MODULE 2 – SCIENCE FOR LIFE

ONLINE HIGH-FLIERS OPERATIONAL MANUAL FOR UNIVERSITY SCIENCE STAFF

A handbook to implement High-Fliers module 2

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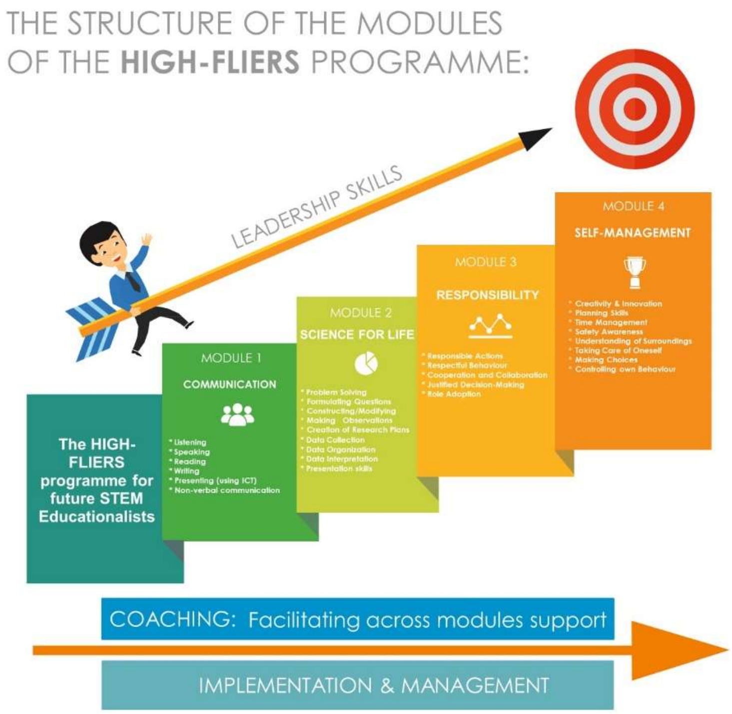

ERASMUS+ High-Fliers – Highly Interactive Guidance Helpful for Leadership in Educationally Relevant Skills

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Contents

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OBJECTIVES OF MODULE 2

After this module, students should be able to:

- Indicate a raised interest in STEM subjects and appreciate the importance of science.
- Recognise science for life as a key base for all future STEM learning.
- Recognise the transferability of science and technology within society.
- Promote the awareness of skills and conceptualisations needed for being a STEM teacher, scientist and community member.
- Create a 3-minute video identifying a scientific, or socio-scientific problem in everyday situations.

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STRUCTURE OF MODULE 2

Types of activities	Unit 1 (90 min.)	Unit 2. (90 min.)	Unit 3. (90 min.)	Unit 4. (90 min.)	End session (45 min.)
Pre-Survey	+				
Theoretical section	+	+	+	+	
Introduction of the scenario	+	+	+	+	
Work in groups	+	+	+	+	
3- minute video				+	+
Summing-up, evaluation, conclusion	+				+
Post - survey					+

Scenario setting/ Contextualization	De-contextualization	Re-contextualization
Two friends undertake a job shadow Dead sea – wonder of the world Family doctor visit	Students ask questions Students identify problems related to a scenario Students understand the difference between science and pseudoscience	Develop problem-solving and explanation skills Develop communication skills

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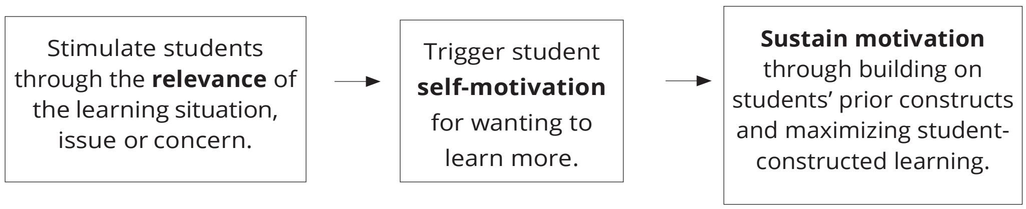
INTRODUCTION TO THE 3-STAGE MODEL

(abstracted from - The Philosophy and Approach on which the PROFILES Project is based by Jack Holbrook and Miia Rannikmäe - CEPS journal vol. 4, no. 1, 2014)

The 3-stage teaching-learning model within science education is based on the recognition that there is a need to initiate the learning from a *familiar and student relevant situation*. The diagram below illustrates how relevance is intended to trigger student's self-motivation (or intrinsic motivation) to promote student involvement in the learning. Such motivation is sustained by student involvement and also by any extrinsic motivational aspects supplied by the teacher.



Stage 1 Designing a Scenario

The use of an 'appropriate' scenario is important. Not any situation is appropriate. Research shows that students identify with specific words, or expressions and these play an important function in determining whether the modules, or the scenario, chosen is appropriate. So important is the title and scenario that, if this fails to motivation students, the module should not be used further and the teaching associated with this module abandoned. This is because relevance is a very useful precursor for developing students' personal interest and a powerful stimulus for science learning. It provides students with a desire to pursue the learning further, going beyond the scenario and into the accompanying new science learning.

The learning approach is thus 'motivation first', leading to science learning second. This contrast with the usual suggested approach - make the science itself interesting so that it will then motivate the students (but, alas, in so many cases it doesn't!!). The theoretical construct is that motivation drives the learning of science and the scenario is intended to enable students to want to get involved, even though this means learning some science. Unfortunately, standard approaches, which assume science is inherently interesting for students, if taught well, have been shown not to appeal to many students at the secondary level (Osborne et al., 2003).

Once motivation is established, the further learning is the curriculum-based conceptual science ideas, which students acquire as steps towards enhancing their scientific literacy. For the learning to be meaningful, as well as continuing to be interesting, the science learning builds on a familiar, socio-scientific scenario as shown in the flowchart.

The purpose of the scenario is to *stimulate students' interest* and to do this from a familiar and student relevant perspective. It is thus importance to persuade teachers to *make changes* to the scenario, if appropriate, to ensure such an approach.

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FAMILIAR STIMULUS (THE SCENARIO) (stage 1)

SOCIO-SCIENTIFIC SCENARIO, RELEVANT FOR STUDENTS

Students identify with the situation (*exhibit intrinsic motivation*) →

STIMULATES INTEREST AND MEANINGFUL ENGAGEMENT

Wishes to consider the situation, concern or issue; student willingness to participate.

GUIDED BY THE TEACHER, STUDENTS REFLECT ON PRIOR SCIENCE KNOWLEDGE

Communicating in a science context; illustrating extent of conceptual understanding

STUDENT-REALISED NEED FOR NEW SCIENCE KNOWLEDGE. THEN, GUIDED BY THE TEACHER, SPECIFIES SCIENTIFIC QUESTION TO INVESTIGATE

Student creative thinking; willingness to participate

Starting from a carefully worded title (intended to be familiar and of interest to the target students), the teaching progresses, in three stages via a scenario, as follows:

INQUIRY-BASED SCIENCE EDUCATION (stage 2)

EXPLORES SCIENTIFIC QUESTION 1

Student constructed, creative thinking, showing - initiative, conceptual understanding, perseverance, planning ability

PROBLEM SOLVING INVESTIGATION

Exhibits process skills, creative thinking, cognitive reasoning, collaboration with others, leadership qualities, safe working

EXPLORES SCIENTIFIC QUESTION 2,3, etc.

(if appropriate) *Creative thinking, initiative, conceptual understanding, perseverance*

PROBLEM SOLVING INVESTIGATION

Process skills, creative thinking, communication, leadership, cognitive reasoning, collaboration with others

SCIENCE CONSOLIDATION AND SOCIO-SCIENTIFIC DECISION MAKING (stage 3)

REFLECTION ON/CONSOLIDATION OF NEW SCIENCE KNOWLEDGE GAINED

Conceptualization, independent thinking, student constructed modelling, communicating

SOCIO-SCIENTIFIC DECISION MAKING

Within the socio-scientific context (the scenario), argumentation, reasoning for making socio-scientific decisions, independent thinking, social values, tolerance of views of others, leadership

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Going beyond the scenario

Once teacher realise the need to *initiate motivational scientific thinking in their students*, the next step is to determine students' prior science knowledge in the area related to the socio-scientific scenario.

In most cases, the teacher should expect to find that the students' prior knowledge is limited and students will be unfamiliar with the science ideas associated with the scenario. However, if this is not the case and students really do have a background in the underlying science, then going further to discuss the scenario *is not likely to involve science learning*. The teaching needs to re-focus so as to address learning.

Preparing for stage 2

While stage 1 is initially about raising student interest, stage 2 is the important stage for the learning of new conceptual science. Experience has shown (re- PARSEL project) that teachers need to be guided to appreciate how to move from stage 1 and into stage 2. The expected steps (considered within stage 1) are to:

(a) enable students to recognise that they can discuss little about the scenario without learning the underlying science ideas, and then;

(b) develop the scientific question(s) (by the students if possible, otherwise by the teacher guiding the students – trying hard to not tell), which are to be answered within stage 2.

Moving from the scenario to developing the scientific question is heavily dependent on the skill of the teacher. Collective teacher discussions, after teachers have tried out a module, can give strong indicators of the way teachers have handled this component.

Undertaking stage 2

This is likely to be the stage where most of the module's teaching/learning time is spent and where students gain conceptually and also at a personal and social educational level (education through science). The approach here is one of maximising student-constructed learning (inquiry-learning or IBSE) and that the pace of teaching will depend heavily on students' skills, developed on prior occasions. If students have much prior experience in carrying out process skills, then undertaking evidence-gathering learning (a key element within a scientific approach) can be facilitated. IBSE can be expected to take far less time than in cases where students have not had prior opportunities for student-centred learning. There is a need to stress the importance of the evidence gathering aspects, whether by experimentation, or by other means.

Explaining inquiry learning

Teachers must have a clear notion of the intentions behind inquiry learning. This understanding must go beyond student attainment of manipulative process skills. The inquiry learning is intended to be student-constructed learning, with the teacher as facilitator. It is definitely NOT simply following a worksheet and recording a given answer.
The following are all very much part of IBSE (although not actually seen as process skills):

- identifying the science in a socio-scientific situation;
- putting forward scientific questions (questions that can be investigated scientifically);

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– if necessary, breaking down questions into sub-questions that can be investigated separately.

Also, students can be expected to learn to use communication skills to present their conclusions in suitable ways (written, oral, ICT) and, as appropriate, discuss the limitations associated with the solutions they reach in attempting to solve the problem (answers to the questions). Furthermore, inquiry learning is also very much interrelated with the development of social skills, especially interpersonal (student-student and student-teacher) developments and also personal skills, associated with aptitudes that support inquiry learning, such as initiative, ingenuity, safe-working and perseverance.

Teachers need to recognise that progression through the approaches given in the paragraph above is NOT expected to be LINEAR. Thus, the stages (guided by the teacher, or through open inquiry) can depend on the module being promoted.

Preparing for stage 3

The solution to the scientific question, carefully detailed and recorded, is expected to be the gateway to stage 3. In stage 3, the science gains from the inquiry learning in stage 2 can be used to further consider the socio-scientific issue that was initiated in stage 1. A good approach for consolidating this science is to construct a concept map (Reiska, Soika & Cañas (2018).

Undertaking stage 3

Stage 3 has two major components:

(a) To consolidate the science ideas introduced in stage 2. This is achieved by involving students in additional tasks (above and beyond the module) related to the concepts, preferable interlinking with the students' prior concepts which were identified in stage 1. These tasks may be presented in different formats e.g. oral discussions; answering written exercises; jigsaw method, etc.

(b) Utilise the science ideas gained to impact on the original scenario situation so as to enable students to discuss the scenario situation in more detail, utilising the newly acquired science. This is an important component of the learning and is expected to achieve two major learning targets
   (i) being able to transfer scientific ideas to a new, contextual situation, and
   (ii) participate meaningfully in a decision-making exercise to arrive at a justified decision, related to the initial socio-scientific situation outlined in the title of the module.

Part (b) involves student groups, or whole class interactions, in activities such as debates, role playing, or discussions. Students are expected to put forward their points of view, the teacher ensuring they incorporate the new science in a meaningful and *appropriately correct* manner. Students are thus involved in aspects of *argumentation*, as well as communicating the new science ideas in a *conceptually correct* manner. The end result is a set of small group decisions, or a consensus decision made by the class as a whole. The actual decision is not, in itself, as important as the justifications put forward, but it is expected to comply with social values accepted by the local society as a whole.

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SESSION 1

1.1. OBJECTIVES

After this session, students should be able to:

- Recognise the power of questioning in STEM education and beyond.
- Identify meaningful question versus factual recall questions.
- Become aware of STEM-related careers and the skills needed.

1.2. STRUCTURE OF ACTIVITIES

Activities	**Time**
Complete the survey questionnaire (pre-survey).	5 min
Introduce oneself by 3 sentences, Name one important person. Justify why.	15 min
Description of the Highflier module structure, its content and objectives.	5 min
Identifying a Scenario setting: job shadow highlighted.	10 min
Expanding the scenario, contextualisation of the task.	10 min
Formulating questions individually. Choosing best questions in a group. Sharing with others (task 1).	20 min
Discussing why one of the students was invited to continue studies in the plant, but the other was not.	15 min
Summing up - which competences are essential for successfully applying for a job.	10 min

1.3. MATERIALS

- Module's slides for this lesson: slides 6 to 14;
- Rannikmäe, M.; Holbrook, J.; Cavas, B. (2017). Promoting twenty first century skills development among international adult learners. In: H. Fehring, S; Rodrigues. (Eds.). *Teaching, Coaching and Mentoring Adult Learners: Lessons for Professionalism and partnership* (138−146). London/New York: Routledge Taylor & Francis Ltd.

1.4. ACTIVITIES

1.4.1. Introduction and the Meaning of Questioning

This activity is designed to encourage participants to think which questions to ask and also to reflect, in terms of science, on their understanding about the work in the cosmetic industry.

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The intention is that participants gain an understanding about asking different types of questions and which of these lead to meaningful discussions.

Based on the types of questions asked, this can play a meaningful role in characterising a person who, for example, is successfully looking for a career in the cosmetic industry.

Question can be classified as -

a) Higher order questions - these require thinking and the response is likely to be unique.
b) Lower order questions - for example, simple factual recall, which can lead to the same response from multiple students.

1.4.2. Scenario setting

This follows on after participants have been introduced to how industry is likely to choose the best candidates (this can also be linked to students' self-introductions !!)

The setting is presented as:

> *Birgit and Laura were friends.*
> *In school, Birgit did not like science classes, because these were too theoretical and seemed far from life. She was always very critical of science learning.*
> *However, Laura wanted to continue studies in paediatrics and never complained about learning science.*
>
> *One day, as part of science studies, a job-shadow programme was introduced.*
> *Several options for job shadowing were put forward e.g. visiting a science laboratory, an industrial complex, or a company manufacturing site.*
>
> *The friends decided to follow up on undertaking shadowing jobs in the cosmetic Industry.*

1.4.3. Task 1

In task 1, the teacher is seeking to guide participants to be able to group questions by different formats e.g. nature/type and also to be able to do the same with the questions created by Birgit and Laura.

Participants are first asked to create up to 6 questions related to the photos (individual work).

Then, participants are asked to select 4-6 questions from those put forward by the members of their group (groupwork for 3-4 participants).

The group is then asked to present 2, most relevant, questions to the class, carefully explaining their choice. (Such a choice can be expected to be based on relevance, interest and being challenging).

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1.4.4. Task 2

Participants are asked to consider the meeting by the 2 students with the visiting company leader. The text presents this as:

> Unexpectedly, Professor Hundy, the company leader from overseas, was visiting the research laboratory on the same day and was interested in what Birgit and Laura were doing in the research laboratory; why did they decide to come, and how did they like the job shadow programme.
>
> Birgit asked him whether the company could employ students over the summer to work in the department of Research & Development. And if so, could they try to design new products. Also, she asked whether the company could advertise a competition for that.
>
> Prof. Hundy asked whether Birgit had an idea of which product to design?
>
> Both Birgit and Laura drew something on a piece of paper – Prof. Hundy laughed and asked whether he could keep those!

> 3 month later: Birgit received a letter from Prof. Hundy asking whether Birgit would like to start studies at the prestigious Cambridge University, funded by a scholarship by industry and including practicing in industry.
>
> However, Laura did not get any letter.

The task is for the participants to discuss, in groups, why Birgit impressed Prof. Hundy and what might she have scribbled on the piece of paper. It is expected that the participants can indicate that:

- Prof. Hundy was impressed by creativity being exhibited (product design idea) pointing to the student being able to undertake an intelligent interaction.
- Prof. Hundy was also impressed by the meaningful questions which Birgit was asking pointing to the ability to ask questions based on deep intellectual thinking.

As an end aspect, the participants can be asked ´Based on the questions you devised, what do you think' – *would you predict you would have got a letter?*

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SESSION 2

2.1. OBJECTIVES

After this lesson, students should be able to:

- Identifying problems for research. (It is suggested to identify 5 different problems)
- Understand there are different types of problems which can be meaningfully investigated by scientists. (In this way problems can be grouped in different ways e.g. as scientific, social and socio-scientific - this can lead to introducing the difference between a problem, which has a specific solution (i.e. a scientific problem) and an issue, which needs to be discussed and resolved as the most appropriate response by the group e.g. a social issue or even a socio-scientific issue).
- Understanding science involved in the Dead Sea. (This is enabling participants to be challenged to come up with scientific research ideas that can be carried out on/in the Dead Sea).
- Commenting on statements. (This is initiated by reflecting on the scope of scientific research and the limitations of scientific research being confined to the real world and is unable to handle aspects seen as value-laden).
- Analyse and evaluate real-life problems, conceiving possible solutions, supported by scientific knowledge.
- Develop autonomous research in the scientific field using critical thinking.

2.2. STRUCTURE OF ACTIVITIES

Activities	Time
Presenting the scenario	10 min
Identify research problems based on the Dead Sea slides	20 min
Analysing problems – seeing these as scientific, social, or socio scientific	20 min
Explaining scientific problem identified (group work)	20 min
Suggest as a group to Israel what to investigate	15 min
Summing up	5 min

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2.3. MATERIALS

Slides for this lesson: Module slides 16 to 20.

2.4. ACTIVITIES

Introducing scenarios about the Dead Sea (via slides, video, stories). The goal is to motivate participants by introducing - Science of the Dead Sea.

From the presentations the student can reflect on the scenarios, such as:

a) Swimming in the water is difficult, as the buoyancy of the person is high.
b) It is easy to float in the water. It is actually able to read a newspaper while floating.
c) The water is very salty and with salt crystals on the bottom. This making wading in the water difficult or painful, without shoes.

2.4.1. Task 1

From viewing the slides or video, identify 5 concerns, or problems which you notice (individual). Select 5 problems, which can be used for initiating research by scientists (groupwork: 3-4 students per group).

Students are requested to justify their reasoning.

Teacher guidelines:

Based on the concerns or problems identified by the participants (or otherwise), the teacher guides students to appreciate:

(a) there are different types of problems (which can be labelled as scientific, social, socio-scientific)

(b) the type of problems which can be taken as the base for undertaking research by scientists? (i.e. the science problems)

- **Exemplary problems re- Dead Sea, which can possibly be identified by students:**

- The water in the Dead Sea has no outlet yet is becoming smaller.
- Climate change and limiting water from the river Jordan has caused a large decrease in the size of the Dead Sea.
- The Dead Sea water is extremely salty.
- The Dead Sea water is painful if in contact with one's eyes.
- Human activity is influencing the surroundings of the Dead Sea.
- Humans may destroy attractive rock salt formations.
- The cosmetic industry is utilising too much Dead Sea water.
- Dead sea minerals can be used to promote homeopathy.
- Tourism is causing problems in the Dead Sea area.

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SESSION 3

3.1. OBJECTIVES

After this lesson, students should be able to:

- Understand what is the nature of processes which are related to science.

3.2. STRUCTURE OF ACTIVITIES

Activities	Time
Answer the NOS questions	10 min
Group discussion, re – set of test questions	20 min
Meaning of science (slides discussed by teacher 21-22)	30 min
Observation (slides 23- 25)	10 min
Theories and laws (slide 26-27)	10 min
Science in society and for society (slide 28)	10 min

3.3. MATERIALS

Slides for this lesson - Module's slides: from 20 to 28

3.4. ACTIVITIES

3.4.1. Participants are asked to answer questions which relate to 'What is science'? 'What is its scope? What, if any, are the limitations of science?

This can be answered individually, or in groups. If individually, answers can relate to the questions presented on a sheet of paper. If in groups, then the slides 21-27 can be used.

This leads to exploring features of science seen as the Nature of Science, or NOS.

I. ***What do you understand by the processes that are intended by the term 'science'?*** (This seeks participants views on what they understand as to the meaning of science)

   Participants respond to the following items given as a hand-out. A 7-point scale is utilised from 'strongly agree' (labelled 1) to 'strongly disagree' (labelled 7). No label is attached to items 2-6, allowing the participants to choose which number to select depending on their degree of agreement/disagreement.

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Science is

a) a study of fields such as biology, chemistry and physics.
b) carrying out experiments to solve problems of interest.
c) a systematic investigative process and the resulting knowledge.
d) inventing and designing things.
e) finding and using knowledge to make the world a better place.
f) a body of knowledge that explains the world around us.
g) exploring the unknown and discovering new things about the world.
h) an organisation of people called scientists who have ideas and techniques for discovering new knowledge.
i) I do not have any understanding.

II. ***In your opinion, to what is Science aiming to achieve?*** *(7-point scale - Agree to False)*

a) To make sure that what has been discovered about the world is really true.
b) To understand, explain and interpret the continuing change in nature and its characteristics.
c) To discover, collect and group facts about nature.
d) To find ways to make people's lives better.
e) I do not know.

III. ***Why do you think Scientists do Scientific Research?***
7- point scale Level indicating Strength of Agreement

a) To make new discoveries.
b) To try out their explanations for why things happen.
c) To make something which will help people.
d) To collect data as much as possible, and to draw out scientific laws from data.
e) I do not know.

IV. ***A Scientific Theory is***
7- point scale Level indicating Strength of Agreement

a) An idea about what will happen.
b) A most appropriate interpretation and explanation which has been approved by scientists.
c) A fact which has been proved by many experiments.
d) I do not know.

After the questionnaire, the teacher can discuss the answers with students. In this way, the teacher can determine the general agreement, or disagreement between participants.

Show slides 20-28 and discuss these in 4 parts

Part 1 21-22

Part 2 23-25

Part 3 26-27

Part 4 28

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SESSION 4

4.1. OBJECTIVES

After this session, students should be able to:

- recognise and understand what is pseudoscience.
- comprehend how pseudoscience differs from science.
- indicate why pseudoscientific thinking is dangerous.
- put forward examples of pseudoscience.
- are able to explain through a 2-3 min. video a chosen scientific/non-scientific problem.

4.2. STRUCTURE OF ACTIVITIES

Activities	Time
Scenario; show slides 29-31 Reflection on pseudoscience phenomena	20 min
Identifying the difference between science and pseudoscience Slides 32-37 - indicate why pseudoscientific thinking is dangerous - put forward examples of pseudoscience	20 min
Presentation of Designed 3 min. video framework, introduced by slide 38	40 min
Complete the survey (the final survey)	10 min

4.3. MATERIALS

Module slides. Slides for this lesson: at first from 29 to 31 and then from 32 to 37.

Introduction to designing a 3 min. video by participants - slide 38

4.4. ACTIVITIES

Reflections on the phenomena of pseudoscience.

Participants reflect, with reasoning, whether the following scenarios can be considered scientific. The scenario discussion can be initiated by means of a hand-out on the scenario, or by observing slide 30.

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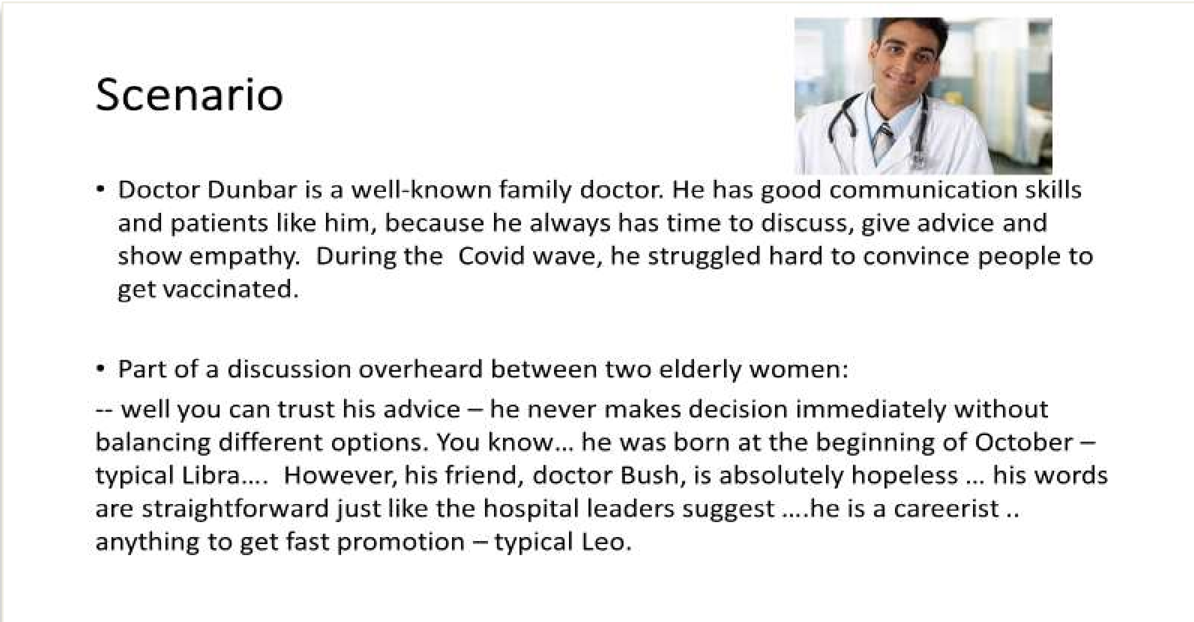

4.4.1. Distinction between science and pseudoscience

In association with the discussion on the two scenarios, the term pseudoscience is introduced and its meaning clarified. This is further supported by discussion on the difference between astrology and astronomy initiated in slides 31 and extended in slide 32**.**

The distinction between science and pseudoscience can be further discussed, and its impact on our lives, based on the slides 33-34. The intention is to make a clear distinction in recognise scientific endeavours and those claimed to be scientific but are actual pseudoscience.

While slide 35 looks at the potential impact of pseudoscience on the society, slides 36 and 37 extend the discussion with respect to scientific careers.

4.4.2. Presentation on Developing a 3-minute video

a. Slide 38 seeks to introduce the participants to the 'end of unit task', which is seen as creating a 3-minute video related to:
   - demonstrating creative problem solving,
   - specifying the difference between science and pseudoscience, or
   - recognising how to promote STEM-related career awareness.

4.4.3. Reflection about the skills developed – the final survey

At the end of the module, participants engage in reflecting about the skills developed during the module by undertaking the survey. This can either be undertaken by participants receiving a handout, or by recording their responses by looking at slides 39-42.

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