who are best.

If time permits, they can also take two readings for each measurement to test accuracy. All students should record the object name, perimeter, and diameter.


Figure 2. Students measure the perimeter and the diameter of the circles

- 5 minutes: Discussion and conclusions.

Ask students to sit with their groups and look over their data. This could be when you pick one or two objects and ask for data from different groups. It helps students understand the concepts when they see the variation in measurement and discuss why this happens.

- 10 minutes: Assessment. Steps to check for student understanding.

  Level 1: (age 8-10) What shape should the object have, so we can find Pi?

  Level 2: (age 11-13) Ask the students what the Pi number is. Tell them the accurate value in four decimal places.

  Level 3: (age 14-16) Calculate the area of the circles on the stop.

Stop 2: Speed, velocity and displacement

(approx. 40min)

Location

This stop is in front of the contemporary concert hall of the Philharmonic Orchestra of the Republic of North Macedonia. The building is between the State School of Music and Ballet Ilija Nikolovski-Luj and the Macedonian Opera and Ballet, which are one of the landmarks of the city of Skopje.

Figure 3. Location of stop 2, the contemporary concert hall of the Philharmonic Orchestra of the Republic of North Macedonia

Overview and Purpose

The main aim of this stop is for students to explore the speed and displacement of objects. We will include rolling objects of different materials and a scooter or bike. Students will measure time and distance to find the speed of the objects. The students will observe the displacement and the velocity of the objects depending on the height of the ramps.

Education Standards

The student will learn to:

3. Applies techniques and tools to accurately measure time and distance (measurement).
4. Solves problems involving speed, velocity and displacement (physics).
5. To identify and discriminate relationships of numerical proportionality and use them to solve problems in daily situations (connections to the world)

References:

1. https://www.bro.gov.mk/wp-content/uploads/2018/02/Nastavna_programa-Fizika-VIII_odd-mkd.pdf (page 18)

Objectives

Students will:

1. Measure time and distance.
2. organize the data in a table or chart in the application
3. calculate the ratio of distance to time (s/t).
4. Discuss speed, velocity and displacement.
5. Determine the average speed of a body experimentally.
6. Analyze and solve further problems.

Materials Needed

1. Tape measure application
2. Stopwatch (on the phone)
3. Phone calculator

4. Rolling objects (for example, wheels, candles, toys) from different materials, scooters or bikes.

Activity

1. 5 minutes: Start the lesson with an introduction to the notion of speed using storytelling.

What is speed? Speed is a measurement of how fast an object moves. The first scientist to measure speed as distance over time was Galileo.
How fast are you? What is the average speed of the car?
Speed of Light. The fastest possible speed in the universe is the speed of light. The speed of light is 299,792,458 meters per second. In physics, this number is represented by the letter "c."

2. 5 minutes: Introduce (or repeat) the following notions:
   - distance between two points
   - measuring time for a corresponding distance
   - determine the right units
   - speed = the ratio between distance and time, average speed

3. 15 minutes: Put students in groups of two or three, and give them the measurement tools. Tell them to open the mobile app and find the speed, velocity and displacement worksheet. Demonstrate measurement on one attempt. The velocity is the ratio between distance and time in the right units. It requires precision in synchronized measures of time and distance.

Figure 4. Students roling objects at stop 2

Explain to students that they should measure time and distance to evaluate the speed of the objects. Demonstrate accurate and less accurate ways of measuring, and ask students who are best. Ask students to measure speed when there is no initial speed and with initial speed. Explain to the students the main difference between speed and velocity. Explain to the students the notion of displacement.

They can also take several readings for each measurement to test accuracy if time permits. Then you can talk about the average speed of one object. All students should find the speed and the velocity of their rolling objects.

4. 5 minutes: Discussion and conclusions.

Ask students to sit with their groups and discuss their data. Determine which object has the greatest speed. Is speed related to the material of the rolling objects?

5. 10 minutes: Assessment. Steps to check for student understanding.

   Level 1: (age 8-10) How do we measure time and distance?

   Level 2: (age 11-13) Determine the speed of the rolling objects with the same instantaneous initial force.

   Level 3: (age 14-16) Does the speed of the rolling object depend on its material, the length of the ramp or height?

Stop 3: Lines and angles

(approx. 40 min)

Location

The narrowest city centre area on the left bank of the river Vardar has one of the most representative objects of modern architecture in North Macedonia – the National Opera and Ballet, the third stop for this trail. This extraordinary work by the architects from the young Slovenian office Biro 71 was influenced by Finnish organic architecture and was inspired by natural elements, such as mountains and topographic reliefs.

Figure 5. . Location of stop 3, National Opera and Ballet

Overview and Purpose

The main aim of this stop is for students to explore lines and angles. The angles are one of the fundamental elements of geometry, and their application in STEM is endless. At this stop, the students will study lines and angles through the global context of cultural expression.

In the past, buildings tended to have a shape of a rectangular prism. Advances in engineering have allowed a more creative use of angles to give a building a distinctive style and increase safety.

Education Standards

The student will learn to:

1. Name and classify different geometric elements: point, ray, and a line segment (geometry).
2. Name and classify different types of angles (geometry).
3. Constructing and measuring angles (connections to the world)
4. Create art using geometry (creation)

References:

- https://www.bro.gov.mk/wp-content/uploads/2018/02/Nastavna_programa-Matematika-VII_odd-mkd.pdf (page 56)

Objectives

Students will:

1. Observe lines and angles (geometry)
2. Learn about different types of angles (geometry)
3. Measure angles (measurement)
4. Use mathematical objects for art.

Materials Needed

Materials are brought to the stop by the teachers. In the case of other parties (for example, parents with children) visiting the trail, measurements can be done using various free mobile applications.

- Laser toy (free mobile application)
- Protractors
- Phone camera
- Pencil, paper

Activity

1. 5 minutes: Start the lesson with an observation, asking the following questions:
    - What do you think when you look at the building?
    - Why do you think this style of art is a modern one?
    - Can you find any mathematical influence in the building?

2. 10 minutes: Introduce the following notions:
    - The point, line, line segment, ray
    - Parallel lines

Put students in one group and ask them where they see a point, line, line segment, or ray on the building in front of them. Discuss similarities between line, line segment and rays. What about the differences? Find other examples of points, lines, line segments or rays around you.
Search for parallel lines on the building, and show parallel lines by using your arms. Show pictures from cubism to illustrate other points, lines and rays in the art.

3. 10 minutes: Introduce the angle. Ask students to search angles on the building. Talk about the size of an angle, and tell them about acute angles, obtuse angles and right angles. Discuss how the size of an angle depends on how far apart the rays are from each other. Introduce the unit for the angle measurement – the degree, and show them a protractor.

   At the end of this section, use storytelling to explain why the circle has 360 degrees. It was chosen because it is close to the number of days in the year. Ancient astronomers saw that the sun made its orbit once every year or roundly once every 360 days. They believed that the sun moves one degree every day.

Figure 6. Various angles at this building

   Explain to the students how to make angles with their arms. Put them in groups of two or three, tell them to take pictures with different (arms) angles and discuss. Measure the angles using protractors.

4. 5 minutes: Group play of “Simon Says”.

Use your arms and/or hands to act acute angle, obtuse angle, parallel lines, rays, and right angles and play a game like "Simon Says" with it.

5. 10 minutes: Assessment. Steps to check for student understanding.

   Level 1: (age 8-10) How many lines and angles can you find on the building?
   Level 2: (age 11-13) What types of angles can you find on the building? How many obtuse angles are on the building? Can you find any triangles?
   Level 3: (age 14-16) Mathematics can be used to create artwork. From cubism to origami to architecture, geometry can be functional and beautiful. Your task is to create your work of art that includes the elements you have seen throughout the stop. You can create a painting, a drawing or any other art.

4.2 Green&STEM trail Number 2 in Skopje

Author: Vesna Andova

General notes

This is a trail in Skopje City Park, located in the city's centre. The trail has three stops, and each stop has a few challenges. Although the stops are enumerated, there is no particular order. You can start wherever you want and in the order you prefer. The assignments in the stops are partly connected. There are different difficulty levels for most of the assignments. The aim is for the student to study science, technology, engineering, and mathematics through outdoor activities. You can try these STEM activities in any season and at many different locations (slightly adapted).

Stop 1 (approx. 35 min)

Overview and Purpose

At this stop, we will measure the dimensions of the objects and calculate area and volume.

Education Standards

The student will learn to:

1. Measure the dimensions of a given object while working in groups (III-A.1, III-A.2, III-A.18, III-B.2)
2. Applies techniques and tools to accurately find measurements (engineering) (III-A.25)
3. Solves area and volume problems (mathematics) (III-A.19, III-A.20, III-A.27)
4. Order the objects by height, area, and volume (problem-solving) (III-A.21, III-A.)
5. Recognizes and applies geometric ideas to everyday life (connections to the world) (III-B.3)

Objectives

Students will:

1. Measure the dimensions of the objects.
2. Organize the data in a table or chart in the application.
3. Calculate the area and the volume of the objects.
4. Order the objects by size (height, area, and volume).

Materials Needed

- Variety of strings/ropes for measurement.
- Paper and pencil for charts
- Phone calculator

Activity

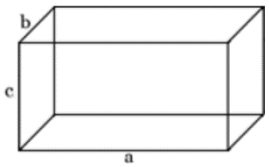
- 5 minutes: Introduction to the problem

The student should be organized into groups of 2 or 3 students. Each group will get a string/rope for measuring the dimensions of the several assigned prism from the playground in the city park. The student in the group chooses a method for denoting their prisms (leaf, rock, etc.). Each group should measure the dimensions of 3-4 prisms and then calculate their area and volume. Students discuss how to prepare the paper chart they will use later for entering the data.

- 5 minutes: Measuring the dimensions.

The students measure the dimensions of their prisms, denote the prism with the mark they chose (using stickers or chalk), and enter the data in the chart.

- 5 minutes: Calculate the area and the volume.



Observe that the walls of a prism are six rectangles. If the dimensions of the prisms are , and (*c*=height), then there are two rectangles of dimensions two of dimensions , and two rectangles of dimensions . The area of a rectangle of dimensions is . Hence, the area of the prism is . The prism that is above ground has five walls, and therefore its area is , i.e. the area of the whole prism minus the area of the rectangle that lies on the ground. The volume of the prism is

Task 1 (age group 1): The students should deduce the formula for the area and then calculate the area of the prism.

Task 2 (age group 2): The students should deduce the formula for the prism area above ground and then calculate the area.

Task 3 (age group 3): The students should draw a horizontal line on the prism and then measure line height (). They should calculate the area of the prism that is above the line. They should also calculate the volume of the prisms. They should observe that in this case, the prism has five walls (like in task 2) and its dimensions are , and , so the area is and the volume is .

Example: Let the prism dimensions be and the horizontal line is above the ground. Then

The area of the whole prism is

.

The area of the prism that is above the ground is

,

and it is exactly the area of the whole prism () minus the area of the rectangle that lies on the ground (.

The prism's length and weight above the horizontal line are the same The height is , so its area is

,

- 5 minutes: Ordering

The student should order the prisms by three criteria: height, area, and volume. Use the formula for the volume $V=cB$, where B is the area of the basis.

- 5 minutes: Discussion and conclusions.

Ask students to sit with their groups and look over their data. The group discusses if there are any relations between height, area, and volume. Why is it so? Do all prisms have the same basis?

- 10 minutes: Assessment. Steps to check for student understanding.

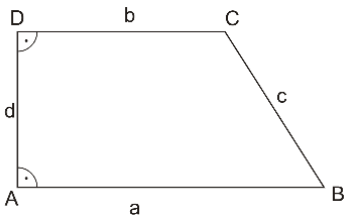
Give the student additional problems to solve.

Level 1: Choose one bigger prism. Ask the students to find two or three smaller prisms with the same volume as the chosen one. Ask them how they would solve this assignment. They should find two or more volumes in the chart with a sum equal to the volume of the bigger prism.

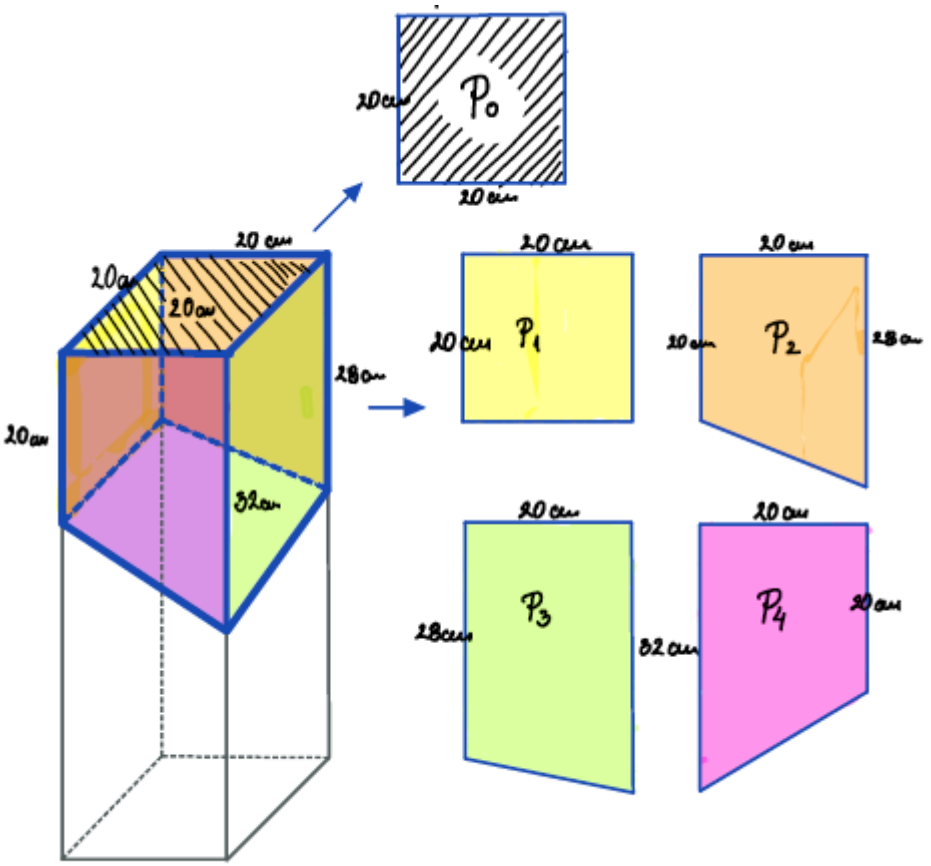
Level 2: Choose one bigger prism. Look for its dimensions in the chart. Ask the students to determine the heights of two prisms such that they have the same weight and length as the bigger prism, and the sum of their volumes equals the volume of the bigger prism. Ask them how they would solve this assignment. Remind them that . Let the height of the bigger prism be , and on the smaller respectively. As they all have the same weight and length, the basis area is the same. Then T

Level 3: Set an imaginary plane that cuts the prism under some angle, or draw lines on the side walls of the prism such that they form a closed polygon. Ask the students to determine the volume and the area of this object. (Additional measuring might be required!)

Observe that the side walls of the prism now are right trapezoids, and the area is . Therefore, the dimensions of all four trapezoids should be determined and their area. The area of the prism equals the sum of the areas of all four trapezoids plus the area of the top side (rectangular).



Example: Let's determine the area of the prism in the figure.



. Then

References

- https://mon.gov.mk/stored/document/standardi-USVOENI.pdf
- https://www.bro.gov.mk/%D0%BF%D0%BE%D0%B4%D0%BA%D0%B0%D1%82%D0%B5%D0%B3%D0%BE%D1%80%D0%B8%D0%B8/?idcat=50&customposttype=documents_category
- https://www.hackmath.net/en/word-math-problems/prism

Annexe

Tasks 1 and 2

Prism mark	Length a ()	Width b ()	Height c ()				Area ()	Volume ()

Taks 3

Prism mark	Length a ()	Width b ()	Height c ()	Height of horizontal line		Area ()	Volume ()

Stop 2 (approx. 50min)

Overview and Purpose

This stop is dedicated to four of the five senses humans have: sight, smell, hearing, taste, and touch. You are going to motivate the student to isolate one sense (sight, smell, hearing, and touch) and discover its powers.

Education Standards

The student will learn to:

1. Observe and take notes (science) (III-A.28, III-A.30)
2. Design an experiment (science) (III-A.31)
3. Design methods that will help him/her to isolate one sense (engineering) (III-A.29)
4. Differentiate the information he/she is receiving from his/hers sense (science) (III-A.43, III-A.54)
5. Match the information he/she gets with the source (science) (IV-A.4, IV-A.6)

Objectives

Students will:

1. Design their own technic for isolating one sense.
2. Make notes.
3. Analyze the observations.

Materials Needed

- Scarf (or something similar).
- Paper cylinders, paper plates, scissors.
- Playdough

Activity

1. 5 minutes: Introduction to the problem.

You should ask the students about their senses. Do they sense something? How many senses do we have? Explain to them that we have five senses (sight-eyes, sound-ears, smell-nose, touch-skin, and taste-tongue). Then ask the students to observe the surroundings and make notes of what they see, hear, and smell.

This activity can be applied to all age groups with small adaptations.

Task 1 (age group 1): The teacher should lead them through the activity, ask the questions, and help them find the answers. The students should create and use the tools by themselves. They should spot the difference between their notes and the observations they will make later in the activity.

Task 2 (age group 2): The students should design, create and use the tools by themselves.

Task 3 (age group 3): The students should design the experiment by themselves; they should also create and use the tools. They can use the internet, and some apps to discover what they saw, heard or felt.

2. 10 minutes: Sense of sight.

The students should create some tool that will help them to localize their sight. It can be a paper plate with a hole in the middle, paper cylinders, etc. This will help them to focus on a smaller area. You should lead them through the process of creating the experiment and tools. They should localize their sight and observe. They should take notes of the observed. Is there any difference? Did they see something different now? Why is that happening? Make a discussion.

3. 5 minutes: Sense of sound.

Next, they will explore the sense of sound. There is always so much to listen to outside! The students should create a method to concentrate only on the sounds. Same as in the previous step, you should lead them in the following steps. They can use a scarf to blindfold their eyes and eliminate the sense of sight. Now, they should concentrate on the sound. Do they hear some new sound? Why? Next, they can try to detect what produces the sounds they hear. You can produce additional sounds: knock on wood, knock on metal, walk on leaves, etc.

4. 5 minutes: Sense of smell.

Like before, the student should be blindfolded, but now they should concentrate on the smell. You should give them different things found in the surroundings (grass, flowers, conepines ...), and they should match the smell with the thing they observed at the beginning. Attention! They don't touch these objects to eliminate the sense of touch.

5. 10 minutes: Sense of touch.

First, give playdough to the kids. Then start a walk by imprinting the playdough with leaves, acorns, rocks, tree stumps, branches, and bark. They should look at all the different imprints that were made and compare sizes and shapes. Can they guess the imprints if they are blindfolded?

6. 10 minutes: Conclusion and discussion.

Ask them what they learned. Give them different objects from the surrounding. Can they guess what it is just by the sense of touch (they should be blindfolded)? Is it easier to guess the object if they combine the sense of touch with the sense of sound and sense of smell?

7. 5 minutes: Assessment.

Discuss the fifth sense, the sense of taste.

Level 1: Do they have any suggestions for isolating this sense? How to test it?

Level 2: Is being blindfolded enough? How do they differentiate between chocolate, chocolate ice cream, and hot chocolate? How do they distinguish lemon and orange? Do they make a difference (when blindfolded) between the tastes of various colours of gummy bears; peanuts and peanut butter; yoghurt and sour milk, different flavours of juice, …? Give them more examples like that; different foods that have similar smells, texture and/or taste. Explain that when they try the food, they recognize the type of food by taste, smell, and texture.

Level 3: Let them design their own experiment and make conclusions.

References

- https://mon.gov.mk/stored/document/standardi-USVOENI.pdf
- https://www.bro.gov.mk/%D0%BF%D0%BE%D0%B4%D0%BA%D0%B0%D1%82%D0%B5%D0%B3%D0%BE%D1%80%D0%B8%D0%B8/?idcat=50&customposttype=documents_category
- https://www.himama.com/blog/assessing-toddler-development-through-observation/

Stop 3 (approx. 45 min)

Overview and Purpose

This stop is a continuation of the assignments in Stop 1 and Stop 2. At this stop, you will measure the perimeter of a 1 square meter area, and then you will explore the creatures, soil, water, and plants in our one square meter piece of land.

Education Standards

The student will learn to:

1. Measure the dimensions of a given object while working in groups (III-A.18, III-B.2)
2. Applies techniques and tools to accurately find measurements (engineering) (III-A.25)
3. Solves area and perimeter problems (mathematics) (III-A.19, III-A.20, III-A.27)
4. Design 1 square meter “yard” (engineering) (III-A.21, IV-A.3)
6. Explores creatures, soil, water, and plants (science) (III-A.28, III-A.30, III-A.43, III-A.54)
5. Uses his/her camera to take pictures of what is seen (technology) (IV-A.1, IV-A.2)
6. Uses the internet or scientific research (science & technology) (IV-A.4, IV-A.6)

Objectives

Students will:

1. Measure the dimensions of the objects.
2. Organize the data in a table or chart in the application.
3. Calculate the perimeter of 1 square meter “yard”.
4. Explores his/her “yard”.
5. Doing online research.

6. Analyze the diversity.
7. Appling the gained knowledge.

Materials Needed

- Variety of strings/ropes with various lengths for contouring the “yard”.
- Measuring tape.
- Scissors.
- Magnifying glass.
- Cups, bottles (if there is a pond, lake, sea,…)
- Paper and pencil for charts and crayons for drawings.
- Phone calculator.
- Phone camera.

Activity

1. 5 minutes: Introduction to the problem.

The teacher (you) explains what 1 square meter means. It is the area of a square with a side length of 1 meter. It is also the area of a rectangle with dimensions 0.5mx2m, … The students should be organized into groups of 2 or 3 students. Each group will get strings/ropes with different dimensions for contouring a piece of land (water) that will be their "yard". Later they will observe what can be seen in their yard.

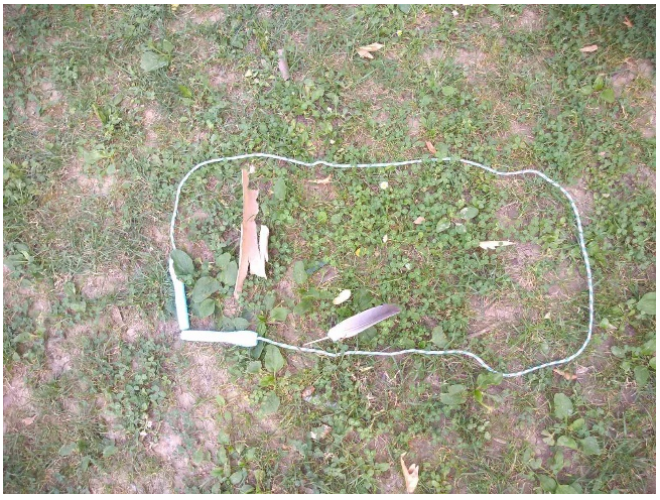
2. 10 minutes: Designing the yard.

The students should choose the shape of their yard.

Task 1(age group 1) Choose a square or rectangular shape.

Task 2 (age group 2) Choose a shape of a triangle or a trapezoid shape.

Task 3 (age group 3) Choose a shape of a circle, ellipse, or other polygons.



The student should measure the perimeter of the yard. They should try to use rope as short as possible. They should decide what shape their yard will be.

3. 10 minutes: Observing the yard

The student should get down and, using a magnifying glass, see what is in their yard. They should push the grass (leaves, rocks,…) aside if necessary to see what's below the surface. They should take notes and pictures and make drawings of what they saw. Later they can search on the internet to learn more about it.

4. 10 minutes: Discussion and conclusions.

Ask students to sit with their groups and look over their data. Discuss the shape of their yards. Why did they choose that shape? What is the perimeter of their yard? Determine the optimal solution.

Then discuss the things that were observed. Is there any difference, and why? What was the most interesting thing they saw? Motivate them to do small research for it on the internet.

5. 10 minutes: Assessment.

Give the student additional problems to solve.

Level 1: If they have 4 (or 8) meters long rope, what will be the area of their squared yard?
Level 2: If they have 4 (or 8) meters long rope, what will be the area of their yard in the form of a regular triangle?
Level 3: What are the dimensions of the rectangular yard with a perimeter of 1m and maximal area? (These problems can be left for homework.)

References

- https://mon.gov.mk/stored/document/standardi-USVOENI.pdf
- https://www.himama.com/blog/assessing-toddler-development-through-observation/
- https://www.bro.gov.mk/wp-content/uploads/2021/04/%D0%9D%D0%9F-%D0%9F%D1%80%D0%B8%D1%80%D0%BE%D0%B4%D0%BD%D0%B8-%D0%BD%D0%B0%D1%83%D0%BA%D0%B8-I-%D0%BE%D0%B4%D0%B4.pdf

4. 3. Green&STEM trail Number 3 in Skopje

Author: Maja Stankovska

Location: Avtokomanda square

This trail consists of three stops. The recommended first stop is the square in Avtokomanda. (coordinates - google maps 42.00186784345106, 21.46175239822501)

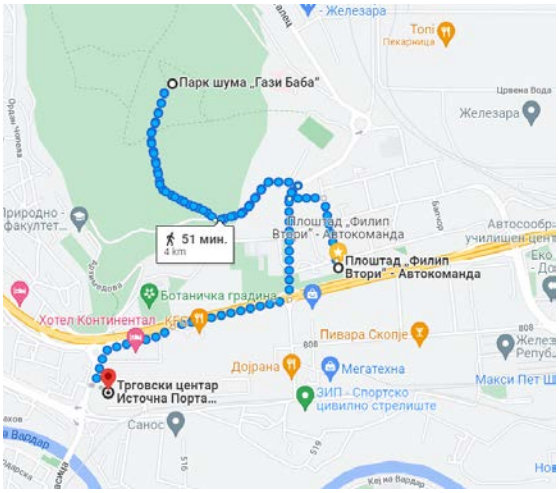


Figure: View 1 of the trail. Source: maps.google.com

Stop 1: Avtokomanda square

Overview and Purpose

To understand the mathematics behind estimating the area of geometric figures, to recognize them in space.

Education Standards

(https://mon.gov.mk/stored/document/standardi-USVOENI.pdf)
The student will learn to:

- to recommend/apply the scale in different contexts of everyday life
- to calculate the perimeter and area of two-dimensional and three-dimensional shapes
- Every individual is responsible for the preservation of the natural environment in the immediate environment and beyond, and he should develop environmental awareness and act in the direction of environmental protection and sustainability,

Objectives

Students will:

- recognize and differentiate shapes;
- estimate real dimensions of length measurements;
- Describe how to improve people's awareness of environmental protection

- Materials Needed

- Meter, calculator, pencil and paper or worksheet

Activity

5 minutes: Start the lesson with a historical note.

The square is located in the metropolitan area of Skopje, in a settlement Avtokomanda, between the boulevard "Alexander the Great" and the Street "Jani Lukrovski".The square is designed as a plateau covered with granite tiles, access paths, and green lanes and colourful with high and low green, two children's entertainment spots, and urban equipment, accompanied by a stage plateau, fountain monument plateau of Falanga warriors and monument plateau for a warrior on horse Filip II. **Philip II of Macedon (** 382 – 21 October 336 BC) was the king (*basileus*) of the ancient kingdom of Macedonia from 359 BC until his death in 336 BC. He was the father of Alexander the Great. Philip II of Macedonia is best known for reforming the Macedonian army - phalanx.

The citizens of Municipality Gazi Baba – Skopje are very proud of this square, built up with the full financial support of the business community in MGB and finalized in December 2008.

The square offers excellent possibilities for relaxation and enjoyment in beautiful sculptures made by the author Valentina Stevanovska.

Concerts and other events are often held on the square.

(http://investinmgbskopje.mk/index.php/tradition/archeology/2-uncategorised/151-square-avtokomanda)

The task for age group 1 (age 8-10**)**

T1: Describe which two-dimensional and three-dimensional shapes you can see in the square.

T2: What shape is the base of the sculptures?

Are the sculptures life-sized or smaller or larger than in real life?

Choose one of the sculptures on the stop and guess how tall the sculpture is.

T3: Measure the radius of each of the different circles.

T4: Count (or estimate) how many red tiles are used on the paths.

The task for age group 2 (age 11-13**)**

T1: Describe which two-dimensional and three-dimensional shapes you can see in the square. What shapes are most represented in the square and the surroundings?

T2: Calculate how many times larger/smaller the size of the sculptures is compared to the normal size (horse: height - 160 cm; body length - 167 cm).

T3: Estimate the diameter and perimeter of each of the different circles. (perimeter=2*radius * or perimeter= diameter*)

T4: Measure the dimensions of a red tile and calculate its area.

The task for age group 3 (age 14-16**)**

Aim: Demonstrate accurate and less accurate ways of measuring, and ask students who are the best.

T1: Describe or draw the irregular geometric shapes in the square.

T2: What shape is the base of the sculptures?
Estimate the height of the sculptures.

T3: Estimate the area of the cobblestone area around the sculpture.

T4: Calculate the area of the black tiles on the stage.

Extension/homework for all age groups
Create promotion materials (posters, Facebook posts, Instagram photos etc.) to keep the square clean and not destroy the monuments, greenery and children's playground.

References:

- https://mon.gov.mk/stored/document/standardi-USVOENI.pdf
- https://www.bro.gov.mk/%D0%BF%D0%BE%D0%B4%D0%BA%D0%B0%D1%82%D0%B5%D0%B3%D0%BE%D1%80%D0%B8%D0%B8/?idcat=50&customposttype=documents_category
- http://investinmgbskopje.mk/index.php/tradition/archeology/2-uncategorised/151-square-avtokomanda
- https://mk.wikipedia.org/wiki/%D0%9F%D0%B5%D1%80%D0%B8%D0%BC%D0%B5%D1%82%D0%B0%D1%80

- **Location: STOP 2**

The second stop is the Gazi Baba forest park in Skopje. (2F26+PW Скопје)

- **Overview and Purpose**

To understand the food chains in a particular habitat and learn to help improve the awareness of environmental protection
Education Standards
(https://mon.gov.mk/stored/document/standardi-USVOENI.pdf)
The student will learn to:

- use basic scientific knowledge to explain the natural world,
- to consider and select ideas; observe, predict and make assumptions (hypotheses); collect and evaluate evidence; check predictions; plan, organizes and conduct research; record, process, analyze and present results; evaluate and discuss conclusions
- every individual is responsible for the preservation of the natural environment in the immediate environment and beyond, and he should develop environmental awareness and act in the direction of environmental protection and sustainability,
- to connect knowledge from the sciences with their application in technique and technology and with everyday life
- to identify and investigate phenomena in living and non-living nature,
- to understand the meaning and need for sustainable development and to critically analyze situations in which there are conflicts of interest between the need for economic-technological development and environmental protection,

Objectives
Students will:

- research and assemble food chains in a particular habitat.
- describe how to improve people's awareness of environmental protection
- develops creativity through designing and making models
- to calculate the perimeter and area of two-dimensional shapes

Materials Needed

- Paper, Scissors, pushpin, a pencil with eraser, yarn, meter, recycled materials (*plastic bottle, cardboard)*

Activity

5 minutes: Start the lesson with a historical note.

The Gazi Baba park is closely related to the formation and development of the city of Skopje, which has a long history from before the new era until today.
Before the Balkan wars, the city of Skopje was located on the left bank of the Vardar River. Kale and Gazi Baba hills were the main green and recreational areas.
Due to its natural-attractive climate and vegetation characteristics, the Gazi Baba hill was planned to serve as public city greenery and a sporting and a recreational spot in Skopje.
The Gazi Baba locality, i.e. the hill, has got its name after the name of the Ottoman kadi, scientist and poet from the 16th century Ashik Cheleby known among the people as kadi Gazi Baba.
In the past, the Gazi Baba hill was surrounded by the Serava valley to the west, the alluvial plain of the Vardar River to the south, and abrasive terraces that extend more than 300 meters above the sea level to the north-northeast.

LOCATION

The Gazi Baba nature park is located within a 3 km distance from the centre of Skopje to the east. It is located among the residential district Zelezara to the east, the urban parts of the Cair settlement to the west, the northern parts of the Avtokomanda settlement and the residential parts of the Butel 2 settlement.

IMPORTANCE

It is an interesting natural area whose values have been recognized long ago. In the fifties of the 20th century, many activities were undertaken to create a green area of about 100 ha, where many different tree species were introduced, which improved the overall forest area. This happened in the period of intensive industrialization and urbanization of this area.
The construction of this green area contributed to the improvement of environmental quality. This area has been declared a protected area following the Law on the protection of natural rarities to ensure its permanent preservation. The Council of the City of Skopje has decided to declare the locality of Gazi Baba a characteristic landscape. In March 2015, the Gazi Baba locality was reprotected with the Law declaring the locality Park forest Gazi Baba a Nature park. (https://parkovi.com.mk/en/gazi-baba-2/)

The task for age group 1 (age 8-10**)**

T1: What plants and animals do you notice or think are in Gazi Baba Forest Park?

T2: Build a Bird's Nest

Build a bird's nest using materials (leafs, moss, grass, twigs) you can find outside and yarn. Things to think about: how deep does the nest need to be to keep the eggs safe? What happens if it rains-will water collect or drains away?

T3: Count (or guess) how many rectangles there are in this shape, with all sides being tubes.

The task for age group 2 (age 11-13**)**

T1: Describe the food chain that exists in Gazi Baba Forest Park.

T2: Make a Pinwheel

Instructions:

- Fold the corner of the paper to form a triangle.
- Cut along the edges of the triangle.
- Fold the triangle cutout into half to make a fold line.
- Unfold and cut 2/3 way into the fold line.
- Unfold the triangle into a square, and you'll see two corners with cuts.
- Repeat the steps for the other two corners.
- Use the pushpin to poke holes in the centre of the pinwheel and in the four corners.
- Twist the pin to make the holes smooth. (This will help your pinwheel spin).
- Stick the pushpin through each corner hole, the centre hole, and then into the top of the pencil eraser.

Do you know what renewable energy sources are? Where does the energy come from to make the pinwheel?

T3: Estimate the total length of wood used to make this shape.

<u>The task for age group 3 (</u>age 14-16**<u>)</u>**

T1: Make an Insects Hotel

Can you find some insects? What is their role in nature?
Make an Insects Hotel
Find natural materials (leaves, pine cones, twigs, flowers, moss, grass, stones).
Cut a plastic bottle into parts.
Start to build Bug Hotel with all the items you have collected and some recycled materials (cardboard, bricks, rope,..). Make the insect hotel nice and cosy. Be inventive! There is no right or wrong way.
(https://www.redtedart.com/simple-bug-hotel-for-kids/)

T2: Estimate the tree height using the Under the legs peek method.
Instructions:
Under the legs peek method

- Find a tree to measure that is on level ground with no obstacles in the way;
- Begin with your back to the tree and start walking away from the tree
- Stop occasionally, bend over and peek through your legs at the tree. Look to see if you can see the very top of the tree. If you can't, keep walking away and checking. Once you can see the top of the tree through your legs, STOP. Mark the spot you are in when the top of the tree is visible.
- Now measure the distance from your marked spot to the base of the tree, and you have an approximate height of the tree.

Estimate the height of the tree using - Pencil partner method.

Instructions:

- For this activity, you will need a partner, a pencil, and either a measurement tool OR to know your stride measurement from above.
- Have your partner stand directly beside the tree while you walk away from the tree
- Look back occasionally as you walk away. When you look back, hold the pencil vertically at arm's length from you and line it up with the tree.
- Keep walking until the bottom of the tree is level with the bottom of the pencil and the top of the tree is level with the point of the pencil.
- Stop in this spot and turn the pencil sideways (horizontally), keeping the bottom of the pencil at the base of the tree.
- Now have your partner start walking away from the tree
- You will need to yell Stop when you see your partner at the tip of the pencil
- Mark the spot where your partner has stopped. The distance from your partner to the base of the tree is the height of the tree
- You can measure this distance with a measuring tool or use the stride method from above

(https://learningwithoutdoors.com/learningactivities/tree-measure)

T3: What geometric shapes can you recognize in the pavilion?
Estimate the table area in the pavilion.
(Measure one side of the table - regular hexagon)

Extension/homework for all age groups

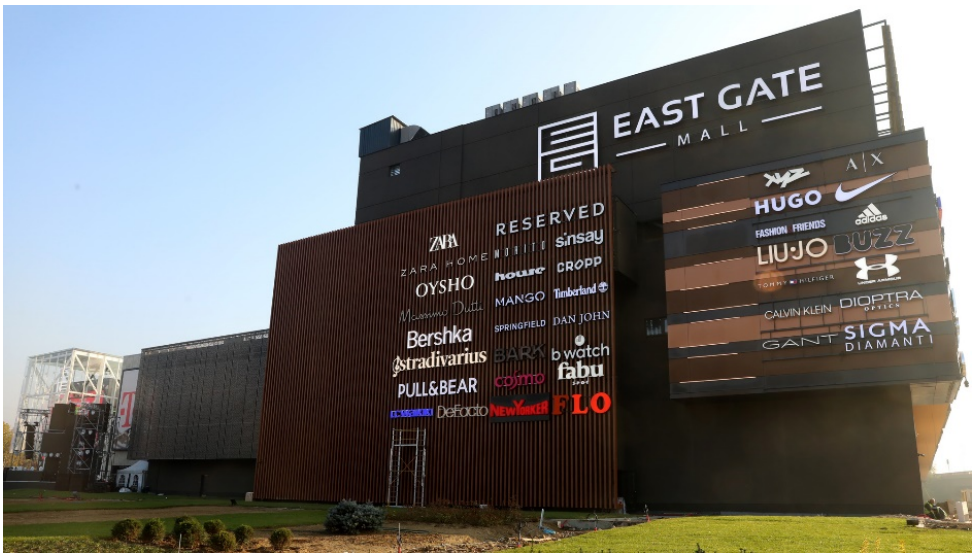
Create a flyer with information about park forest-Gazi Baba and rules of conduct.

References:

- https://mon.gov.mk/stored/document/standardi-USVOENI.pdf
- https://www.bro.gov.mk/%D0%BF%D0%BE%D0%B4%D0%BA%D0%B0%D1%82%D0%B5%D0%B3%D0%BE%D1%80%D0%B8%D0%B8/?idcat=50&customposttype=documents_category
- https://schools.bchydro.com/activities/sustainability/energy-transformations-wind-power
- https://www.canva.com/design/DAE8jtHo128/icaEnsYjo0QmiKEr-ZRrPA/view?utm_content=DAE8jtHo128&utm_campaign=designshare&utm_medium=link&utm_source=publishshare link#10
- https://learningwithoutdoors.com/learningactivities/tree-measure
- https://www.redtedart.com/simple-bug-hotel-for-kids/)

Stop 3: East Gate Mall

The third stop is East Gate Mall (Coordinates 42°00′00″N 21°25′59.9″E)



Overview and Purpose

To understand the mathematics behind estimating the numerical state of elements in a real environment.

Education Standards

(https://mon.gov.mk/stored/document/standardi-USVOENI.pdf)

The student will learn to:

- to recommend/apply the scale in different contexts of everyday life
- calculate the perimeter and area of two-dimensional and three-dimensional shapes

Objectives

Students will:

- Apply basic mathematical operations.
- Estimate the number of elements in real space.
- Converts time and length units from larger to smaller and vice versa.
- Calculates a percentage.
- Calculates the area of real objects in space.

Materials Needed

- Meter
- Calculator
- Pencil
- paper or worksheet

Activity
5 minutes: Start the lesson with a historical note.

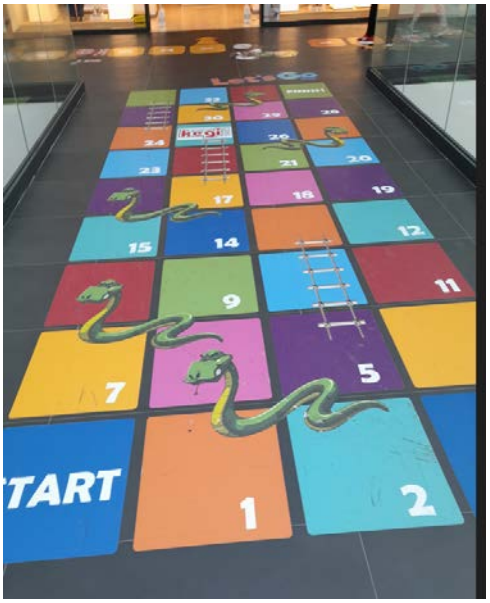
Shopping centres have existed for over 1,000 years as ancient market squares, bazaars and seaport commercial districts. The modern shopping centre, which includes everything from small suburban strip centres to the million-square-foot super-regional malls, had its genesis in the 1920s.
The first shopping mall was the Country Club Plaza, founded by the J.C. Nichols Company and opened near Kansas City, Mo., in 1922. The first enclosed mall, called South-dale, opened in Edina, Minnesota (near Minneapolis) in 1956.
(https://www.yourarticlelibrary.com/mall-management/history-of-malls-management/87292)
The shopping and entertainment centre, called East Gate Mall, opened on October 29-2021, and by far is the largest shopping mall in North Macedonia and the third largest overall in the region of the Balkans. East Gate Mall has a retail area of 57,000 m^2 (610,000 sq ft) and 2000 parking places. East Gate Mall is a five-floor building with over 220 international and local shopping brands, a hypermarket, electronics shops and other services. It also has a gastronomy area with multiple choices of cuisines and over 800 seats. The mall also has five Café Avenues, a fitness centre, a video playground and 8 Cineplexx Cinemas theatres.

The task for age group 1 (age 8-10**)**

T1: Count the number of visitors entering and exiting the mall's main entrance during a 5-minute period. Estimate how many visitors will enter the mall in 2 hours.

T2: Guess and count how many parts the mall bench is made of.

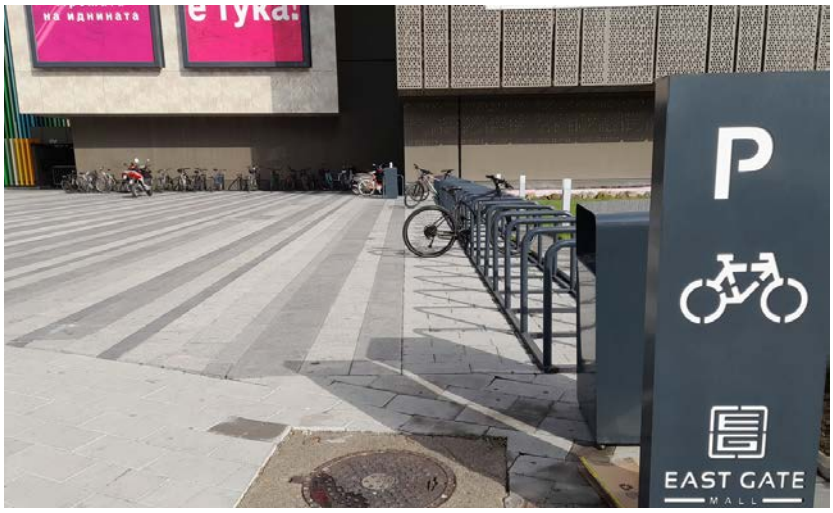
T3: In the central boulevard on the 01st floor is a Snakes and Ladders playground and a path with numbers. (Calculate only number fields)
Calculate the sum of all prime numbers.
Calculate the sum of all odd numbers.
Which digit (0-9) appears the most and which the least?
Time for fun. Play Snakes and Ladders.



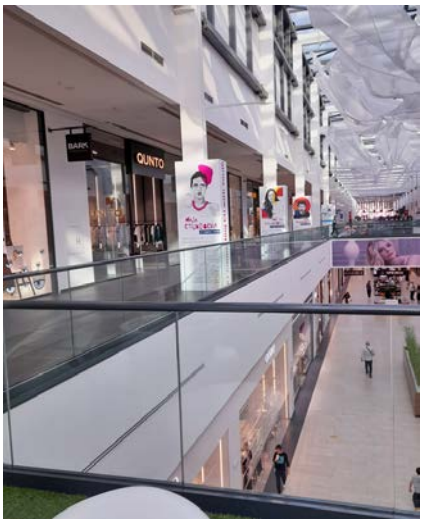
The task for age group 2 (age 11-13**)**

T1: Count the number of visitors entering and exiting the mall's main entrance during a 3-minute period. Estimate the total number of visitors to the mall for the opening hours of 10 am to 10 pm based on the number of visitors you counted in 3 minutes plus 20%.

T2: Count how many bike spaces are in front of the mall and calculate what percentage of the spaces are currently occupied.



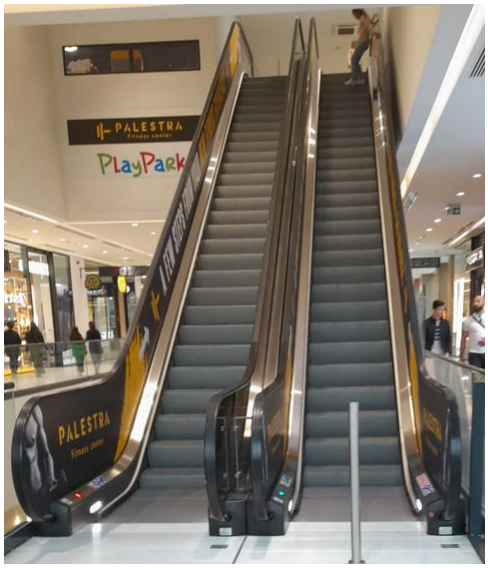
T3: Count how many pillars in the central boulevard on the 01- floor have advertising space. Measure the dimensions of an advertising space and calculate its area.
Calculate the total area of the advertising space from all columns



The task for age group 3 (age 14-16**)**

T1: Divide into groups, and at the elevators between floor 00 and floor 01, count how many visitors go up and how many down for 5 minutes.

Compare the results and find which elevator was used by more visitors.



T2: Count how many stairs the elevator has.
Measure how long it takes the elevator to go up and down.
Calculate the maximum number of visitors who can use the elevator in 5 minutes if there is one visitor on each stair.
How many times can you go up and down in 2 hours?

T3: There is a train for children in the central boulevard on the 01st floor. It starts from the central boulevard and goes along the path marked in black on the map. Estimate how long the path that the train takes.

Estimate how long the train will take to cross the road if the train's speed is twice the speed of a person.

Extension/homework for all age groups

A hidden message

Create a hidden message with the name of our project (GREEN&STEM) so that the instructions are the names of the stores on Floor 01 and the number of the letter in parentheses. A different store should be used for each letter. Try to find the shortest path between the shops.

Example:

G	R	E	E	N	&	S	T	E	M
KEGI SHOES(3)	ORIGINAL MARINES(2)								

References:

- https://mon.gov.mk/stored/document/standardi-USVOENI.pdf
- https://www.bro.gov.mk/%D0%BF%D0%BE%D0%B4%D0%BA%D0%B0%D1%82%D0%B5%D0%B3%D0%BE%D1%80%D0%B8%D0%B8/?idcat=50&customposttype=documents_category
- https://www.first4playgrounds.co.uk/playground-markings-explained-snake-and-ladders/
- https://en.wikipedia.org/wiki/Skopje_East_Gate
- https://eastgatemall.mk/

4.4 Green&STEM trail Number 4 in Skopje

Author: Aleksandra Vojneska-Zikova

Stop 1: National Arena “Toshe Proeski”

This trail consists of three stops. The recommended first stop is national arena Toshe Proeski. (coordinates - google maps 42.00570, 21.42563)

The ground exists since 1947, but construction of high quality stands began no sooner than in 1978. Two years later new south grandstand was opened and soon became famous due to its steepness and capacity, highest in all of Macedonia. However no further works were carried out until 2008, when construction of almost identical structure began on the other side of the pitch. By 2009 the new one was ready and older one renovated. Then came time for end-stands. Further works on new pitch and athletics track were scheduled for 2011-2013.

The ground soon became host of almost all important games in Macedonia with national team leaving it very rarely and tenant clubs Vardar and Rabotnički giving it day-to-day use with most European games in Macedonia being also played here. In the summer season it is also used as major concert venue, attracting crowds of 20,000-40,000 for domestic performers’ gigs.

- **Overview and Purpose**

To understand the mathematics behind estimation of steps and speed using athletic sports activity. Students will get acquainted with the impact of sprinting on cardiac performance of people.

- **Education Standards**

The student will learn to:

- To use order of operations with whole numbers, fractions and decimals,
    - o including brackets;

- to running at top speed from a low start;
- to apply knowledge about the basic life processes that take place at the level of
    - organisms in order to improve the quality of their own life.

- **Objectives**

  Students will:
    - learn to approximate the number of steps in 100 m;
    - learn to approximate the average time for running a distance of 100 m;
    - learn to calculate the raising frequency of the heart after running at 100 m;
    -

- **Materials Needed**
    - Stopwatch,
    - sports equipment,
    - calculator,
    - mobile phone or pencil,
    - paper and worksheet.

Activity

5 minutes: Start the lesson with a historical note.

Toše Proeski National Arena is a sports stadium in Skopje-North Macedonia. It is currently used mostly for football matches, but sometimes also for music concerts or athletics. It is the home stadium of FK Vardar and FK Rabotnički from Skopje, both of which compete in the Macedonian First League, as well as the home ground of the North Macedonia national football team on almost all occasions.

The stadium was previously known as the City Park Stadium until 2009 and Philip II National Arena until 2019. By an executive decision of the government of North Macedonia adopted on 9 April 2019, the National Arena was to be renamed "National Arena Todor Proeski" in honour of the Macedonian pop icon Todor "Toše" Proeski. With the capacity of just over 33,000, the National Arena is the largest stadium in the country and one of the largest in Southeastern Europe.

The stadium hosted the 2017 UEFA Super Cup.

Task for age group 1 (age 8-10**)**

The students are lined up at the starting position of 100 m. They move in a straight line and with the usual length of step. Each student should count how many steps he took to cover the distance of 100 m and then calculate the average length of the step.

Task for age group 2 (age 11-13**)**

Students are positioned at the starting line for 100 m. From a low starting position, they run 100 m at full speed. At the finish line, the teacher measures the time of all students with a stopwatch. Together, they should calculate:

- the average time for 100 m for the entire age group

- the average time for women,

- the average time for men and

- calculate the difference between the results for men and women

Task for age group 3 (age 14-16**)**

The students measure the pulse in a state of rest. Then they run a distance of 100 m and immediately after the end of the race they measure the pulse again. After 5 min they measure the pulse again. The students who managed to reach a normal physiological state in 5 min indicate a good physical condition, while those who still have an elevated heart rate should work on their form.

References:

- https://en.wikipedia.org/wiki/To%C5%A1e_Proeski_Arena
- https://mon.gov.mk/stored/document/standardi-USVOENI.pdf

Stop 2: Ezerce – City Park

The second stop is “Ezerce”, the small lake in the City park in Skopje

(coordinates - google maps 42.0046882, 21.4239517)

- **Overview and Purpose**

To expand the students’ knowledge about the plant and animal world in and around a marsh environment and to learn to orient themselves in space.

- **Education Standards**

  The student will learn to:

  - use basic scientific knowledge to explain the natural world;
  - consider and select ideas, observe, predict and make assumptions (hypotheses), collect and evaluate evidence, check predictions, plan,

- organize and conduct a research, save records, process, analyze and present the results, evaluates and discusses conclusions'
- orientate in space with the help of sketches, maps, recordings and digital views of given geographic areas.

- **Objectives**

  Students will:
  - understand the difference between evergreen and deciduous trees,
  - upgrade their knowledge about animal and plant life in a marsh environment,
  - learn to orientate in space with the help,
  - learn to use technology.

- **Materials Needed**
  - Hammer,
  - glue,
  - map,
  - phones,
  - pen,
  - worksheet.

Activity

5 minutes: Start the lesson with a historical note.

City Park — a public park in Skopje and the largest city park in the country. It started to form sometime in the XIX century[1]. The culture of arranging gardens and growing flowers among Macedonians is as old as their existence. Still, green areas of a public character in Skopje did not appear until the end of the 19th and the beginning of the 20th century when the first data about the city park date. The park was built during the time of the Skopje governor Hafiz Mehmed Paşa (Turkish: Hafiz Mehmed Paşa), immediately after the construction of the "Islahane" craft school, in its immediate vicinity. The initial green area covered an area of about 16,000 m2. Part of this first park location still exists today, and it is the area around the Kermes restaurant.

The task for age group 1 (age 8-10**)**

The students walk around the lake and look at what types of trees are around the lake. They see the difference between evergreen and deciduous trees. Then the students are divided into two groups, one group which has the task of collecting leaves and fruits from deciduous trees and the other group of evergreen trees. The collected leaves and fruits are then glued to a hammer, and a collage is made from them.

The task for age group 2 (age 11-13**)**

The students line up by the lake and observe the current plant and animal life in and around the lake. Then they have the task of making a food chain (pond ecosystem) to be presented through a schema view.

The task for age group 3 (age 14-16**)**

The students are given a task for orientation in space.They are separated into two groups. First, they should get a map and coordinates of the places they need to visit. All the points they need to visit are in the city park, but they work in the opposite order - those who use a map start in one direction, and those who use coordinates have the same route; they just start in reverse order from the first group. The goal is to compare which way of orientation is faster and easier to use among the young population.

References:

- https://mk.wikipedia.org/wiki/%D0%93%D1%80%D0%B0%D0%B4%D1%81%D0%BA%D0%B8_%D0%BF%D0%B0%D1%80%D0%BA_(%D0%A1%D0%BA%D0%BE%D0%BF%D1%98%D0%B5)
- https://mon.gov.mk/stored/document/standardi-USVOENI.pdf

Stop 3: Tennis courts Jug

The third stop is the tennis court Jug, City park in Skopje
(coordinates - google maps 42.006088, 21.421951)

- **Overview and Purpose**

To perceive the representation of elements of mathematics and physics through tennis as a sport.

- **Education Standards**

  The student will learn to:
  - to distinguish and analyze 2D geometric shapes,
  - to use the units of measurement (length, mass, volume, area and volume) in
  - different context, and
  - to know what friction is and what the force of friction depends on.

- **Objectives**

Students will:
  - learn to recognize two-dimensional (2d) geometric figures,
  - understand how many square meters are needed to build a tennis court, and
  - learn how the surface affects the ball speed.

- **Materials Needed**
  - Meter,
  - pens and
  - worksheet.

Activity

5 minutes: Start the lesson with basic information.

Tennis is a racket sport played either individually against a single opponent (singles) or between two teams of two players each (doubles). Each player uses a tennis racket strung with a cord to strike a hollow rubber ball covered with felt over or around a net and into the opponent's court. The game's object is to manoeuvre the ball so the opponent cannot play a valid return. The player unable to return the ball validly will not gain a point, while the opposite player will.

Tennis is an Olympic sport played at all levels of society and all ages. The sport can be played by anyone who can hold a racket, including wheelchair users. The modern game of tennis originated in Birmingham, England, in the late 19th century as lawn tennis. It had close connections to various fields (lawn) games such as croquet and bowls and to the older racket sport today called real tennis.

The task for age group 1 (age 8-10**)**

The students are set up next to the field and have an excellent overview of the entire playground. Their task is to find as many geometric 2D shapes as possible, including the net. Then, in their workbooks, they sketch the playground in appropriate proportions without looking at the field.

The task for age group 2 (age 11-13**)**

The students measure the external dimensions of the field and, based on the obtained results, should calculate how many square meters are needed for constructing one area and how many for constructing a complex of four fields.

The task for age group 3 (age 14-16**)**

Discussion! What is friction? What does the force of friction depend on? On which terrain is tennis played faster: grass, soil, concrete (hard surface playgrounds) or synthetics? Analysis!

References:

- https://en.wikipedia.org/wiki/Tennis
- https://mon.gov.mk/stored/document/standardi-USVOENI.pdf
- William J. Baker (1988). "Sports in the Western World". p. 182. University of Illinois Press,
- ^ *"tennis | Rules, History, Prominent Players, & Facts | Britannica"*. *www.britannica.com. Retrieved 19 October 2022.*
- https://en.wikipedia.org/wiki/List_of_racket_sports

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