Galileo XR: Finding the forgotten scientist

Key elements

Overview	
Subject	*Information and Communication* *Physics* *Technology (including ICT)*
Topic	Application of the scientific method in the discovery of physical phenomena with micro:bit programming, experiments and deciphering
Age of students	7 - 9
Preparation time	2 h
Teaching time	6 h in total (2-3 h for workstation activities + 3 h for presentation preparation, presenting, and evaluation) – group activity [1]
Online and offline teaching material	Student age 7 – 9 activities materials **Individual links to the specific material and instructions can be found in the detailed activities and work process description tables below.*

Aim of the learning scenario activities

● Improve students programming knowledge - create computer programs for the micro:bit (visual programming in MakeCode micro:bit editor or code programming in micro:bit Python editor) while using basic programming concepts: variables, loops, conditional statements, and I/O operations.

● Develop and apply computational thinking, critical thinking and problem-solving methods.

● Develop information literacy by getting to know Caesar's cipher and using it for clue decryption.

● Revise and extend students knowledge on the fundamental physical phenomena in everyday life.

● Get acquainted with the universally applicable scientific method of Galileo Galilei.

● Conduct experiments to learn and understand the working principles of sensor devices, hidden in smartphones, modern cars and other indispensable technology in today's society.

● Develop communication and social skills by working in teams and presenting their conclusions to an audience.

Trends

Project-Based Learning: students get fact-based tasks, problems to solve and they work in groups. This kind of learning usually transcends traditional subjects.

Collaborative Learning: a strong focus on group work.

STEM Learning: Increased focus on Science, Technology, Engineering, Mathematics subjects in the curriculum.

Game Based Learning & Gamification: learning is mixed with games or with game mechanisms.

Student Centered Learning: students and their needs are at the centre of the learning process.

Peer Learning: students learn from peers and give each other feedback.

Assessment: the focus of assessments is shifting from "what you know" to "what you can do."

Edutainment: playful learning. Learning while having fun.

Augmented Reality: by pointing devices like smartphones and tablets to objects of reality you receive extra information.

Cloud Based Learning: data, tools, software is all online and can be reached and modified from different devices.

21st century skills

LEARNING & INNOVATION SKILLS

- Creativity and Innovation
- Critical Thinking and Problem Solving
- Communication
- Collaboration

INFORMATION, MEDIA & TECHNOLOGY SKILLS

- Information Literacy
- Media Literacy
- ICT (Information, Communications, and Technology) Literacy

LIFE & CAREER SKILLS

- Flexibility and Adaptability
- Initiative and Self-Direction
- Social and Cross-Cultural Skills
- Productivity and Accountability

Galileo XR: Finding the forgotten scientist – official project presentational video

To get an insight into all of the activities that the students need to carry out, watch the official project presentational video available at this link.

Teachers' instructions – necessary materials for classroom and workstations setup	
15 micro:bits	● 6 micro:bits (transmitters; beacons) - hidden in the classroom/school/school yard, transmitting radio signal to the specific radio group (micro:bit receiver) ● 6 micro:bits (receivers; trackers) - one per team; students' read the signal strength and search for the signal transmitter (like a treasure hunt) ● 3 additional micro:bits - two for radio connection experiment (workstation #4), and one for the sound experiment (workstation #5) - micro:bit V1 with the microphone module or micro:bit V2 with integrated microphone For further information about the difference between micro:bit V1 and V2 follow this link.
Micro:bit transmitter and receiver programs	Teacher uploads programs (find them in this Teacher material folder) and prepares the micro:bits for the treasure hunt (students are looking for the information about their workstation and instructions for conducting the task). There are also two additional micro:bits that needs to be pre-programed for experiment on station #4, so you'll find necessary programs in the same folder with the detailed instruction available here.
1 smartphone / tablet device with camera, internet access and installed Metaverse app per team	Teacher prepares tablets – downloads and installs Android, iOS or APK on each device - for treasure hunt (or micro:bit programming on a specific workstation to conduct an experiment). *Important note:* If the school does not have tablet devices, the teacher can use the BYOD (Bring Your Own Device) principle and help students install the Metaverse app on one smartphone/tablet of one member of each team.
6 QR codes for Metaverse XR app	Print and (if possible) laminate the Metaverse QR codes available in this folder and place them nearby hidden micro:bit transmitters in the classroom / school building / school yard. *Important note:* The Metaverse app occasionally crashes, so you'll find two app versions which are accessible via QR codes in the shared materials folder. V1 in which the correctness of deciphered clues is checked within the Metaverse application itself and V2 in which the correctness of deciphered clues is checked using the external LearningApps application. See a video example of using each version of the Metaverse app at the following links: Metaverse app V1 and Metaverse app V2. You can also create your own user account in the Metaverse studio to clone and translate XR experiences. A list of each station's XR app Metaverse studio link is available here.
6 tables with 1 computer / tablet device per table	Each workstation table has one device. Internet connection for using MakeCode editor is optional. MakeCode is an HTML5 web application that's automatically cached locally (saved to your computer or device) when first viewed in your browser. After the web app has loaded you will

	have everything you need to continue working without an internet connection. Optionally, instead on the computers, students can write micro:bit programs on their smartphones, but they should have the Micro:bit application installed on them (the programs can be flashed via Bluetooth on the micro:bit). Detailed instructions how to perform that are available in students' instructions (web or text version).
Workstation ID images	Each workstation has a unique image that is shown in the Metaverse XR app, that should be printed out and placed on the workstation table so the students can identify it after they find the Metaverse QR code and start the XR app. You can find ready-to-print A4 workstation ID images document on this link.
Student instructions (offline or online version)	Each workstation needs either printed version of *Students' instructions*, or web version pre-opened on the computer or tablet on the workstation table.
Workstations measuring tables and team notes document	Print workstations measuring tables and team notes document for each workstation.
Caesar cipher	Fixed encryption offset that students will use to decipher 3 clues form Galileo's life. For more information about Caesar cipher follow this link.
Necessary materials for workstations' experiments	Detailed list of each workstations' necessary materials available on this link.
Finding Galileo	This final escape room activity is made of three steps: 1. Hangman game to assemble 2-letter clues given at the end of each workstation's XR experience 2. Final clue *EPPUR SI MUOVE* shuffler (at the end of this activity students will find link to the Genially app in which they will enter the name of the scientist) 3. Entering the name of forgotten scientist – exit from the escape room
Student participation certificates	This activity is optional. Prepare certificate for each student. You can use printing template (use this free online PDF editor to enter students names) or, if you are registered Canva user, duplicate and use this online template.
Evaluation	Activities Exit Slip (for registered Canva users – use this template to modify it, download and print) Self-evaluation, peer evaluation
Micro:bit program solutions, correct quiz answers, deciphered Metaverse clues	

* ***Micro:bit introduction document***	If your students never programmed micro:bit before, you can use this document (or this web site - to translate it in the browser, press right mouse button > select *Translate*) for this microcomputer introduction as a preparatory activity.

Work process and workstations visual overview

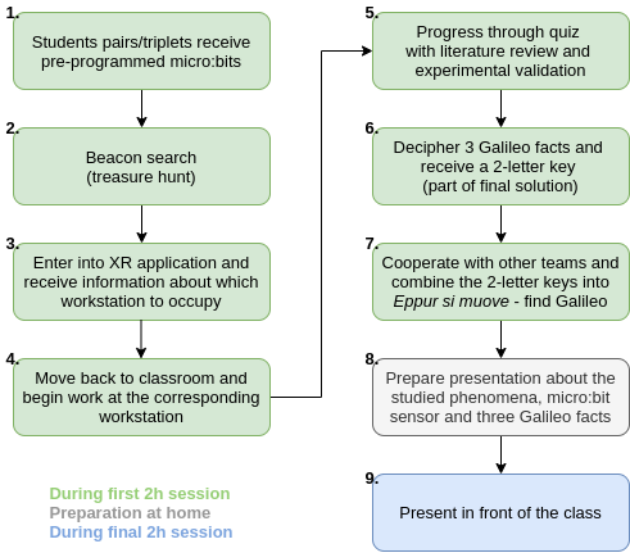

Figure 1. Workflow for the *Group activity*.

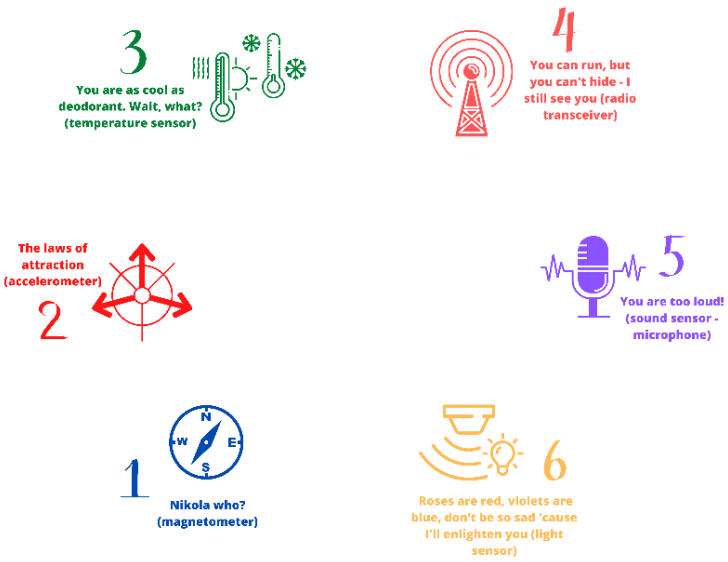

Figure 2. Workstations overview (interactive image link) – one student team per workstation

List of workstations, sensors, and necessary materials

1. **Nikola who? (magnetometer)**

a) printed or web instructions for students
b) compass
c) whiteboard magnets, different sizes
d) (optional) an electromagnet that can be switched on/off, such as a an electric motor, e.g. in a vacuum cleaner, or transformer, e.g. in a computer power supply

2. **The laws of attraction (accelerometer)**

a) printed or web instructions for students

3. **You are as cool as deodorant. Wait, what? (temperature sensor)**

a) printed or web instructions for students
b) one bottle of cheap pressurized deodorant

4. **You can run, but you can't hide - I still see you (radio communication)**

a) printed or web instructions for students
b) additional micro:bit
c) 2 paper plates
d) aluminum foil, baking paper, A4 paper

5. **You are too loud! (sound sensor - microphone)**

a) printed or web instructions for students
b) additional micro:bit (V1 with mic module or V2)

6. **Roses are red, violets are blue, don't be so sad cause I'll enlighten you (light sensor)**

a) printed or web instructions for students
b) pocket flashlight
c) red, green and blue foil (square cut to approximately 5cm x 5cm), colored glass or any other red, green or blue material that allows light to pass through (like cellophane)

Activity	Procedure	Duration
Activity introduction; student teams forming	Introduce the students with the activity – escape room *Finding the forgotten scientist.* Gather the students and briefly describe how the activity will be carried out: *The whole class will participate in an escape room in which you must find a forgotten scientist together. You will only succeed if you work together and collaboratively solve all the challenges you will encounter. First, we will form 6 student teams. Each team will receive one micro:bit (if the students have not yet had the opportunity to use this microcomputer, show it to them and briefly explain what it is and what it is for, while omitting unnecessary details for students of the younger age group) and the treasure hunt will begin. More lights on your micro:bit will light up the closer you get to the hidden micro:bit that is transmitting a signal, letting you know you're close to it. Once you've found your transmitter, you'll see a QR code next to it. Scan the QR code with your smartphone / tablet and the Metaverse app (show students how to do this) and follow the instructions that will bring you to one of these workstations where tasks and challenges await you. The Metaverse app contains a knowledge quiz and clues from the life of a forgotten scientist that you will have to decipher (if necessary, prepare the students for deciphering Caesar's code before implementing the escape room activity). On your workstation, you will have to create a program for your micro:bit according to the instructions and conduct an experiment. You will also write down the results of the measurements and the deciphered clues on a special document that contains tables and is located on the desk of your workstation. Keep it well, because based on all the records, you will prepare a team presentation to familiarize the other teams with the tasks at your workstation. When your team collects all the data and decipher all the workstation clues, you will gather and based on these clues, guess who the forgotten scientist could be. In doing so, you can use the Internet search engine and collaborate with each other between teams to exchange ideas. When you're ready, you'll gain access to apps to confirm your guess as to who the forgotten scientist is and complete the escape room.* After introduction, divide students in 6 teams (3 members per team, if plausible, for best work results and equal participation of each member). Each student team chooses its team name. Make sure to leave extra time for students' questions.	30'
Micro:bit & QR code treasure hunt	Each student team picks one of the pre-programed micro:bits (radio signal receivers) and start a treasure hunt.	15'
Workstation's activities	After finding the corresponding transmitter (beacon) and Metaverse app QR code, students scan the code with the Metaverse app on their smartphone/tablet and discover what workstation to occupy. They will recognize it from the workstation ID image given in the XR app and find	90' – 120' (depending on the age and

	it on the workstation table in the classroom. When settled on the workstation, students read instructions (printed or web version). 1. Getting acquainted with the micro:bit sensor. 2. Making the program and uploading it on the micro:bit. 3. Getting acquainted with the physical phenomena and conducting the experiment. 4. Making notes, answering the quiz questions, and deciphering the clues.	abilities of the students)
Finding Galileo	Student teams gather to revise and discuss deciphered clues. Instruct them to use the Internet for more information about each deciphered clue. The teacher provides them links to web resources to find Galileo (it can be displayed on the screen and visible, so the whole class could see it), and they can confirm their "who is the forgotten scientist" assumption.	45'
Dissemination activities - team presentation preparing	After finding the final solution - Galileo Galilei, students collaborate on creating a joint presentation in which each team will present their work (the physical phenomena, the micro:bit sensor they used, and the measurement results, as well as explain which three clues they discovered in the AR application and how they are connected to Galileo); students can carry out this dissemination activity in several ways (depending on student age and abilities): 1. oral presentation - each team prepares one segment of the presentation and presents it to the other teams (most suitable for the youngest students who do not yet have developed digital competencies or are not skilled in creating digital content but still affects the development of communication and presentation skills as well as organizational skills and time management) 2. digital presentation - each team creates its own digital presentation in an application or web tool of its choice and presents it to the other teams (development of digital competencies and creation of digital content, social, communication, and presentation skills, as well as time management and organizational skills) 3. collaborative creation of one presentation by all teams in a virtual environment - on a cloud service (like MS Office PowerPoint, Google Slides, Canva, Genially, etc.); each team presents their part of the presentation (development of digital competencies and creation of digital content, collaboration, and communication in virtual communities and environments, social, communication and presentation skills, as well as time management and organizational skills). To create their digital presentation, students use search filters available on web search engines to find Creative Commons licensed images or Public domain images, they can use free image repositories (Wikimedia	90'

	Commons, Pixabay, Unsplash, Pexels, Freepik etc.) giving credit to the author, or they can use various web tools to create their own images. Also, there are numerous free AI text-to-image generators (DeepAI, Canva, HotPot AI Image Generator, NightCaffe AI Art Generator, Replicate text-to-image collection) - as images are generated using artificial intelligence (synthetic media) based on text entered by a human, copyright belongs to the person who entered the description based on which the image content was created.	
Presenting in front of the class	Students present in front of the class.	30’
Evaluation	**Evaluation of activities** - through a conversation (discussion) with the teacher or writing (essay, evaluation sheet, online (Mentimeter, Google Forms, MS Forms, Padlet etc.) or offline). Students evaluate the activities (what they like and why, what they didn't like and why, and their suggestions for improvement). **Self-evaluation** - after the implementation of all activities, students access the self-evaluation process, in which they reflect on their own involvement in the activities (personal engagement in participation in both workstations and presentation activities) **Peer evaluation:** 1) students evaluate members of their own team for participation in activities at workstations and presentation activities (constructive comments about what was good and what they are proud of as a team, what should be improved and how) 2) evaluation of presentations by other teams - emphasis on constructive criticism (what they like and why, what should be improved and how).	30’
Ideas and suggestions for implementing further activities	Students can disseminate the results of activities at the school level (to other students and teachers), parents, but also to the wider local community through the organization of a forum, science festival or a round table. After carrying out the activity, students can create various digital content (posters, infographics and other multimedia content such as websites, videos, chatbots, quizzes, animations or video games - check this website for web 2.0 tool resources and links) about the physical phenomena they experimented with through the activities, and/or about Galileo Galilei himself.	/

	Students can also research, find and present some other "forgotten" scientists or they can design an escape room themselves, working independently or in a team. Based on the clues from Galileo's life and further research about his life, students can create: - Galileo's Fakebook with main events from his life: https://www.classtools.net/FB/home-page - Galileo's picture badge with text: https://www.classtools.net/badgemaker/ - animated 3D timeline with main events from Galileo's life: https://www.classtools.net/timeliner/ - newsflash for events from Galileo's life: https://www.classtools.net/breakingnews/ - a fictional SMS chat with Galileo: https://www.classtools.net/SMS/ - draw Galileo and revive him by moving your body: https://www.scroobly.com/ In this way, students, instead of merely consuming digital content, become its creators, while developing numerous skills and competencies important for the 21st century (digital competencies, soft skills, and the 4C's - critical thinking, communication, collaboration, and creativity).	