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Project Acronym: PAFSE

Project title: Partnerships for Science Education

EDUCATIONAL SCENARIO

THE MATHEMATICAL MODELING OF AN EPIDEMIC AND THE IMPORTANCE OF NON-PHARMACEUTICAL INTERVENTIONS

(For Middle School classes – English version)

University of Ioannina

earth LAB – Educational Approaches to Virtual Reality Technologies

AUGUST 2023

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grantagreement No 101006468.

Scenario Title: The mathematical modeling of an epidemic and the importance of non-pharmaceutical interventions **(**Middle school / Junior high school version)

Main partner responsible

The Educational Approaches to Virtual Reality Lab (EARTH Lab), Department of Primary Education, University of Ioannina, Ioannina, Greece

Overview

This educational scenario focuses on the mathematical modeling of an epidemic - the SIR modeling in particular - and the importance of non-pharmaceutical interventions for the promotion of public health. Students are initially introduced to the distinction between communicable and non-communicable diseases and express their conceptions about the function and importance of certain non-pharmaceutical interventions. Afterwards, they are concerned with various transmission routes and the way they affect the needed interventions. Through interactive maps and timelines students study the spatial and temporal evolution of endemic, epidemic and pandemic diseases in the past twenty years. Then, students are involved in successive inquiry processes, with a lot of scaffolding at answering the assigned questions at the beginning, but with complete independence in the end. During their inquiries students use three SIR simulations from the simplest to the more realistic one, and they study questions concerning the effect of epidemiological parameters (e.g. infectivity, incubation period, mortality, asymptomatics percentage), societal structure (existence of central locations, travelling and transport, healthcare system capacity) and non-pharmaceutical interventions (social distancing, quarantining, mask use, distance education) on the epidemic curve. Students, then, work in small groups and carry out a school project with three options. The first option is the design of a viable plan for the management of an epidemic outbreak by using the SIR models and authentic epidemic data. The second option concerns the input of authentic COVID-19 data to the SIR models and the comparison between the model outcomes and the real COVID-19 values. The third option is the development of a short-scale informative material targeting the general public, regarding the importance of applying non-pharmaceutical interventions during an epidemic. Student groups present their work and findings to one another and discuss about them.

Scientific content and its relevance to Public Health Education

- SIR modeling as a quite common way of describing an epidemic and as a case of a model used in authentic scientific research.
- Visualization and active inquiry of epidemiological parameters such as cases, deaths, asymptomatic cases, infectivity, healthcare system capacity and the epidemic curve, which are commonly referred to in the public sphere, during an epidemic.
- Education on the decisive importance of non-pharmaceutical interventions during an epidemic, for helping the healthcare system, and for the prevention of the spread of communicable diseases in general, as well.
- Education on the enactment of non-pharmaceutical interventions and hygiene measures as a means of prevention of future epidemic outbreaks.
- Understanding of the decisive importance personal behavior has for the public benefit during an epidemic.
- Familiarization with cases of recent endemics, epidemic, and pandemics and, consequently, with the still constant problem of emerging and re-emerging infectious diseases.

Estimated duration & relevant subjects

12 teaching hours (extended version of the scenario) organized in continuous two-hour periods if possible.
6 teaching hours (short version of the scenario).
Designed for Biology, Science or Mathematics classes of middle school (junior high school) grades (K7-9 grades). The scenario might also be applicable for Computer Science or Technology classes.
The Biology (or Science, or Mathematics, or Computer Science) teacher could cooperate with the English language teacher in order to combine Science Learning with English Language Instruction, according to the Content and Language integrated learning (CLIL). In this way both scientific literacy and English fluency are promoted. The learning sequence is appropriate for this method since all the DLOs and SERs are available in English.

STEM Content

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- Fundamental concepts of biomedical sciences (e.g. communicable diseases, infectivity, epidemic).
- Function, use and nature of scientific models.
- Introduction to transdisciplinary issues, such as scientific modeling – Convergence of sciences (natural sciences, medical sciences, mathematics, computer science) and technology towards handling complex problems.
- Use and interpretation of mathematics (numerical data, indices, variables, graphs) in natural and health sciences (scientific and health numeracy).
- Scientific work on authentic problems and data.
- Authentic scientific data driven decision making.
- Critical understanding and appraisal of medical issues in the public sphere (e.g. descriptive measures of an epidemic, application of non-pharmaceutical interventions during an epidemic outbreak).
- Creation of positive attitude towards scientific research and progress.

Non STEM Content: *Importance of personal civic actions for public benefit, importance of scientific work for civic decision making.*

Content glossary

Airborne disease: A communicable disease is characterized as airborne if it is transmitted through the air, mainly via tiny droplets produced by exhaling, talking, sneezing and coughing. These droplets come into a person mainly through inhaling. Some examples of airborne diseases are influenza, common cold, the COVID-19 and measles.

Asymptomatic cases: Asymptomatic cases of the disease are called the cases that although infected by a disease they do not show visible disease symptoms. Without biomedical tests they do not know if they are infected, whereas they can often transmit the disease.

Case fatality: Case fatality is the probability one has to die because of a disease in a given population, given that one has been infected by the disease (conditional probability). Supposing an epidemic has infected 50 people in a population of 1000 people, and 20 of them die. The case fatality rate is 20/50 = 40%. Case fatality depends on the pathogen attributes, the disease infectivity, the underlying health condition of the citizens, vaccination, and the healthcare system.

Communicable/infectious/contagious disease: Communicable diseases are the diseases (which are in turn the harmful unnatural conditions for the human organism) which can be transmitted from one person to another. Communicable diseases are mainly caused by pathogens, such as bacteria, viruses, fungi and protozoa (they can be rarely caused by infectious particles, as in the case of Creutzfeldt-Jakob disease). Disease transmission can be direct (through human intercourse) or indirect (e.g., through insects or infected objects). Some examples of communicable diseases are influenza, chickenpox, malaria and the Ebola disease. On the other hand, there are non-communicable diseases, such as diabetes, phenylketonuria and Alzheimer's disease.

Endemic disease: A disease is called endemic when it has constant presence in a region or in a population and it stays within the usual number of cases. For instance, chickenpox, rubella and measles are considered endemic in Europe.

Epidemic curve: Epidemic curve is the graphical representation depicting the cases of a disease as a function over time during an epidemic outbreak.

Epidemic/epidemic outbreak: Epidemic or epidemic outbreak is called the sudden and unexpected rise in the cases of a communicable disease within a population in a short period. The term is sometimes used for non-communicable diseases as well (e.g., obesity epidemic). Epidemic often refers to a restricted geographic region. Some recent cases are multiple Ebola epidemics in central Africa, the 2015-2016 Zika epidemic in Latin America and the 2015 MERS epidemic in South Korea.

Healthcare system capacity: Healthcare system capacity refers to the maximum limit of patients of a certain disease who can be hospitalised, or supported in general, by the healthcare system of a region.

Incubation period: Incubation period is the time from the time of infection by a pathogen until the time of the first symptoms appearing. It is the period when the pathogen multiplies within the human body until the

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pathogen population, or its actions cause symptoms. A person may or may not transmit the disease during the incubation period, depending on the disease.

Infectivity: Infectivity is the ability of a pathogen to cause infection to a susceptible person given that they have come in contact with an infected person. Infectivity depends on the biological characteristics of the pathogen, health condition of the susceptible person and vaccination.

Mortality: Mortality is the probability one has to die because of a disease in a given population. Supposing an epidemic has infected 50 people in a population of 1000 people, and 20 of them die. The mortality rate is 20/1000 = 2%. Mortality depends on the pathogen attributes, the disease infectivity, the underlying health condition of the citizens, vaccination, the healthcare system, and the frequency, or rareness, of the disease in the population.

Non-pharmaceutical interventions: As non-pharmaceutical interventions are regarded all actions which can be applied to limit the spread of a disease without including pharmaceutics, like vaccines. Common non-pharmaceutical interventions include quarantining, hygiene rules, use of masks, gloves and condoms, object disinfection and insect killing.

Pandemic: Pandemic is the case of an epidemic that has spread to a great number of countries, or even continents. It usually includes a high number of cases. Resent pandemic examples include the COVID-19 and the H1N1 influenza.

Qualitative variable: A variable is called qualitative when its values are not numerical. Gender is a typical example of a qualitative variable.

Quantitative variable: A variable is called quantitative when its values are numerical. It might take all the possible values between two limits (constant variable) or it might take only certain values (discrete variable). Height is a typical example of a quantitative variable.

Quarantine: Quarantine is the limitation of the contacts of people who are considered to be infected and aims at the slowing down of the spread of the disease.

Scientific model: A Scientific model is the representation of a natural or social structure, phenomenon or process that some characteristics of the original are included in the model whereas some others are omitted. A model is less complex than the original structure, phenomenon or process, but has significant scientific or educational value. It is common for scientific models to incorporate some kind of mathematical formulation of the original. Well-known examples of scientific models are the atom models, the meteorological models and epidemiological models.

SIR (Susceptible, Infected, Recovered) modeling: SIR modeling is a very common mathematical description of an epidemic outbreak with significant predictive value. In SIR modeling the population is divided into susceptible (people who have not been infected), infected and recovered (people who have been infected and recovered). Dead are usually incorporated to number of the recovered. Some important conventions of the SIR model is that the population is usually considered to be stable, that all people have the same probabilities of infection and, sometimes, death, that the disease attributes (e.g. infectivity, disease duration, etc.) are considered the same for all the susceptible people of the population, and that recovered people cannot catch the disease again. The values of these three variables change over time, according to appropriate mathematical functions, and their values stand for the epidemic situation. SIR models often include a graph depicting the S, I and R variables over time.

Social distance: By the term social distance we refer to a group of non-pharmaceutical interventions and measures taken for slowing or hindering the spread of a communicable disease. Social distance includes interventions such as keeping spatial distance, hand washing and remote working.

Transmissibility: Transmissibility is the ability of transmission of a pathogen from an infected person to a susceptible, given that they have contact. Transmissibility depends on various factors including the pathogen characteristics, the health condition of the susceptible person, vaccination and external conditions (e.g. non pharmaceutical interventions such as medical masks and social distance).

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Transmission route: Transmission route are the ways through which pathogens are transmitted from one person to another. Main transmission routes include direct transmission (through direct human intercourse, including sexual intercourse), transmission through infected objects, airborne transmission (through the air) and vector transmission (through animal vectors, like mosquitoes).

Pedagogical glossary

Assessment rubric: Assessment rubric is a strictly organized assessment system with certain assessment criteria, which is used for the precise quantitative assessment of several features of an answer or a project according to certain criteria and grading scales.

Brainstorming: Brainstorming is an instructional technique with several variations, that might take place within small groups or with the participation of the entire class. During brainstorming all students shortly express their ideas or concepts which are relevant to a given guiding question or central term. Criticism on the ideas is absent during brainstorming and its aim is the production of a lot and divergent ideas.

Collaborative learning: Collaborative learning is a teaching model that involves a set of instructional techniques, during which students cooperate and/or collaborate during the learning process, instead of the atomistic, even rival, view of students by the traditional school. Collaborative learning can boost the learning outcomes, students' interests and participations and their collaboration and communication skills.

Digital simulation: With the term educational digital simulations we mean the digital representation of functions, processes and phenomena which have an educational value, but they cannot usually be done in natural conditions at school for practical reasons. Through digital simulations their educative value remains, but the difficulties of their practical application are bypassed.

Inquiry based learning: By the term inquiry-based learning we refer to the engagement of students in learning activities during which they practice several scientific skills. Students make use of these skills in order to answer scientific questions either posed by the students themselves or by the teacher, by the handling of authentic data, either experimentally collected by themselves or be given them already collected. Some common inquiry skills include construction and use of models, carrying out experiments, data collection and organization, handling of variables, data driven conclusion making and communication about scientific topics. In structured inquiry students are given the research question to-be-answered, as well as detailed step-by-step guidance of the entire process of inquiry. In guided inquiry student are only given the research question to-be-answered and the decision-making processes about the research procedure are set up to them.

Models in science education: Models are important in science education and have various meanings. In this scenario we refer to educational scientific models, which are selective representations of the natural world. It is important for the students not to consider the model to be the same with the natural phenomenon represented.

Project based learning: Project based learning is an instructional model of active learning. It has several forms, during which students work in groups on the development of projects, often referring to authentic problems or situations approaching real life conditions. Project based learning includes the phases of project initiation, project development and project presentation.

Problem solving: The problem-based-learning approach includes students groups practicing higher thinking skills and making decisions in to analyze a given problem and propose solutions to it. At first, the problem settings are described to students along with the desirable aim, and some basic limitations. Each groups analyzes the problem and comes up with as more and as diverse solutions possible (creative thinking), and then evaluates these ideas (critical thinking) through group discussions, pros and cons comparisons, assessment according to criteria, pilot tests, tests, or other ways, and come down to a final proposed solution, as detailed as possible. After testing the proposed solution, or getting feedback on it, the group might have to repeat the steps of improve the solution.

Competences / Learning Goals

I. Knowledge (Core Concepts)

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a) Transdisciplinary concepts: Scientific modeling, graphs and mathematics in science, public health literacy.
b) Specific content concepts: Communicable diseases, epidemic, pandemic, disease transmission route, SIR (Susceptible, Infected, Recovered) model, asymptomatic carriers, non-pharmaceutical interventions, infectivity, social distance, quarantine.

II. Skills
a) General skills: Critical thinking, reflective thinking, problem solving, decision making, collaboration and communication within small groups, presentation skills.
b) Specific skills: Use of scientific models, scientific data collection, analysis and interpretation, variable distinction and handling, scientific hypotheses testing and question answering, data-driven conclusion drawing, discussing on science topics, presentation and interpretation of scientific conclusions, use of mathematics in scientific contexts, handling of educational simulations.

III. Attitudes (Affective domain)
a) Attitudes and values: Acknowledgment of the fact that communicable diseases pose a global and diachronic problem, appreciation of the vital importance of non-pharmaceutical interventions for the limitation of disease spreading, appreciation of the importance of models in scientific research, shaping of positive attitude towards science during a health crisis, roughly empathizing with scientists in terms of the complex nature of their work and the necessary decision-makings, upgrading of the position of science in students' personal value systems, comprehension of the role of discussion and disagreements within the scientific community.
b) Behaviours: Considering the concepts of disease transmission and non-pharmaceutical reasoning to daily health-related decision-making, constant application of simple non-pharmaceutical interventions (e.g. fundamental hygiene rules, face mask use, condom use) for the limitation of communicable disease spread.

Classroom organisation requirements

From the 1st until the 8th teaching hour students work in groups of two, each group working on a computer. These groups are occasionally combined to form four-member groups. From the 9th until the 12th teaching hour students form four- or five-member groups which carry out the school projects.

Prerequisite knowledge and skills

- Microbial nature of contagion of communicable diseases.
- The existence of epidemics and pandemics, e.g. through historical examples, the news or the experience of living during the COVID-19 pandemic.
- Fundamental hygiene rules as non-pharmaceutical interventions for preventing the spread of communicable diseases.
- Ability to interpret mathematical graphs.
- Ease in handling digital simulations.
- Ease in making digital presentations.
- Intermediate, or at least limited, fluency in English in case that DLOs and SERs other than the ones of the PAFSE repository are used.

School research project

Topics
A. How could an epidemic outbreak be represented in a quantitative way?
B. To what degree could a scientific model be efficient in representing precisely and confronting an epidemic?
C. How do characteristics of a communicable disease, citizen behaviour and social organization features influence the progress of an epidemic?
D. What non-pharmaceutical interventions would you choose to restrict an epidemic outbreak?

I. Research management, design and administration
Application of SIR models to propose and test public health interventions for the effective management of an epidemic outbreak.
Input of authentic data into SIR models and comparison between real data and model outputs.

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Creation of informative material highlighting the importance of non-pharmaceutical interventions for the promotion of public health.

II. Data analysis and reporting
Use of educational SIR simulations for testing how effective various public health interventions would be, by changing the simulation variables.
Input of authentic data from databases into the SIR models and comparison between model outputs and the authentic epidemiological data.
Creation of a short informative presentation for the general public, arguing for the importance of non-pharmaceutical interventions for the promotion of public health.
Preparation of a short, written report reviewing the project conclusions and presentation of the conclusion and the material produced to the rest of the class.

III. Target audience for recommendations
The rest of the class, maybe teachers and students of the entire school providing the project is presented at a school event. The parents of the students or even local authorities could also attend the event.
Some of the highest-quality informative material made by the students could be distributed to members of the local community (e.g., health structures, municipal authorities). Some of the informative material and the students' proposed action plan could be communicated via local media (printed or online press), and if the quality of the study of the model precision, or the overall project in general, is high, it could be presented in a student conference.

IV. Public debates and recommendations
Presentation of the project outcomes within a school event. If the quality of the project outcomes is high, they could be communicated through the local media, in health structures, through local governmental, municipal or educational authorities, or in student conferences.

Teacher guidance notes

- Students often underestimate the importance of non-pharmaceutical interventions (e.g. keeping on with hygiene measures, quarantine, social distancing and the use of face masks) as a way of confronting communicable disease outbreaks, and, consequently, not applying them to the degree they ought to. This phenomenon highlights a major deficiency in public health education, thus pointing out a fundamental topic of public health education.
- It is common for students to bear misconceptions concerning the nature and the function of scientific models, a common one of which is to think of the model as an exact representation of the natural phenomenon or function represented. Students often fail to make the distinction between the scientific model and the real world. For confronting such misconceptions, the use of different models of the same phenomenon is recommended as well as the notion of the limitations of each model.
- Students often have difficulties in understanding and interpreting graphs as forms of representations of natural phenomena.
- It is important to practice the ability of student teams to work independently in inquiry-based learning. Novice students may need a lot of scaffolding, but the scaffolding provided should gradually be decreased and students should be in charge of more decision making concerning their work. Different students need a different amount of scaffolding which can be provided by the teacher in the form of meaningful questions.
- Inquiry-based learning is crucial for students to practice scientific inquiry skills, apart from gaining content knowledge. These skills include proper gathering and analysis of data, formulating and testing scientific hypotheses, handling of qualitative and quantitative variables, using of scientific models, using mathematics in scientific contexts, drawing data-driven conclusions, and communicating and presenting scientific ideas.

Assessment activities

The assessment activities act complementarily to one another and aim at the close monitoring of the students' learning procedure. Some activities aim at formative and some others at summative assessment, some assess students in a quantitative and some others in a qualitative way, some aim at conceptual understandings, some at critical thinking skills, some at collaboration and communication skills and some

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others at affective domain assessment. They all contribute to having a multi-perspective view for each student. The teacher can omit or undermine some of the assessment activities if they think so. Some of the assessment actions happen as the lesson takes place without special activities done or special assessment material designed (e.g. observation of students' participation or performance at question-and-answering).

- Initial student assessment (through the first activity) concerning the function and the effectiveness of restrictive measures during an epidemic.
  Diagnostic qualitative assessment aiming at conceptual understanding and logical reasoning.
- Formative assessment of students' worksheets during the entire learning sequence.
  Formative qualitative assessment aiming at conceptual understanding and inquiry skills.
- Formative student assessment through question-and-answering techniques and through observation of student participation, collaboration and individual work.
  Formative qualitative assessment aiming at interest, participation and collaboration skills.
- Summative descriptive and quantitative assessment of the student projects outcomes and presentations according to concrete evaluation criteria (assessment rubrics).
  Summative qualitative and quantitative assessment aiming at conceptual understanding, higher thinking, inquiry, reasoning, collaboration and communication skills.
- Summative quantitative and qualitative assessment of cognitive learning objectives through a short questionnaire with close-ended questions and case studies at the end of the learning process.
  Summative quantitative and qualitative assessment aiming at conceptual understanding and logical reasoning.
- Summative quantitative assessment of students' self-referred beliefs, attitudes and behaviours through a questionnaire with Likert-scale questions at the end of the learning sequence.
  Summative quantitative assessment aiming at affective features.
- Summative quantitative and qualitative assessment of the learning procedure by the students in terms of likeability, interest, difficulty, self-fulfilment, collaboration and time management.
  Summative quantitative and qualitative assessment aiming at self-reflection.
- Reflective and metacognitive discussion with the students on the learning procedure and the final project presentations.
  Summative qualitative assessment aiming at self-reflection.

Teacher professional development actions

Teacher professional development on:
- Inquiry-based teaching and learning in accordance with the learning objective areas involved (content knowledge, inquiry skills, nature of science).
- Issues concerning the use of models in science and STEM education.
- STEM literacy aspects being promoted through the educational scenario (use of scientific models, authentic problem solving, inquiry-based learning, attitudes towards science, science within societal contexts) and the issues of scientific and health numeracy.
- Project-based teaching and learning and principles and techniques of collaborative learning
- Inquiry-based-learning contextualization of the scenario's digital learning objects (structured inquiry, guided inquiry, case study, argumentation, problem solving)'.
- Handling of the digital learning objects of the scenario.

Digital Learning Objects (DLOs)

A. DLOs created specifically for the needs of the PAFSE project

I. *'Global map of communicable diseases'*
http://photodentro.pafse.eu/handle/8586/44
Interactive global map depicting the geographical distribution of specific endemic, epidemic and pandemic diseases during the last twenty years.

II. *'Map and timeline of communicable diseases'*
http://photodentro.pafse.eu/handle/8586/34
Interactive global map and timeline depicting the spatial and temporal evolution of specific recent endemic, epidemic and pandemic diseases. Students can study the temporal variance of cases per country for different cases of diseases.

III. *'SIR model of an epidemic'*

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http://photodentro.pafse.eu/handle/8586/49
Simple SIR simulation, with emphasis on SIR graphs. Students can modify a restricted number of variables (e.g. infectiousness, social distancing, healthcare system capacity) and observe how the SIR graph changes.

IV. *'SIR model of an epidemic and non-pharmaceutical interventions'*
http://photodentro.pafse.eu/handle/8586/35
Complex SIR simulation of an airborne disease. The epidemic depiction is dynamic and variables can be modified as the epidemic goes on. The SIR graph includes curves for the dead and patients in critical condition. Apart from the graph there is also a realistic graphical representation of the citizens of a city during an epidemic. Students can handle features of the disease (e.g. infectivity, disease duration, incubation period, asymptomatic percentage, mortality), societal features (e.g. healthcare system capacity), and non-pharmaceutical interventions (e.g. quarantine, remote working, remote schooling, mask use).

B. DLOs which have been taken from online resources

V. *'SIR model of an epidemic and non-pharmaceutical interventions'*
https://prajwalsouza.github.io/Experiments/Epidemic-Simulation.html
Complex SIR simulation, including the graphical representation of people as moving spots in a box. The epidemic representation is dynamic and variables can change even during the epidemic. Students can modify various variables standing for disease features (e.g. infectivity, asymptomatic percentage, disease duration), societal organisation features (e.g. existence of central location, existence of small communities) and non-pharmaceutical interventions (e.g. quarantine, social distance, transport limitation, degree of social distancing). Digital Learning Object made by Prajwal Souza.

Supplementary Educational Resources (SERs)

I. *'Historical pandemics'*
https://www.visualcapitalist.com/history-of-pandemics-deadliest/
Infographics depicting the harshness of certain historical pandemics. Constructed by Visual Capitalist.

II. *'The meaning of the SIR modeling'*
https://www.youtube.com/watch?v=gxAaO2rsdIs
Educational YouTube video about SIR modeling from science communication channel 3Blue1Brown. The rationale behind SIR modeling and the function of an SIR model very similar to DLO VI are presented.

III. *'Spread of an airborne disease'*
https://whdh.com/coronavirus/3d-simulation-shows-how-a-single-cough-can-spread-coronavirus-through-a-grocery-store/
Video visualizing the transmission of an airborne disease in a closed place, when a person coughs.

IV. *'Face masks against the spread of airborne diseases'*
https://www.youtube.com/watch?v=xEp-Sdgl9AU
Informative YouTube video by Washington Post concerning the transmission of airborne diseases. The air flow coming out when exhaling or speaking is visualized with the aid of an infrared camera, and the importance of face masks for stopping the air flow is highlighted in the same way.

V. *'Global COVID-19 database II'*
https://covid19.csd.auth.gr/
Interactive COVID-19 database by the Aristotle University of Thessaloniki, Greece. Students can find epidemiological data, relevant social and demographic indices, and application of policy measures for a country and time period of their choice.

VI. *'E-me platform H5P tools for the school project'*
H5P tools of the e-me platform (https://e-me4all.eu/). By choosing 'e-me content' students can use the 'Course Presentation' tool to create an interactive and multimodal presentation, with texts, images, videos, short questions, etc, for the health promotion campaign.

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Teaching -learning activities

Some educational activities have been framed in dotted frames, like the following one:

These activities could be seen as optional under conditions. Even though they are parts of the educational scenario, they are not inseparable ones, and they could be omitted if the teacher thinks so, mainly due to reasons relevant to restricted teaching time, limited student competences, or low student motives. This can be done according teacher's will and the omission of some framed activities does not affect the other ones, e. g. the framed activities of the 2nd, 5th, and 6th hours can be omitted, thus the framed activities of the 1st, 3rd, and 4th hours be carried hours properly. Some of the framed activities might be used as optional activities for more 'advances' student groups that end their task earlier than the rest, or as alternative, or optional homework for students interested.

1st teaching hour – Students' conceptions concerning non-pharmaceutical interventions and different transmission routes of diseases

Learning objectives

Knowledge	Skills	Attitudes and Behaviours
➢ Distinction between communicable and non-communicable diseases ➢ Naming disease transmission routes ➢ Naming non-pharmaceutical interventions applicable to each transmission route	➢ Handling of digital simulations ➢ Data gathering ➢ Data-driven conclusion making	-

Teaching phase according to the inquiry & project based instructional model: Engagement – Externalization of students' initial conceptions – Initiation of reconstruction/completion of students' initial conceptions

- At first, students are engaged with the topic of the learning sequence by the exemplification of some historical (both old and modern) epidemics and pandemics. At this point infographics from SER I could be utilized.
- During the engagement phase, the distinction between communicable and non-communicable diseases should also be made clear through explicit examples from both categories, which are already familiar to students from their daily life. A short brainstorming could be carried out during which students mention examples of diseases and classify them as communicable and non-communicable. It is stated that the learning sequence will focus exclusively on the case of communicable diseases.
- During the phase of externalizing students' ideas, they are given some examples of non-pharmaceutical interventions (e.g., quarantine, use of face masks, social distancing, lockdowns, travelling limitations, use of condoms, disinfections and disinfestations) that have been applied as precautionary measures in real cases of epidemics and pandemics. Non-pharmaceutical interventions are emphasized because they can be applied at every case of communicable disease regardless of the biomedical progress has been made. Students express their ideas on paper about the possible way each intervention works and their estimation on how effective and realistic it would be. In order to save time, each student can be assigned just with a few interventions and not with all of them. For example, 2-3 non-pharmaceutical interventions could be provided per student, maybe different for each student. There could be a numbered list with non-pharmaceutical interventions and each student could randomly be given 3 numbers.

The activity aims to the externalization of students' conceptions in terms with the function behind the non-pharmaceutical interventions (to what extent the biological or medical grounds behind these measures is known), the estimated efficacy of the interventions (research has shown that students do not consider such interventions efficient), and the estimated applicability of the interventions (students often do not consider them applicable). It must be made

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clear that it is not an evaluation test, nor are their answers be graded, and that they should sincerely express themselves.

- Afterwards, the entire class participates in a brainstorming process mentioning different disease transmission routes. The teacher adds routes that have not been expressed (e.g., through air, respiratory droplets, water, animals, human contact, feces, insects, sexual intercourse, objects of shared use and body fluids). Then, each group is assigned to propose possible non-pharmaceutical interventions for the limitation of two transmission routes by brainstorming. The results from all teams are announced to the rest of the class and their classification in a table reveals that even if some measures are common for all routes (e.g., quarantine), the transmission route is a decisive factor determining which interventions are proper for each case (e.g. use of face masks and condoms).

During the group brainstorming, students are urged to find as many suitable non-pharmaceutical interventions they can.

2nd teaching hour – The spread of recent epidemics and pandemics

Learning objectives

Knowledge	Skills	Attitudes and Behaviours
➢ Distinction of endemics, epidemics, and pandemics ➢ Exemplification of recent epidemics and pandemics ➢ Explanation of the role of travelling in the spread of epidemics ➢ Explanation of how possible ways of the restriction of epidemics could work	➢ Map reading ➢ Handling of digital simulations	➢ Acknowledgement of the public health concern about communicable disease, even for Western countries ➢ Acknowledgement of the constant danger of disease (re)-emergence ➢ Appreciation of the importance of vaccination ➢ Awareness about geographical health disparities

Teaching phase according to the inquiry & project based instructional model: Continuation of the inquiry phase

- During this hour students try to answer questions on the temporal and spatial evolution of epidemics and pandemics. They use an interactive global map (DLO I) to study the geographical presence of 9 selected communicable diseases (endemic, epidemic and pandemic) during the last 20 years. Students choose each disease from a list, and they distinguish epidemics from pandemics according to their geographical distribution. Moreover, they recognize cases of communicable diseases that have hit Europe and the 'western world' in general, during the past twenty years and they consequently conclude that communicable diseases still pose a serious threat for public health in spite of the medical progress has been done. They also note the unequal geographical distribution of communicable diseases on the globe and draw conclusions on the areas that are more severely hit by communicable diseases, making speculations on the possible causes of this situation.

The use of DLO I could be omitted in favor of time economy or simplicity, and the relevant tasks (e.g. finding diseases that affected students' country, distinction of endemics, epidemics, and pandemics) could be answered with DLO II.

- Afterwards, students use DLO II which includes an interactive timeline with the aid of which they can watch the temporal evolution of selected communicable diseases (endemic, epidemic and pandemic) on the globe. By studying authentic epidemiological data in a visual and interactive form of representation, students understand that the same disease can reappear at different times and on distant places, thus conceptualizing what an epidemic outbreak is. They point out and note cases of disease outbreaks by using the timeline and the map, and specifically cases of outbreaks with large spatial or temporal distance, or outbreak of diseases often considered belonging to the past, are emphasized. It is shown that epidemic outbreaks are not restricted to developing countries but appear in so-called developed ones, as well.

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Measles, MERS, Zika disease and Avian Influenza might offer appropriate examples for this activity, without excluding other diseases, as well.

- The following activity focuses on the temporal evolution of diseases, with the aid of DLO II. Authentic disease case studies reveal how a disease spreads, evolving gradually to an epidemic or a pandemic. Students note how quickly a pandemic escalates and formulate hypotheses on possible factors defining whether a disease is going to cause a pandemic or stay geographically more restricted. They recognize the vital role of nowadays travelling and transporting in disease spreading and compare to the role they had in past ages. They also argue why travelling is strictly restricted during epidemics and pandemics.

COVID-19, and Swine Influenza might offer appropriate examples for this activity, without excluding other diseases, as well.

- Having studied the spread of communicable diseases students focus on ways for the restriction of disease spread. Through DLO II they study countries and areas where cases seem to get decreased. They correlate these cases either to the strict application of non-pharmaceutical interventions or the administration of mass vaccination programs. Examples of diseases that were dramatically restricted through vaccination programs introduce students to the notion of communicable disease eradication. Cases of real disease outbreaks in countries where mass vaccinations already take place are used by students in order to explain why vaccination is necessary even if the diseases do not pose a visible threat at the time. Inquiry and case studies activities are heavily based on DLOs I and II during the entire teaching hour.

Measles, Rubella, HIV infections, and COVID-19 might offer appropriate examples for this activity, without excluding other diseases, as well.

The teacher could suggest students elaborate on certain diseases in the DLO II for each activity (e.g. COVID-19, Measles, MERS, etc.), that show characteristic examples of the phenomena examined. Then, students can navigate freely to find other examples in the same and in other diseases of the DLO.

3rd teaching hour – An introduction to SIR modeling

Learning objectives

Knowledge	Skills	Attitudes and Behaviours
➢ Description of an epidemic with the SIR model. ➢ Explanation of the shape of the epidemic curve ➢ Explanation of the effect of transmissibility and infectivity of a disease on an epidemic outbreak ➢ Explanation of the effect of sociability during and epidemic outbreak ➢ Distinction between dependant and independent variables	➢ Understanding SIR graphs ➢ Hypotheses testing via variable modifying ➢ Gathering and analysis of data ➢ Data-driven conclusion making to answer research questions ➢ Matching model elements to the real world ➢ Handling of digital simulations	-

Teaching phase according to the inquiry & project based instructional model: Main inquiry

- For the following teaching hours (3rd to 6th) students use educational SIR simulations to explore through active learning research questions on the possible correlations between the relevant variables. As the learning sequence evolves, students are responsible for making more decisions concerning the inquiry process and they work more and more independently. After the first two teaching hours they change the SIR simulation they work on, moving from a simpler to the more complex and realistic ones. The SIR models they use are DLOs III, V and IV. During all inquiry processes students are trained in the distinction between dependent and independent variables and between qualitative and quantitative

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variables. They are also assigned to interpret why during each question testing all the other variables, apart from the independent ones being tested each time, should remain as constant as possible.

It is suggested to emphasize the differences between independent and dependant, and between qualitative and quantitative variables during all the inquiry activities (3rd to 6th hours), so that students are practiced in these distinctions.

- Students begin by using a rather simple SIR model (DLO III) in order to get used to this way of representing an epidemic. Students are trained to understand and interpret a SIR graph and explain what the shape of each SIR curve means. They are given some SIR graphs and they have to extract numerical data and more general conclusions about the situation of the epidemics represented, according to the curves' shapes. The shape and the meaning of the SIR graphs should be taught explicitly with numerous examples and case studies. Different SIR graphs and epidemic curves and be compared and contrasted to one another. The video SER II could be shown in order to match the real progress of an epidemic outbreak to the shape of the SIR graph in real time.

Some SIR graphs for students' practice can be taken from the DLO III environment.

- Afterwards, students use DLO III through successive inquiry processes to test how disease transmissibility and infectiousness affect the evolution of an epidemic outbreak. After estimating the outcome of the testing and reasoning about their estimations, they change the transmissibility value - keeping infectiousness constant- and describe the changes of the epidemic situation qualitatively and quantitatively, according to the graph. The dependent variables that students measure are the epidemic duration, the cumulative percentage of infected and the maximum percentage of infected cases. They repeat the inquiry steps by changing infectiousness values and keeping transmissibility constant.

The inquiry process with the DLO III is suggested to be as detailed as possible, because it is a relatively simple simulation. For instance, each inquiry procedure could include the statement of the research question, the characterization of the variables as dependant, independent, qualitative, and quantitative, the expression of the estimations for the results, the gathering of data, the extraction of conclusions, the explicit answer to the research question, and the matching to authentic life settings. Even if the points are poorly answered by some groups, the procedure is suggested to be followed –more or less- during all the inquiry activities during the following hours.

4th teaching hour – Using an SIR model to examine why it is important to 'flatten the curve'

Learning objectives

Knowledge	Skills	Attitudes and Behaviours
➢ Argumentation for the need of keeping a low number of cases during an epidemic ➢ Evaluation of the severity of an epidemic	➢ Understanding SIR graphs ➢ Discussion on scientific topics ➢ Handling of digital simulations	➢ Appreciation of non-pharmaceutical interventions for the management of an epidemic ➢ Appreciation of non-pharmaceutical interventions for the promotion of Public Health

Teaching phase according to the inquiry & project based instructional model: Main inquiry

- Students go on examining qualitatively and quantitatively the relationship between sociability and the dependent variables previously referenced. It is clarified that by the term 'sociability' we refer to extended social intercourse without precautionary measures depending on the disease transmission route. Students mention examples of 'sociability' behaviors and the correspondent precautionary interventions depending on the transmission route.
- Students continue the inquiry-based learning process by using the DLO III. They choose the healthcare capacity to be appeared on the SIR graph and explain what would happen if the infected curve exceeded the healthcare capacity limit during the epidemic. They evaluate which of the 3 epidemiological variables mentioned before is the most critical when handling an epidemic crisis and are assigned to explain where the public call for 'flattening the curve' refers to. In order to evaluate each parameter

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(epidemic duration, cumulative infected percentage and maximum infected percentage) students write down within small groups what would happen to society if each parameter intensified and how important these consequences would be.

Which consequence of an epidemic is the most important, depends on the disease and on the specific case examined. In general, it is the maximum number of infected cases, which needs to remain as low as possible, in order that the healthcare system is able to take care of the patients. Moreover the duration of the epidemic is expanded and it is more likely for more effective biomedical services (e.g. vaccines, medical treatments) to be developed against the disease.

- Students, subsequently, modify the disease severity and healthcare system capacity and note down how the epidemic impact would be affected.
- A discussion with the entire class follows concerning the inquiry that proceeded. They classify DLO III variables into independent and dependent and they explain whether each variable depends on disease biological factors, citizens' behaviour and society organization. They argue on which of these variables can get modified during an epidemic, which cannot change, and which have to have been modified before the epidemic burst out. Then, the profiles of a 'severe' and a 'light' epidemic disease are outlined based on the previous activities and students' own ideas.
- Finally, students form 4-member groups. Each group is assigned a problem of an epidemic due to a hypothetical disease (the values of transmission routes and biological parameters are given). Each group has to input the given values to the model and try to modulate the rest of the variables to proper values. According to their choices, the students propose a viable non-pharmaceutical intervention plan to the rest of the class. A discussion on the proposed plans follows.

The activity above concerning a hypothetical infectious disease is an introductory activity for the following activities focusing on decision-making as part of the effective management of an epidemic. The activity could be omitted for now if necessary, because the learning objectives of the activity are served to a larger extent during the next activities with the aid of the next digital learning objects.

5th teaching hour – Using a more complex SIR model to study how decisive non-pharmaceutical interventions are during an epidemic

Learning objectives

Knowledge	Skills	Attitudes and Behaviours
➢ Evaluation of the severity of an epidemic ➢ Argumentation for the importance of social distancing, quarantining and avoidance of travelling ➢ Distinction of dependent and independent variables ➢ Distinction of quantitative and qualitative variables	➢ Hypotheses testing via variable modifying ➢ Gathering and analysis of data ➢ Data-driven conclusion-making to answer research questions ➢ Match of model elements to the real world ➢ Discussion on scientific topics ➢ Handling of digital simulations	➢ Appreciation of the importance of non-pharmaceutical interventions ➢ Social distancing, quarantining, and avoidance of travelling during an epidemic ➢ Adoption of experimentation as a way of studying the natural world ➢ Respect of research ethics (e.g. sincere description of research actions and results)

Teaching phase according to the inquiry & project based instructional model: Application of new knowledge and skills through inquiry

- With the contribution of a more complex SIR simulation (DLO V) students continue the inquiry process for this teaching hour, by applying and expanding their attained knowledge and skills. DLO V allows the modification of much more variables, provides a visual representation of people during an epidemic, shows the epidemic progress in real time and incorporates a kind of indeterminism as the input of the same variable values does not lead to unchangeable outcomes.

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A short guide with the initial values for the simulation parameters to-be-used should be given to students for the initiation of the inquiry activity, since some parameters values differ from the default ones (e.g. asymptomatic rate). Moreover, it would be useful to have the simulation centrally shown with a projector machine, so as to guide students step-by-step in order to scaffold students with the inquiry process. It would be useful because the simulation is complex, includes several variables and the simulation is in English.

- In order to get used to the new simulation, the students firstly study the impact of some variables that they have already tested with the DLO III. The variables of the simulation are set to some given initial values and asymptomatic percentage is set to 0%. Students modify successively the infection radius (similar to infectiousness of DLO III) and infection duration parameters and note what they expect to happen. Then, they observe what happens at the two modes of representation (people vizualization and graph) and note down the variables of epidemic duration, cumulative infected percentage and maximum infected percentage.
- Furthermore, students change variables being inaccessible in the previously used DLO III, and variables representing the application of various non-pharmaceutical interventions in particular. Having as reference values the ones attained from the absence of all precautionary measures, they test how social distancing affects the epidemic spread. Half of the groups are assigned to study a disease of low infectivity (low infectious radius) and the other half of the groups study a disease of high infectious disease (high infectious radius). They organize the collected data in tables and contrast them with the reference values and with a hypothetical limit of healthcare system capacity. They note down how much the social distancing value should be, in order to be a tolerable situation in terms of Public Health.
- Afterwards, the teacher organizes the indicative results of the four cases (low infectivity/no measures, low infectivity/social distancing, high infectivity/no measures, high infectivity/social distancing) on the whiteboard. The cases are compares in pairs, and conclusions are drawn about a) the effect of infectivity on the epidemic, and b) the extent of precautionary interventions needed to be taken in each case. Students discuss what ‘social distancing’ means in real life conditions.
- As a last phase of inquiry on social distancing, students study the parameter of the degree of application of social distancing. Students change the percentage of citizens applying social distancing for the cases of a low infective or a high infective disease and draw conclusions on the importance of applying social distance interventions during an epidemic. Then, they are given certain percentages of obedience to social distancing and students have to find exactly how strict the social distancing measures have to be in each case, again for two different infectivity values. A certain maximum infected percentage representing maximum healthcare system capacity is given to students to carry out all the necessary tests.
- The teacher shows what happens if the modes ‘Quarantine’, ‘Central location’, and ‘Communities’ are chosen with the aid of a projector machine. Students make short assumptions what would happen in each case and, then, they see if they were right or wrong. They discuss why this result happens in each case, and what it could mean in authentic life settings.

A short, yet more extensive and detailed study, study on one of the three last options (Quarantine, Central Location, Communities) might be assigned in groups as homework. They should explain how the selected condition affects the epidemic and why. Moreover, they could match the selected cases in real life settings, e.g., what central locations are, how quarantine could be achieved, and how could travelling be restricted. Another option is to carry out simple tests on the simulation on their own and make comparisons of qualitative or quantitative data in order to draw conclusions.

6th teaching hour – Using an SIR model to examine parameters affecting the spread of an airborne epidemic

Learning objectives

Knowledge	Skills	Attitudes and Behaviours
➢ Evaluation of the severity of an epidemic ➢ Evaluation of the effectiveness of non-pharmaceutical interventions ➢ Description of the transmission mechanism of an	➢ Hypotheses testing via parameter modifying ➢ Data gathering and analysis ➢ Data driven conclusion making to answer research questions ➢ Match of model elements to	➢ Appreciation of non-pharmaceutical interventions for the administration of an epidemic ➢ Enforcement of non-pharmaceutical interventions during an epidemic

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airborne disease ➢ Argumentation for the use of medical masks	the real world ➢ Discussion on scientific topics ➢ Handling of digital simulations	➢ Use of medical masks ➢ Adoption of experimentation as a way of studying the natural world ➢ Respect of research ethics (e.g. sincere description of research actions and results)

Teaching phase according to the inquiry & project based instructional model: Application of new knowledge and skills through inquiry

- During the following inquiry phase, students continue the inquiry processes working more independently and being responsible for much more decision making. They make use of the last SIR model they are going to handle, which is DLO IV.
- In order to get the students familiarized with the new simulation environment, the simplest initial conditions of the simulation are selected. No precautionary intervention is chosen, the values of asymptomatic, hospitalization and mortality are set to zero, and infectivity, illness duration and incubation period are set to low values. Students observe how the pandemic evolves through the graph and the graphical representation and it is highlighted that citizens' behavior reflects a more realistic lifestyle than in the other two SIR simulations. Students locate different locations in the simulation within which citizens move (houses, workplaces, schools, parks and hospital).

The exploration of the virtual environment of the simulation could be done through direct instruction with the aid of a projector machine.

- Afterwards, students study the degree to which four non-pharmaceutical interventions (remote work, remote schooling, quarantining, using of face masks) could limit the epidemic outcome given the initial conditions mentioned before. The effectiveness of the interventions is compared to one another, and students try to interpret the differences. It is made clear that this specific SIR model simulates airborne diseases particularly, which are transmitted through the air or through respiratory droplets. To promote the comprehension and meaningful learning concerning the airborne diseases, the visualization SER III could be utilized. SER III shows how easily an airborne disease may spread, which cannot be easily understood without some kind of visualization. Students observe that the use of face masks can dramatically drop the spread of the disease. At this point SER IV could be shown, which reveals how a mask can disrupt the flow of exhalation and respiratory droplets, with the aid of an infrared camera. SERs III and IV could be projected with a projector machine and the reason of the high effectiveness of the use of medical masks could be explained in the grounds of these SERs. Students are expected reach themselves to this conclusion.
- Then, students choose hospitalization and mortality percentages in the simulation to appear and turn the relevant choices on the graph on. They explain what 'critical' and 'dead' stand for in the graph and observe the visual representation of hospitalization in the hospital building. They repeat the test of the effectiveness of the four non-pharmaceutical interventions and compare the number of deaths in each case.

The comparisons do not have to be as detailed as the previous ones.

- Students are assigned to study how asymptomatic percentage, infectivity, incubation period and disease duration affect the effectiveness of each one of the non-pharmaceutical interventions. Students are completely responsible for the test designs, and variable handling. They assess the effectiveness of each intervention, they carry out comparisons, correlate variables, extract and interpret the results. This process might need to be continued to the following hour for some student groups.

The activity, which is a series of numerous alternative options for activities, is might be optional and aiming only to 'advanced' groups, that have completed the previously assigned tasks earlier than the other student groups.

7th teaching hour – Using an SIR model to take policy decisions for a hypothetical epidemic

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Learning objectives

Knowledge	Skills	Attitudes and Behaviours
➢ Evaluation of the severity of an epidemic ➢ Evaluation of the policy measures concerning the management of an epidemic ➢ Comparison of scientific models representing the same natural phenomenon	➢ Match of model elements to the real world ➢ Discussion on scientific topics ➢ Critical thinking and decision-making ➢ Problem solving in authentic settings	➢ Appreciation of the difficulty of taking policy decisions ➢ Appreciation of the role of models in science ➢ Acknowledgement of the element of intrinsic uncertainty in science

Teaching phase according to the inquiry & project based instructional model: Application of new knowledge and skills through inquiry

- Students discuss in class about the inquiries they have made. The teacher chooses certain research questions, namely two or three. Each research question is discussed successively. For each research question, each group shortly presents the test design they applied, the results they found and the conclusions they drew. Moreover, they are urged to come up with different alternative research designs than the ones been done. The methodological options, the results and the interpretations of each group are discussed. Differences among student groups and alternate approaches or interpretations are emphasized. In this way, it is attempted to approach the complex nature of scientific study, which does not necessarily fall into unique or absolute research administrations.
- Next, each group is assigned with a problem which they have to cope with. Each group chooses variable values of an authentic communicable disease in the simulation (infectivity, mortality, incubation period etc.) and they have to design a viable series of non-pharmaceutical interventions in order to minimize the harsh effects of the epidemic. They have to reason on every decision they take, and they are urged to opt for a realistic solution avoiding extreme ones. On the contrary, they have to simulate a real epidemic management by the state, for example the enforcement of looser measures as the first cases appear, or the avoidance of adopting unnecessary measures, in order to promote the functionality of society. They have, also, to evaluate which precautionary measures will be lifted first and which last. Students are made clear that this is the first problem of such a case they cope with and that they will administrate a similar problem afterwards, much more extensively. Each group shortly presents their plan to class and hands it to the teacher, who returns it to them with comments for further improvement.

The activity is optional and it is an introduction to the research project, in fact. It could be omitted, at the moment, since it is done to a greater extent in the following activities. The time could be afforded for the more detailed study of the student inquiries and their different methodologies and approaches.

- As a closing part of the application of knowledge and skills through inquiry with SIR models, students are introduced to the notion of scientific modeling. They note down the similarities and dissimilarities the three SIR models they used have with the real world, as well as the advantages and disadvantages each model has when compared to one another. They explain in what ways an SIR model could be useful for scientists, and if an SIR model totally same to the real world could exist, or even if it would have any meaning at all. The topic is discussed in the class and students mention examples of models used in natural sciences. Moreover, it is discussed whether mathematical models are flawless and if a flawless model would ever be possible to be made. Students express themselves whether the integral uncertainty of a model cancels its predictive or even its scientific value.

The comparison of the three SIR models with one another, and with the real world are quite important for the distinction between the concepts of models and the real natural phenomena in the students' conceptualizations.

8th – 10th teaching hours - Using SIR models for policy making, model precision checking or informing the public (School project)

Learning objectives (depending on the school project selected)

Knowledge	Skills	Attitudes and Behaviours

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➢ Explanation of the function of policy measures for the administration of an epidemic ➢ Evaluation of the effectiveness of policy measures for the administration of an epidemic ➢ Explanation of the differences of scientific models from the real world ➢ Explanation of way that non-pharmaceutical interventions work ➢ Argumentation for the implementation of non-pharmaceutical interventions	➢ Hypotheses testing by using models ➢ Match of model elements to the real world ➢ Critical thinking, argumentation and decision-making ➢ Communication and collaboration ➢ Critical thinking, decision-making and problem solving ➢ Discussion on scientific topics ➢ Presentation skills for the general public	➢ Acknowledgment of the complex nature of taking policy decisions ➢ Acknowledgement of the complex nature of a real society ➢ Adoption of experimentation as a way of studying hypotheses ➢ Respect of scientific ethics (e.g. sincere description of research actions and results) ➢ Enforcement of non-pharmaceutical interventions

Teaching phase according to the inquiry & project based instructional model: Project initiation – project development

- In order to make links to the previous instructional phase, students comment in small groups, and later in the entire class, on news from the recent COVID-19 pandemic which refer to behaviours that burden public health (e.g. avoidance of spatial distancing and mask use, transportations among places, overcrowding in central locations, avoidance of quarantining). Students argue on the reasons why this kind of behaviours put a burden on public health, by using what they have already learnt.
- Students form four- or five-member groups in order to take upon their project task. They have the chance to select among three different project options that have different topics, include quite different tasks and demand different skills.
- The first project option is a problem solving activity. Each group gets a card with the biological and epidemiological features of the recent COVID-19 pandemic for a certain area in a certain period of time. Students enter the relevant data into one or more of the three SIR simulations they have used (DLOs III, IV, V) in a way they judge to be closer to reality. They are also given an upper limit of the healthcare system capacity. Each group uses the simulations complementarily, in a way that the pros of each simulation outweigh the cons of another. Students act as scientists and policy makers during an epidemic crisis, the COVID-19 in particular. They are assigned to use the simulations in order to test the outcome of the epidemic under various conditions and choose through this way a series of non-pharmaceutical interventions in the form of precautionary measures protecting public health. They have to minimize the harmful consequences of the epidemic, as well as to balance between the enforcement of strict measures and a proper function of the society. It is made clear, that the suggested plan must be as functional and viable as possible, under real circumstances. Students are urged to use the SIR models, but not to get stuck on them. The ultimate target of their plan is a real society, not a model. So, they ought to think of other interventions not included in the models, modify and specify the interventions of the simulations, and, also, take into consideration the special features and the inhomogeneous nature of a real society if possible. The teacher monitors students' work and often scaffolds students' ideas and work through appropriate questions, depending on each group's choices. The project development begins in this hour but will be continued for the following two hours. Hints, feedback, or guiding questions should be provided to students when they feel blocked or run out of ideas, specifically adapted to each student group. Students can, also, navigate in the database SER V, where they can find ideas about authentic examples of precautionary measures during the COVID-19 pandemic taken by various governments around the globe, as well as how extensive the application of each measure was. Finally, students compile a text or a diagram which refers in detail to the proposed measures, alternative measures, probable difficulties in the application of the measures, and mainly to the rationale behind each choice. A detailed worksheet in order to scaffold students that choose this project is necessary, in order to write a final report.
- The second project option is a guided inquiry activity. It is considered of higher difficulty than the other options, and it might be more appropriate for students with strong interests and tendencies in Mathematics and Science. It is concerned with the test of the compatibility of one of the three SIR

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models studied (DLOs III, IV and V) with the real evolution of the COVID-19 pandemic. Students extract the COVID-19 epidemiological data for a certain moment and from a certain area (e.g., the country or province they live in) from databases SER V. The only necessary requirement is the chosen period to be before the application of vaccinations against COVID-19 in the area, because this pharmaceutical intervention changed dramatically the pandemic outcome in a way that cannot be represented by the simulation used. Students can find information in SERs V. about the main precautionary measures that were imposed to the area of study during the period of study. They have to find the appropriate way to input the authentic data to each one of the three models by making the necessary reductions, drawing parallels between real world features and simulation parameters and making appropriate mathematical manipulations. They are assigned to compare the model outcomes to the authentic data as shown in the databases SERs V. The interpretation of the differences by each group is of high importance for this activity. A detailed worksheet in order to scaffold students that choose this project are necessary, in order to carry out the research, draw conclusion, and write a final report. They note down in detail the way they worked, including the handlings and conventions they used during the data input, the models' outcomes, the results from the comparisons and a thorough interpretation of their findings, where they are urged to incorporate as many parameters and ideas as they can think of.

The second alternative of the research project, which is the precision test of the SIR models in comparison with the authentic epidemic data, is clearly of greater difficulty it might be more appropriate for students with strong interests and tendencies in Mathematics and Science. The database SER V is available in English and Greek.

- The third project option is a science communication one, and it is more appropriate for students having less ease in Science and Mathematics. It does not focus on inquiry and experimentation skills. It focuses on general conceptual understanding and communication skills, instead. Each group is responsible for making a short informative campaign for the general public concerning behaviours which promote public health during an epidemic. Each group is given six actions taken at random from a list with non-pharmaceutical interventions (e.g., travel restrictions, quarantining, use of masks, disinfections, use of insectivores against mosquitoes). They must use resources (e.g. screenshots from the SIR simulations, or videos) to explain how each intervention work, why is important, and in what cases they can be used. Each group is tasked to make a short digital presentation with ten slides (SER VI), one for each intervention, by using the appropriate software. Students can, also, include information about recent epidemics, endemics and pandemics, as well as information and resources found on the Internet. Presentation must be concise, without scientific flaws, aesthetically pleasuring and comprehensive for the general public, explaining the scientific reasons for applying each measure, in simple words. Students recall and apply the knowledge they gained through the learning sequence and are urged to utilize all the DLOs and SERs they have used. For instance, they can use disease examples from DLOs I and II, visualizations and images, graphs and numerical data from the SIR models, always accompanied by the necessary explanations.
- During the 9th teaching hour student groups having selected the same project options briefly discuss the progress of their projects. In that way they are expected to exchange ideas concerning the choices they made, complementary options and methodologies, ideas have not thought of, difficulties they found.

The activity is suggested providing that the school class climate among student is suitable for the proper cooperation and mutual aid among students about the lesson.

- The final project outcome of the first option is an administration report or diagram. The final project outcome of the second option is a scientific report. The final project outcome is a digital presentation. The teacher has to constantly monitor students' progress and support them by helping them to come over the difficulties, asking them guiding questions, suggesting ways for improvement, and highlighting cases that students had not thought of.

11th-12th teaching hour – Presentation of the project outcomes (School project)

Learning objectives

Knowledge	Skills	Attitudes and Behaviours
-	➢ Provision of feedback and active listening	➢ Development of positive attitude towards feedback

	➢ Communication and presentation skills ➢ Reflection on the learning procedure	

Teaching phase according to the inquiry & project based instructional model: Project presentation – Final assessment – Self-reflective phase

- Each group has completed one of the three project outcomes at this point (plan for epidemic administration, report on the models' precision and informative campaign). The phase of project presentation follows, in front of the entire class.
- Each group successively presents their work and findings. Three presentation rounds are made, one for every project options. All the students of each group must take part in the presentation. Each presentation ought to be short (about 5 to 10 minutes) and a discussion among groups follows after each presentation round. Active listening, constructive criticism, interaction and respect among students are promoted during the discussion.
- After all the presentations have finished a more general discussion takes place in class concerning the subject, the learning sequence, the students' impressions and difficulties. This discussion is appropriate for question answering, conceptual clarifications and expansions depending on students' needs and interests.
- Students are given a short questionnaire with a few close-ended questions and two short case studies aiming at individual student's assessment of the cognitive learning objectives.
- The presentations and the project outcomes (two reports and one presentation) are assessed by the teacher according to criteria shared for all groups via an assessment rubric designed specifically for each outcome.

Short version of the scenario (6 teaching hours)

The initial (expanded) version of the educational scenario lasts for 12 teaching hours. Difficulties that may arise due to its long duration (e.g. alignment with the Curriculum, availability of rooms, or resources). For that reason a shorter version of the scenario of 6 teaching hours is provided, which can be opted for if the teacher thinks so. The suggested modifications to the structure of the scenario are the following ones:

Expanded version of the scenario (12 hours)	**Short version of the scenario (10 hours)**	**Modifications**
1st-2nd hours	1st hour (fusion)	Some activities from the initial two-hour session are chosen and carried out. The chosen activities are the group brainstorming on transmission routs, and the use of DLO II (not DLO I) to on the distinction of epidemics, endemics, pandemics, the rise and spread of epidemics, and the decrease of epidemics.
3rd-4th hours	2nd hour (fusion)	Some activities from the initial two-hour session are chosen and carried out. The chosen activities are the familiarization with the SIR graph, a concise study of transmissibility (not infectiousness) and sociability, and the importance of healthcare system capacity. The aims of the other activities can be covered by the rest of the scenario.
5th hour	- (omitted)	The activity is omitted since the concept of SIR is already covered, and the English language and big number of variables might confuse some students.
6th-7th hour	3rd hour (fusion)	Some activities from the initial two-hour session are chosen and carried out. The chosen activities are the familiarization with the new environment, the test and explanation of the effectiveness of mask using, and a

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		short problem solving on the administration of a disease.
8^{th}-10^{th} hours	4^{th}-5^{th} hours (fusion)	The demands of the project are decreased. Only the first and the third project options are given, since the second action needs more time. The activity of ideas exchanges is done only in a form of a short classroom discussion. The administration plan (outcome of the first option) is less detailed, and the informative presentation (outcome of the third option) is decreased in topics and slides.
11^{th}-12^{th} hours	6^{th} hour (fusion)	The project presentations are fused into a single teaching hour. The presentation time for each group is also modified. The final feedback about the lesson is done anonymously and in written, to save time.

Supplementary learning activities

I. Discussion with experts

Some discussions with experts could take place as optional educational activities, which act complementary to the educational activities previously described. They can have the form of a short presentation, a free discussion, an interview or a combination of those and they could take place in the physical presence of the expert or via teleconference. The expert might be a person whose scientific specialization or whose profession closely relates to issues that having been discussed in the classroom during the learning sequence. The students' discussion with the expert has some additive STEM educational value which is summarized with the following points:

- The experts have an advanced scientific or professional expertise, so they have deeper content knowledge and are more suitable to give students a deeper understanding of the scientific contents and answer students' advanced questions.
- Students can see how the content of the learning sequence can be reflected to real world professional specializations. In this way they connect what they learn to authentic contexts and can learn further information about the real work of STEM professionals.
- Students have the opportunity to discuss with STEM professionals, which would otherwise be probably inaccessible to them. They can learn about the real work of scientists and about the real way new scientific knowledge is produced (Nature of Scientific Inquiry).
- Experts can act as role models for some students and trigger them to follow STEM related careers in the future.
- Experts can give students some more specific guidelines or answer advanced students' questions concerning their research project.

It is suggested to have the discussions done after the general activities have been completed and before or at the beginning of the school project (more specifically around the 8^{th} or the 9^{th} teaching hour). In this way students will have a good background in order to discuss and meaningfully understand the topics discussed with the experts and can ask them questions that will help them in decision-making concerning the conduct of the school project. Of course, if the teacher thinks that the discussions are better to take place at a different time they, are free to do so.
Some scientific and professional specializations that could be cases of experts are listed below with some indicative topics for discussion:

1. Doctors or medical professionals specialized in communicable diseases – They could discuss with students about recent cases of communicable diseases, transmission routes and the importance of non-pharmaceutical interventions.
2. Epidemiologists – They could discuss with students about evolution and features of an epidemic or pandemic, the modeling of an epidemic, the epidemic curve and how to 'flatten' it.
3. Health data scientists or models creators – They could discuss with students about the importance of mathematics and model in medical science, the process of making a model, the function, the precision and the limitations of a scientific model and how models help science advance.
4. Members of public health institutions - They could discuss with students about the importance of non-pharmaceutical interventions for the prevention of spread of communicable diseases, different types of

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non-pharmaceutical interventions and the importance of everyday habits for infectious disease prevention.
5. Health communicators, specialists in health outreach – They could discuss with students about health communication during COVID-19 and about the features that an effective health communication campaign should have.
6. Academics or university professors with relevant expertise.
7. Members of the PAFSE consortium with relevant expertise.

II. Educational visits

Some educational visits could take place within the context of this learning sequence. In this way the school's educational activities will be complemented with educational activities from other organisations or with visits to authentic places where research or work on relevant topics is being done. It would be preferable to make these visits after the students have examined the relevant issues in the learning sequence so that they will be able to meaningfully conceptualize what they examine during the educational visit. A short discussion before and after the educational visit is also necessary in order to determine and summarise the context of the visit and link it to the learning sequence.
Some suggested places for educational visits are listed below:

1. Medical museum – During this visit, students could probably come across items concerning historical cases of infectious disease outbreaks, epidemics and pandemics and how the different non-pharmaceutical interventions were adopted as medical knowledge has expanded over the ages.
2. Research laboratory concerning medical data analysis or medical modeling – During this visit, students could see the actual work of medical data scientists and model developers, discuss about their work and see the convergence and collaboration of scientists from different fields (mathematics, medical science, biology, computer science etc).
3. Institution of public health promotion or policy making – During this visit, students could get informed about the importance of non-pharmaceutical interventions for the promotion of public health, about the processes that hide behind policy decision making and see informative material from past cases of infectious disease outbreaks, epidemics and pandemics.
4. Institution for health awareness, promotion or education – During this visit, students could take part in educational activities concerning infectious disease transmission routes, disease prevention, non-pharmaceutical interventions and maintenance of hygiene rules.

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Assessment Questionnaire: Knowledge, Skills, Beliefs, Attitudes and Behaviors

Scenario topic: “The mathematical representation of an epidemic: the case of SIR (Susceptible, Infectious, or Recovered) modeling”

A. I. Knowledge	
1. Distinguishes communicable from non-communicable diseases	**Question 1.1:** Which of the following diseases is non-communicable? A) Alzheimer disease B) Influenza C) AIDS
2. Distinguishes among endemic, epidemic and pandemic diseases	**Question 2.1:** COVID-19 has been characterized as a pandemic because … A) a lot of cases have been found in many distant countries B) the disease is highly infectious and causes several deaths C) the disease is a quite new one **Question 2.2:** A disease which exists in an area and has a small number of cases each year us characterized as ... A) endemic B) epidemic C) pandemic **Question 2.3:** In 2012 a lot of measles cases were found in Greece in contrast to previous decades years during which number of cases was low. We can say that … A) measles is endemic in Greece and it had an epidemic in 2012 B) measles had a pandemic in Greece in 2012 C) measles had an epidemic in 2012 in Greece and then it became an endemic disease **Question 2.4:** If COVID-19 transforms from a pandemic into an endemic disease, this means that … A) there will be COVID-19 cases worldwide but their number is going to be small in general B) COVID-19 cases are going to appear rarely and only in a few countries C) despite COVID-19 cases are going to be a lot, deaths are only going to be few
3. Explains different transmission routes of diseases	**Question 3.1:** Communicable diseases are transferred from one person to another because … A) pathogens are transferred from one person to another B) toxic substances are transferred from one person to another C) a healthy person gets close to an infected one **Question 3.2:** A disease can be transmitted between two closely distanced people if the disease is transmitted through … A) respiratory droplets B) contact with infected objects C) insects **Question 3.3:** Which of the following does NOT describe a disease transmission route? A) Through solar radiation B) Through blood transfusion C) Through insects

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4. Exemplifies non-pharmaceutical interventions appropriate for each disease transmission route	**Question 4.1:** Which of the following measures describes a non-pharmaceutical intervention against a communicable disease? A) Use of medical gloves B) Antibiotic prescription C) Mass vaccination of the population **Question 4.2:** Which of the following daily habits is NOT a non-pharmaceutical intervention against the spread of diseases? A) a balanced diet B) The use of condoms during sexual intercourse C) Coughing into an one-use napkins
5. Explains the ways non-pharmaceutical medical interventions work	**Question 5.1:** A non pharmaceutical intervention does NOT hinder the spread of a disease by … A) curing infected people B) preventing a healthy person to catch the disease C) killing pathogen microorganisms **Question 5.2:** Which of the following interventions would be inappropriate against a disease transmitted through respiratory droplets? A) Mass killings of insects B) The use of medical face masks C) Spatial distancing among people **Question 5.3:** Which of the following intervention is suitable against every type of infectious disease? A) Quarantining of the infected B) Spatial distancing C) Disinfection of objects of communal use **Question 5.4:** What is the main advantage non-pharmaceutical medical interventions have compared to pharmaceutical interventions? A) They can be applied in diseases even if no treatment is known B) They are more economical than a lot of expensive pharmaceutical interventions C) They usually are more effective **Question 5.5:** Non-pharmaceutical interventions during an epidemic must be held … A) by everyone in order to slow down the transmission rate of the disease B) only by people in danger of severe disease in order to minimize deaths C) only by people in danger of severe disease and their close contacts in order to minimize deaths
6. Explains the importance of the epidemic curve and ways of handling it	**Question 6.1:** When referring to the 'epidemic curve' we refer to … A) the change of the number of cases over time B) the change of the number of deaths over time C) the change of the number of healthy people over time **Question 6.2:** The number of disease cases during an epidemic is crucial to remain low … A) so as the healthcare system is able to efficiently handle the patients B) so as to end the epidemic as soon as possible C) so as to restrict the overall percentage of the population been infected **Question 6.3:** The strict application of non-pharmaceutical medical interventions during an epidemic contributes to … A) the decrease of cases B) the earlier end of the epidemic C) the increase of the healthcare system capacity limit

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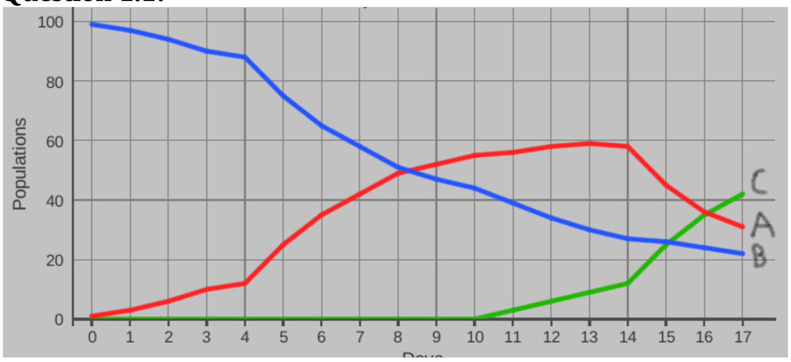
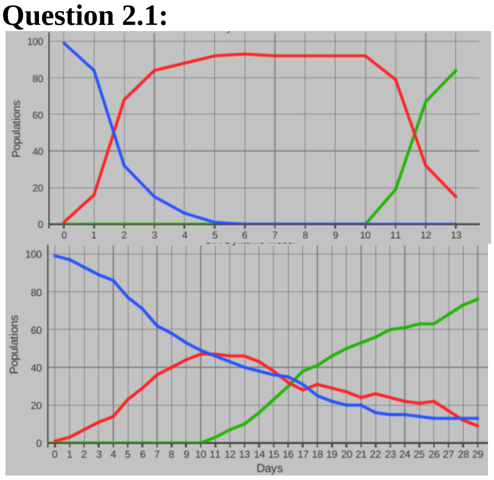
	Question 6.4: A high percentage of asymptomatic carriers of a disease … A) makes the restriction of the disease spread more difficult B) makes the restriction of the disease spread easier C) does not influence the efforts of the restriction of the disease
7. Recognises the nature of a scientific model	**Question 7.1:** A scientific model is … A) a selective representation of a natural phenomenon which can contribute to original scientific research B) a selective representation of a natural phenomenon having solely educational value C) a close replication of a natural phenomenon which might have scientific ore educational value
B. Skills	
1. Interprets graphic and numerical SIR data	**Question 1.1:**  The graph shows the evolution of an epidemic. The letters A and B stand for … A) the numbers of infectious and susceptible people respectively B) the numbers of susceptible and recovered people respectively C) the numbers of infectious and recovered people respectively **Question 1.2:** What is the shape of an epidemic curve of infectious people in an SIR graph during an epidemic? A) At first increases and then decreases B) It steadily increases C) It steadily decreases
2. Uses SIR models to interprets the evolution of an epidemic	**Question 2.1:** These two graphs depict the evolution of two epidemics in the same city. In the upper case … A) the healthcare system might have had more difficulties in dealing with the epidemic B) the epidemic would have lasted last longer C) it is likely to have been enforced stricter measures for the restriction of the disease spread

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3. Uses SIR models to make decisions concerning the handling of an epidemic	**Question 3.1:** In which of the following cases it is necessary to have more extensive or stricter precautionary interventions enforced for the restriction of the spread of the epidemic? A) In a disease having high infectivity, long duration and high percentage of asymptomatic carriers B) In a disease having high infectivity, long duration and low percentage of asymptomatic carriers C) In a disease having low infectivity, short duration and low percentage of asymptomatic carriers **Question 3.2:** Which of the following is preferable in the case of a highly infectious and severe disease in a city with low number of hospital units? A) Keeping the number of cases as low as possible B) Ending the epidemic as soon as possible C) Enforcing a small number of non-pharmaceutical interventions **Question 3.3:** If the epidemic curve starts suddenly increasing it is preferable to … A) Strengthen the precautionary measures before the epidemic curve comes to its maximum B) Strengthen the precautionary measures after the epidemic curve comes to its maximum C) Minimize the precautionary measures applied
4. Designs research plans to test hypotheses	**Question 4.1:** I want to know to what extent the use of medical masks affects the number of seasonal flu cases during an epidemic in a city. Which of the following comparisons would be more suitable to make? A) To compare the cases in a city after the application of wearing masks with the cases of another city of the same country and similar population in which the measure of masks was not imposed B) To compare the cases of flu after the application of wearing masks in a city with the flu with the number of cases in the city before the application of the measure C) To compare the flu cases after the use of medical masks in the city with the influenza cases that appeared in the same city during the H1N1 pandemic, when wearing masks was not mandatory **Question 4.2:** In order to test the effectivity of vaccination against COVID-19 it would be preferable to compare … A) data from unvaccinated and vaccinated populations which are as similar to one another as possible (e.g., in terms of gender, age, health condition) B) data from unvaccinated and vaccinated populations for which I can obtain a big load of data, even if the populations are quite dissimilar C) data from unvaccinated and vaccinated populations for other diseases (e.g., measles, influenza, polio) because they are more easily available and have been studied to much greater extent
5. Gathers and processes mathematical data	**Question 5.1:** I am able to gather and organize numerical data (e.g., put them in appropriate tables) with ease. 1) I strongly disagree … 5) I strongly agree **Question 5.2:** If I am given organized numerical data regarding a research question (e.g., how many were infected when an intervention was applied and when it was not), I am able come to a conclusion quite surely. 1) I strongly disagree … 5) I strongly agree
6. Interprets graphs (self-	**Question 6.1:** I am able to understand what an SIR graph depicts.

referred)	1) With great difficulty … 5) With great convenience **Question 6.2.:** I am able to understand if an epidemic gets better or worse by looking at an SIR graph. 1) With great difficulty … 5) With great convenience
7. Designs a plan for restricting the spread of a communicable disease	**Question 7.1:** I am able to come up with possible non-pharmaceutical interventions which could be applied in the context of an epidemic, regardless how realistic they are. 1) I strongly disagree … 5) I strongly agree **Question 7.2:** I am able to evaluate the applicability of various proposed non-pharmaceutical interventions for the handling of an epidemic and explain which of them would be applied more difficultly and why. 5) I strongly disagree … 5) I strongly agree **Question 7.3:** I am able to propose a concise plan of measures for the administration of an epidemic, which seems to be realistic, but without defining a lot of details. 1) I strongly disagree … 5) I strongly agree **Question 7.4:** I am able to propose an extensive plan of measures for the handling of an epidemic while defining a lot of details and making specializations and seeming to be quite realistic and applicable. 1) I strongly disagree … 5) I strongly agree
8. Handles digital simulations	**Question 8.1:** I am able to handle digital SIR simulations. 1) With great difficulty … 5) With great convenience
C. Beliefs, Attitudes and Behaviours	
1. Recognises the global and diachronic nature of the issue of communicable diseases	**Question 1.1:** Communicable diseases are not a primary health issue for the Western world. 1) I strongly disagree … 5) I strongly agree **Question 1.2:** Epidemics and pandemics belong mainly in the past and there is no great concern about them for the future. 1) I strongly disagree … 5) I strongly agree **Question 1.3:** International cooperations are necessary for confronting with the issues of communicable diseases. 1) I strongly disagree … 5) I strongly agree
2. Appreciates the value of non-pharmaceutical interventions for the administration of communicable diseases	**Question 2.1:** The application of precautionary measures against the spread of a disease is necessary only in urgent cases of health crises. 1) I strongly disagree … 5) I strongly agree **Question 2.2:** The application of non-pharmaceutical interventions is able to lead to the prevention of an epidemic outbreak. 1) I strongly disagree … 5) I strongly agree **Question 2.3:** Small daily habits such as proper handwashing and object disinfections can have great effect in the prevention of a disease outbreak. 1) I strongly disagree … 5) I strongly agree **Question 2.4:** The application of non-pharmaceutical interventions can contribute even to the total eradication of communicable diseases. 1) I strongly disagree … 5) I strongly agree

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3. Appreciates the value of non-pharmaceutical interventions for the effective administration of an epidemic outbreak	**Question 3.1:** The application of non-pharmaceutical medical interventions is totally necessary during an epidemic. 1) I strongly disagree … 5) I strongly agree **Question 3.2:** Non-pharmaceutical interventions are always less important than pharmaceutical interventions during an epidemic. 1) I strongly disagree … 5) I strongly agree **Question 3.3:** Non-pharmaceutical interventions are sometimes the sole mean of confronting some epidemics. 1) I strongly disagree … 5) I strongly agree **Question 3.4:** Non-pharmaceutical interventions such as quarantining, social distancing and wearing masks during an epidemic can have only small benefit for public health. 1) I strongly disagree … 5) I strongly agree **Question 3.5:** The kind of non-pharmaceutical interventions applied, and the time of their application are quite important for the outcome of an epidemic. 1) I strongly disagree … 5) I strongly agree
4. Recognises the importance of the collective application of precautionary measures during an epidemic	**Question 4.1:** In order to be effective the application of a non-pharmaceutical intervention (e.g. avoiding overcrowding, wearing masks) it must be applied by the majority of the population. 1) I strongly disagree … 5) I strongly agree **Question 4.2:** Even if a small percentage of the population does not apply the precautionary measures during an epidemic, then the effectiveness of the measures might be affected to a great extent. 1) I strongly disagree … 5) I strongly agree **Question 4.3:** The effectiveness of the health measures during an epidemic lies only upon the civic structures and not upon the citizens. 1) I strongly disagree … 5) I strongly agree **Question 4.4:** Non-pharmaceutical interventions during an epidemic (e.g., wearing masks, quarantining, avoiding overcrowding) cannot lead to a big relief of the healthcare system. 1) I strongly disagree … 5) I strongly agree
5. Shapes a positive attitude towards science for the administration of an epidemic crisis	**Question 5.1:** The management of an epidemic ought to rely on scientific data and follow the scientists' guidelines. 1) I strongly disagree … 5) I strongly agree **Question 5.2:** If scientific data and citizens' perceptions referring to the administration of an epidemic conflict, then it is preferable to follow the citizens' beliefs. 1) I strongly disagree … 5) I strongly agree **Question 5.3:** The effective administration of a health crisis can be designed solely upon scientific knowledge. 1) I strongly disagree … 5) I strongly agree **Question 5.4:** The economic and social function of a society ought to keep going during an epidemic even if it is not compatible to scientists' recommendations. 1) I strongly disagree … 5) I strongly agree
6. Recognizes the importance of scientific models for scientific research and decision making	**Question 6.1:** Models have little importance for scientific research. 1) I strongly disagree … 5) I strongly agree **Question 6.2:** Models cannot lead to making new predictions. 1) I strongly disagree … 5) I strongly agree

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	Question 6.3: Scientific models are not a trustworthy source for making civic decisions. 1) I strongly disagree … 5) I strongly agree
7. Applies precautionary personal hygiene rules for the restriction of the spread of communicable diseases	**Question 7.1:** How often do I apply urgent health measures imposed during the COVID-19 pandemic? 1) Never … 5) Always **Question 7.2:** How possible would it be to apply urgent health measures (e.g. overcrowding avoidance) during an epidemic even if this was contrary to my personal desires (e.g. for entertainment). 1) Completely impossible … 5) Completely possible **Question 7.3:** How often do I apply fundamental hygiene rules (e.g. proper handwashing, common-use objects disinfections) when no health crisis exists? 1) Never … 5) Always

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Partnerships for Science Education

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