June 2023



# PROBLEM-BASED LEARNING: DIDACTICAL AID IN THE EXAMPLE OF TEACHING "MASS, WEIGHT AND GRAVITY" IN A STEAM APPROACH



Co-funded by the Erasmus+ Programme of the European Union



### PROJECT

PROJECT ACRONYM	STEAMTeach
PROJECT TITLE	STEAM Education for Teaching Professionalism
PROJECT REFERENCE	2020-1-ES01-KA201-082102
START DATE	1 <sup>st</sup> October 2020
KEY ACTION	Cooperation for innovation and the exchange of good practices
ACTION TYPE	Strategic Partnerships for school education

The European Commission's support for the production of this publication does not constitute an endorsement of the contents, which reflect the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.





## **Problem-Based Learning**

# Didactical Aid in the example of teaching "Mass, weight and gravity" in a STEAM Approach

Author Csilla Fülöp, Ph.D.

STEAM areas physics, mathematics, languages, technology, history, IT, integrated science, biology, health studies, astronomy, metrology, engineering, PE, astronautics

#### Summary

Subject	Physics
Topic	Mass, weight, gravity
Age of students	14–19-year-old
Project time	7 x 45 classes (for 8-12 students)
Number of participants	3-30 (preferably 8-12) students
Online teaching material	The links are all listed in the related content of the programme
Offline teaching material	All are listed in the related content
21st century skills	<ul><li>Innovation</li><li>Creativity</li></ul>





- Problem solving
- Active learning
- Critical thinking
- Decision making
- Improving skills in presentation
- Evaluating content
- Discussion

Learning The students can get familiar with the latest results in physics:

#### objectives

- Classical mechanics
- Modern physics
- Contemporary research projects and results

They take great advantage of the use of classical secondary physics

#### **Project Plan**

Name activity of Mass, weight, gravity

activity

	Procedure	Time
8	What is the history of the topic?	1 <sup>st</sup> class
	Who are the researchers of the topic?	
Questioning	Are there any scientists in our nation?	
	What is the main idea of the topic?	
	Can we observe gravitational and inertial phenomena?	
	What is the connection between simulation and real-life phenomena?	
	What do we already know about the topic?	1 <sup>st</sup> class
	What subtopics can be the focus of our interest?	





#### Brainstorming

Prepare	What topics do we revisit? What topics do we investigate? What online/offline information can we use? What tools do we need?	2 <sup>nd</sup> class
Predict	There are some in situ experiments we can make or do. We can learn about proven science and the cutting edge of contemporary science investigations.	2 <sup>nd</sup> class
Plan	<ul> <li>What content can we learn?</li> <li>How can we find relations to our everyday life and experience?</li> <li>Can we make any product like <ul> <li>In-situ experiments</li> <li>A collection of online materials</li> <li>An artistic interpretation of what we have learned</li> <li>Any crafts</li> <li>Demonstration</li> </ul> </li> <li>Investigating the aspects of the appointed topic on a wide range of scales.</li> </ul>	2 <sup>nd</sup> class 3 <sup>rd</sup> & 4 <sup>th</sup> class
Explore Cont Record	Record what material you met. Evaluate them. Suggest for others interested in the topic.	3 <sup>rd</sup> & 4 <sup>th</sup> class



This project has been co-funded by the Erasmus+ programme of the European Union under grant no. 2020-1-ES01-KA201-082102.

3



Also record if you found them useful or not.

Note why.



Some areas that can be great examples:

5<sup>th</sup> & 6<sup>th</sup> class

#### Area 1. History

Demonstrate

Some students find understanding concepts easier when familiar with the historical background. It is worth it for all to find out what questions arose and when, how scientists made efforts to figure out science. Main steps of science at the international level:

- Aristotle
- o Newton
- Cavendish
- Eötvös
- Einstein
- the SI system, standards
- the LIGO experiment

#### Area 2. Basic notions in science

There are some basic notions that appear in most secondary curricula, yet very important in our topic.

We should study or revise these:

- a) secondary level
  - o Mass
  - o Density
  - Force
  - Weight
  - Gravity
  - Weightlessness
  - Types of fields: homogenous and radial



Co-funded by the Erasmus+ Programme of the European Union





- Pendulum
- **b**) applied level
  - o Inertia
  - Particle physics
  - The standard model
  - The higgs boson
  - Error propagation
  - Pendula
  - Gravito-magnetism

#### Area 3. Mathematics in use

The great book of nature is written in mathematical language.' wrote Galileo Galilei We still believe that mathematical relationships reflect real aspects of the physical world. Science declares we live in an ordered Universe, and also that it is a subject to mathematics.

- o scalars and vectors
- o solving equations
- o calculating the volume and surface
- o inverse square laws
- o direct proportionality
- algebra with the normal form of numbers
- maxima and minima of functions

#### Area 4. "In-situ" experiments

- o making a cylinder
- o making a sphere
- demonstrating the curved space-time
- o mathematical pendulum
- the Párkányi machine



Co-funded by the Erasmus+ Programme of the European Union



- use of PC to measure gravitational field strength
- tearing a thread with a mass slowly or rapidly

#### Area 5. IT

- searching for and evaluating materials
- o making a list of recommended materials

#### Area 6. Artistic creativity in action

0	jewellery set
0	poems
0	essays
	• •

- o jokes
- fashion

$\leftarrow$	What material was useless for you? Why?	$5^{th} \& 6^{th}$
	What did you learn?	class
Reflect	What did you find interesting?	
	What ideas were reinforced?	
	What ideas had been overridden?	
	Present the result of your investigation. It can be	$5^{th} \& 6^{th}$
	o a game,	class
	• an artistic activity,	
Presentation	• a presentation,	
	• a crossword,	
	• an experiment,	
	• a video, etc.	







· .	• ppt	$5^{th}$ & $6^{th}$
	• video	class
Product	• hand-out	
Tioduct	• poem	
	• essay	
( Ç	Overview of the notions and methods that we used.	7 <sup>th</sup> class
	Evaluate them.	
Re-design	Suggest or substitute	

#### **Stations**



- measuring mass
- demonstrating inertia
- measuring weight
- demonstrating gravity
- Problems in science history
- problems and results of contemporary research
- astronomy and physics
- engineering and physics
- metrology

We highlight active pedagogy, and promote hands-on, minds-on didactics also in problem-based learning.

There are a number of possible solutions also in this very field, like

IT-related

#### Others

• PC

• Scissors

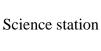
Ruler

Glue

Blank paper

- Smartphones
  - Digital camera
- Internet

This project has been co-funded by the Erasmus+ programme of the European Union under grant no. 2020-1-ES01-KA201-082102.





Research station



Technology

station

Co-funded by the Erasmus+ Programme of the European Union

7



- YouTube
- Calculator
- Plasticine
- Rubber sheet
- Heavy loads
- Small balls
- Wrap paper
- Markers
- Pendulum
- Párkányi machine

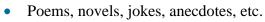


Engineering station

- Pendula
- Fishing scales
- Scales

#### Tools and materials

- Calculator
- Pc
- Internet
- Cardboard paper, ruler, pencil



- Fashion
- Jewellery
  - Farewell and retirement cards

#### Tools and materials

- Paper and pen
- Video recorder
- Plasticine
- Scissors
- Cloths, thread, buttons, etc.



- Art and Design

station



Math station	<ul> <li>Hand-out</li> <li>Maps</li> <li>Calculator</li> <li>Pc, laptop or smart phone</li> <li>Paper, markers</li> </ul>
Recording station Experiences	<ul> <li>Paper, pen or pencils (different colours)</li> <li>Digital camera</li> <li>Pc or laptop</li> <li>Smart phone</li> </ul> Students can recognize the difference and relation among the notions of mass, weight, gravity
	Students can learn about facts and models relating natural phenomena Students can reflect and show how the results and methods of science can reflect their conceptions regarding the topic
Annexes	<ul> <li>In Hungarian:</li> <li>A tömeg és a súly, mint különböző fogalmak - YouTube</li> <li>4 ProFizika A tömeg fogalma és mérése - YouTube</li> <li>6 ProFizika A gravitációs erő, a súlyerő és a tömeg - YouTube</li> <li>A Gravitáció Lenyűgöző Világa - Az Életünket Formáló Erő - [HD 720p] - YouTube</li> <li>LIGO – Wikipédia (wikipedia.org)</li> <li>Gravitációs hullámot észlelt a LIGO   WIGNER Fizikai Kutatóközpont</li> <li>Kibble-mérleg – Wikipédia (wikipedia.org)</li> <li>Itt a legújabb gravitációshullám-hegy!   csillagaszat.hu</li> <li>Mi a gravitációs hullám?   magyar felirattal - YouTube</li> <li>Dálya Gergely: Csillagászat gravitációs hullámokkal (2019.10.10.) - YouTube</li> <li>Raffai Péter: Csillagászat gravitációs hullámokkal (Atomcsill, 2017.04.06.) - YouTube</li> <li>Mik is azok a gravitációs hullámok és hogyan fedezték fel őket? - YouTube</li> <li>Frei Zsolt - A gravitációs hullámok felfedezése (Mindenki Akadémiája) - YouTube</li> </ul>



Co-funded by the Erasmus+ Programme of the European Union





- veto\_b.pdf (elte.hu)

#### In English:

- What is Mass? (eschooltoday.com)
- Your Weight on Other Worlds | Exploratorium
- Are Mass and Weight the same thing? | Physics | Don't Memorise - YouTube
- <u>What is Gravity? | Physics | Gravitation | Don't Memorise -</u> <u>YouTube</u>
- Mass and weight clarification (video) | Khan Academy
- <u>Mass vs Weight</u> The Difference Between Mass and Weight (sciencenotes.org)
- Why Are Astronauts Weightless? YouTube
- <u>RIP 'Grand K' YouTube</u>
- Gravity Wikipedia
- LIGO Lab | Caltech | MIT
- <u>The Kilogram Is Dead. Long Live the Kilogram! The New York</u> <u>Times (nytimes.com)</u>
- Kibble Balance I How we re-defined Kg? YouTube
- Gravitational wave Wikipedia
- <u>What Is a Gravitational Wave?</u> | NASA Space Place NASA Science for Kids
- Sources and Types of Gravitational Waves | LIGO Lab | Caltech
- Mi a gravitációs hullám? | magyar felirattal YouTube
- <u>b\_veto.pdf (elte.hu)</u>

+ many pictures, videos from the internet



