

A group of people, mostly young women, are wearing white lab coats and are gathered around a table in what appears to be a museum or laboratory setting. They are looking at something on the table, possibly a worksheet or a small experiment. The background shows other people in lab coats and some equipment, suggesting a busy, educational environment.

## YOUR ROLE IN RESEARCH INQUIRY INTO CHEMICAL REACTIONS

# MUSEUM

### INTRO

The toolkit is a ready-to-use digital collection of modules aimed at teenagers to be used by teachers, informal learning organisations, researchers and industry.

The aim is to engage young people and especially girls in STEM and in the discovery of the variety of STEM related careers in a gender inclusive way. The toolkit includes a wide range of hands-on activities: workshops with a scientific content, informal discussions and meetings with STEM professionals.

Each module is composed of three guidelines:

- Explanatory guidelines specific for each activity
- Guidelines dedicated to the theme of gender inclusion
- Guidelines with suggestions for the facilitation

The guidelines give practical support and guidance for the users, recommendations on how to debate gender approaches and differences with young people, support and guidance for facilitators on how to overcome their own stereotypes and suggestions on how to manage the group dynamics by implementing different facilitation strategies.

The toolkit is produced in the context of the Hypatia project by five science centres and museums (NEMO Science Museum, Museo Nazionale della Scienza e della Tecnologia “Leonardo da Vinci”, Bloomfield Science Museum Jerusalem, Experimentarium, Universcience) in collaboration with gender experts, teachers, research industry institutions and teenagers.

The Vision of Hypatia is of a European society that communicates science to youth in a gender inclusive way in order to realise

the full potential of girls and boys around Europe to follow STEM related careers.

Below is the complete list of modules that compose the Toolkit, divided into the three contexts.

#### Schools

- Find Gender Stereotypes in STEM Representations
- Gender Inclusiveness in your Science Teaching
- Inquire: Shape and Action
- Play Decide Game & Debate
- Science Ambassadors and Ambassadors
- STEM Women Cooperative Card Game
- Test Yourself
- What's your Opinion?

#### Science Centres & Museums

- Find gender stereotypes in STEM Representations
- Science Café or *Café Scientifique*
- STEM Women Cooperative Card Game
- Test Yourself
- Wearable Technology
- Your Role in Research: Inquiry into Chemical Reactions

#### Industry & Research Institutions

- Gender optimizing software programming
- Science Ambassadors and Ambassadors
- Skill Game
- Speed Dating
- Your Role in Research: Inquiry into Chemical Reactions

## **YOUR ROLE IN RESEARCH** **INQUIRY INTO CHEMICAL REACTIONS**

### **AT A GLANCE**

Age Group	13 – 16 years old
Format	Workshop
Duration	60 minutes

### **OVERVIEW**

An authentic way to interact with materials, chemical substances and specimens. Boys and girls perform an experiment to test the characteristics of common substances. The students are directly involved in an inquiry process and will be able to see the link to the larger picture of the societal context wherein this activity fits. They use this experience in a discussion on the profession and roles within laboratories and will be able to see the link to the larger picture of the societal context wherein this activity fits.

### **OBJECTIVES**

- Provide a way to practically engage with STEM content and material.
- Create the condition for participants to alternate between the specific details of a task, and its more overarching implications.
- Enthuse a diverse group of young people for scientific research/topics.
- Introduce working with an inquiry process.

- Introduce a look into the working life of a scientist.
- Get acquainted with the different roles within laboratories.
- Introduce the societal context of research.
- The experiments proposed in the activity stimulate wonder and surprise with the students.

### SUGGESTED SCENARIO

Open days for families, orienteering days for secondary schools, workshop for school groups. As a workshop in the laboratory of a science museum. A workshop for school classes, for families (e.g. special holiday workshop), for teenagers (career orientation events or open nights).

### TARGET AUDIENCE

Age	13 – 16
N. participants	25 – 30
N. facilitators	2
Type of audience	Students, visiting families or teenagers

### FORMAT

Workshop.

### TOPICS COVERED BY THE ACTIVITY

This activity will relate to the science curriculum for chemical reactions of BTB (bromothymol blue) diluted in distilled H<sub>2</sub>O, CaCl<sub>2</sub> and NaHCO<sub>3</sub>. The essence of the test is an acid/base reaction, with BTB as an indicator.

It gives an image on the work a scientist/researcher can do and helps the students to see science as a serious career choice.




During a discussion the link is being made to the context of the laboratory and examples where the students can relate to.










### DURATION OF THE ACTIVITY

1 hour.

### RESOURCES

### MATERIALS

Short guideline for the facilitator	<a href="#">Annex 1</a>	1
Short guideline for the students	<a href="#">Annex 2</a>	1 per working station
Re-sealable zipper bags, 1 Liter, max. 1 ½ Liter		3 per working station
20ml bottles of BTB (bromothymol, acidity indicator) diluted in distilled H <sub>2</sub> O, with pipette		1 per working station
Black pots with CaCl <sub>2</sub> (calcium chloride)		1 per working station

White pots with NaHCO <sub>3</sub> (sodium bicarbonate/baking soda)		1 per working station
Measuring cups small	 or 	3 per working station
Measuring spoon		1 per working station
Pen or pencil & paper		2 per working station
Mortar (if needed)		1 per working station
Lab coats		1 per student
Lab glasses		1 per student
Paper towels		1 per working station

#### USEFUL LINKS, VIDEOS, ARTICLES

- [Zip lock bag reactions on chymist.com](http://chymist.com)
- [Reaction in a Bag on ucsb.edu](http://ucsb.edu)
- [Reaction bag on YouTube](https://www.youtube.com/watch?v=1111111111)

#### SETTING

Prepare the experiment in part 1: a scientific experiment which includes the opportunity for the participants to make choices about the variables, and not only follow the instructions of a procedure.

Choose the facilitators with care.

- Students might react better to a charismatic person that has experience in leading conversations with students or some might react better to a young person with whom they can identify better.
- Ensure that the involved science educators and scientists reflect a variety of personalities/characteristics and roles within the organisation! Make sure the level of ranking is not divided high = male, low = female.

Make sure the space where you receive the students has the possibility to do the experiment and have a group discussion. 1 Working station/table per 3/4 participants is needed.

#### DESCRIPTION AND TIME SCALE

##### GROUP MANAGEMENT

The students will be working in groups of 3/4 all the time with clear instructions. In general the facilitator encourages participation by all students, make sure that students don't get stuck, encourages questions and discussion, makes the transitions of what this experiment shows and what that tells us in the larger view of the socio-scientific role of the specific institution, makes an active link to diversity where possible

## INTRODUCTION

### Introductions, 5 minutes

The facilitator shows the materials, explains the safety rules and introduces his/herself:

- *What is your role and how did you get there (education and/or prior jobs)?*
- *What do you do on a regular day of work? You work together with who?*
- *How that relates to being a scientist?*
- Briefly tells what the students can expect, explain that they are going to do the work a scientist does, doing their own inquiry with experiment they'll chose themselves

Start with a general question that will be answered in this experiment and put it in a context. The facilitator asks the students this question and valorises the answers. The students let their ideas go freely.

- *Have you ever been in a chemistry lab?*
- *What, do you think, does a chemist do?*
- *How do you become a scientist?*
- *What, do you think, is a reaction?*

### DEVELOPMENT OF THE ACTIVITY

The facilitator explains that the following experiment they will do provokes a chemical reaction determining whether a substance is alkali or acidic.

A type of experiment we would do to, for example, test cleaning products: acid products react with calcium (bathroom) and alkali/base products react with fat (oven), but also to your skin.

### Guided experiment, 15 minutes

Scientists sometimes need to follow very specific guidelines/ already established procedures to conduct an experiment to discover and understand the specific characteristics of specific substances. For example when they want to perform the same test on different products.

First we are going to do an experiment in a zipper bag with guided action:

Each group (4–5 students) has a kit with:

- 3 zipper bags
- 3 measuring cups
- a bottle 50ml BTB (bromothymol, acidity indicator) diluted in distilled H<sub>2</sub>O
- 1 measuring spoon
- a mortar (if needed)
- a paper and pen
- paper towels
- a black pot with CaCl<sub>2</sub>
- a white pot with NaHCO<sub>3</sub>

The facilitator does this experiment together with the students to guide them through the guideline:

- (If needed) grind the chunks of CaCl<sub>2</sub> with the mortar.
- Take 1 zipper bag.
- Put three teaspoons of NaHCO<sub>3</sub> and one teaspoon of CaCl<sub>2</sub> in the zipper bag.
- Fill the measuring cup with 10 ml. BTB in H<sub>2</sub>O and place it upright on the bottom of the bag.
- Close the bag and try to squeeze out the air, while the measuring cup stays upright.
- Shake the bag and see what happens.
- Write down all your observations.

The students collect observations.

The facilitator moves between groups and focuses on the comments about changes in colour, change in temperature, foam/volume changes, but does not comment on them.

When mixing  $\text{CaCl}_2$ ,  $\text{NaHCO}_3$  and BTB in a zipper bag, we can see and feel different phenomena (from the outside of the bag):

- Heating and subsequent cooling of the bag.
- The change of the colour.
- Foam formation resulting in the inflation of the bag.

We continue without discussing the observations

### Open experiment, 15 minutes.

Scientists sometimes conduct a more open experiment/procedure if the scientific question is more open on the substances. For example when they want to know what different reactions are with different proportions. So we will try this out as well. Freely experiment with zipper bag:

**The facilitator explains that, to find out what is happening, we are going to repeat the experiment by changing the variables. For example, we may choose to use only two substances at a time.**

Each group of students has 2 extra zipper bags and 2 extra measuring cups and are free to choose variables to experiment with to find out what happens in the zipper bags and understand it.

The students collect observations. The facilitator moves between groups.

## CONCLUSION

Discussion of the results & findings of each group, 25 minutes

- *What have we discovered in this specific experiment?*
  - A solution of  $\text{CaCl}_2$  is slightly acidic and BTB gives it a yellow colour. Explain the terms acid–base
  - A solution of  $\text{NaHCO}_3$  is alkalic and BTB gives it a blue colour.
  - If these solutions are added together, an acid–base reaction occurs, releasing  $\text{CO}_2$  gas. At first it generates bubbles and the air blows up the bag ( $\text{CO}_2$  – carbon dioxide– generated by the reaction of  $\text{CaCl}_2$  and  $\text{NaHCO}_3$  with  $\text{H}_2\text{O}$ ).
  - At first it is warm to the touch (because heat is released during the reaction between  $\text{H}_2\text{O}$  and  $\text{CaCl}_2$ ), this is an exothermic reaction.
  - Then we feel cold (because the formation of  $\text{CO}_2$  –from  $\text{CaCl}_2$  and  $\text{NaHCO}_3$ – absorbs the heat), this is an endothermic reaction.
  - The essence of the trial is an acid–base reaction with BTB as indicator substance.
- *What did each of you just do? What different roles did you have/what role does a scientist have in these kinds of experiments?*
  - selecting variables
  - conducting observations
  - making deduction
  - documentation.

The facilitator might add needed skills as well, speaking from her/his own experience: persistence, diligence, patience, to be able to work alone and on the other hand to work in a team, to be prepared for satisfaction besides moments of frustration.

- *What other roles can a scientist have/what kind of job can a chemistry graduated do?*

The facilitator can point out the following examples when the students don't think of them, to give a good idea of the societal impact a scientist can have:

- Teacher, like your own teacher present.
- Explainer, like a facilitator in a science museum.
- Interviewer, like science journalists.
- Writer, every experiments should be shared in science magazines.
- Briefing of (inter)national colleagues, so the outcome can be used by others.
- Creative, to think of what is important in the research by writing research plans.
- Influencing policy, so governments act on discoveries made.
- ...etc.

During this discussion the facilitator or another present researcher discusses with the students her/his daily work.

- *What does a(n average) day look like?*
- *Who does (s)he work with?*
- *What are the different activities that are typical to her function?*
- While going into this, (s)he explains what is being done in laboratories:
  - Substances that do not exist in nature are being produced.
  - Substances that do exist in nature can be purified
  - Producing chemicals (legally or illegally).

- Research into materials (like research into radioactive materials and yet undiscovered elements).
- There are also a range of laboratories that do all kinds of analyses (for example analyses of soil samples or household cleaners).

- *What do you think we do in this kind of laboratories?*

Explain that laboratories can be part of a hospital or a university, but also be part of a small or large company, or a government agency. Next to laboratories for scientific research there are also laboratories for practical uses:

#### Quality Laboratory

Many companies have a quality laboratory, where they test the purity and properties of raw materials, auxiliary materials, semi-finished and finished products. In the pharmaceutical and food industry a microbiology laboratory is essential to avoid the risk of food poisoning and contamination of the final product.

#### Hospital Laboratory

Hospitals have a general clinical chemical/haematological, medical microbiological, pharmaceutical toxicological and pathological laboratory. To examine all bodily fluids, but especially blood, urine, faeces, sputum and tissue. Mainly the general clinical chemical/haematological laboratories perform a 24/7 role and are continuously available for urgent analysis. The other laboratories listed are not constantly being used, only when needed. At the head of a hospital laboratory is a laboratory specialist. In the case of the clinical chemical laboratory, this is the clinical chemist. In the case of the

microbiological laboratory, this is the clinical microbiologist. At the pathology lab, this is the pathologist. And the hospital pharmacist manages the pharmaceutical toxicological laboratory.

#### Forensic laboratory

A forensic laboratory investigates traces to determine the facts of crimes and identify the perpetrators. The investigation into traces of DNA has boomed in recent years, so even older crimes can be solved, where researchers previously searched for a solution unsuccessfully.

#### Construction Physical Laboratory

Some examples of research are:

- Wind nuisance and wind loads on and around buildings in the wind tunnel.
- Sun and shade on and around buildings
- Air- and waterproofness of facade elements
- Sound insulation of walls, doors and facade elements.
- Fire resistance of structural parts.
- *What aspects of this work do you think is most socially relevant and why? How can we impact the society most?*  
The facilitator notes and points out his/her observations in this: different type of people, gender etc.
- *Who sees him/herself becoming a scientist (like me☺)?*

### **GENDER INCLUSION CRITERIA**

The “gender inclusion criteria” developed in the Hypatia project are relevant for the adaptation of Your Role in Research and should be reflected on and discussed with the people who are offering such a class or activity. Even more they might lay the ground for the success criteria in which to measure the results

of the adapted activity. The following are some examples of how this workshop addresses gender inclusivity on the different criteria levels.

#### **INDIVIDUAL LEVEL**

- Encompasses a variety of different ways of engaging students by doing an activity, using discussing both in a groups as well as in small groups and showing different contexts where research can take place (different kind of labs, different roles).
- Involves activities that include a variety of problem solving and research methods such as selecting variables, conducting observations, making deductions and documentation.
- Uses activities that incorporate a clear context so participants understand what their role in research could be.
- Reflects on which previous knowledge and experience participants have.

#### **INTERACTIONAL LEVEL**

- Alternates between instructions in plenum; work in groups and discussions in plenum.

#### **INSTITUTIONAL LEVEL**

- Support the planned activities within the organization, the lab that already exists
- Include thinking about what kind of an impact the institution itself has – in the discussion the workshop leader discusses with the group what different roles scientist can have in society.



## SOCIETAL/CULTURAL LEVEL

- Puts the different carriers you can have in science into context.
- Showcases and/or discuss areas where science is used to benefit the society.
- Broadens the views students have on science and scientists.
- Discuss the 'whys' and 'where's' of society's use of science.

## LEARNING OUTCOMES

The following learning outcomes are divided accordingly between teachers or facilitators and participants:

### • Teachers or facilitators:

After planning and preparing this workshop the facilitator or teacher should have knowledge of and/or be able to:

- Adapt the activity in relation to targeting a broader group of participants.
- Gain inspiration from science.
- Have an awareness and understanding of how to motivate girls and boys to engage in the activity.
- Have awareness and understanding of the cultural restraints that might be part of a classroom teaching in regards to gender.
- Realize how to counter target some of the cultural restraints in regards to gender that might be part of a classroom teaching.

### • Students/participants:

At the end of the lesson participants should be able to:

- Deduce which factors influence different phenomena in a chemical reaction.
- Have an idea how to work with an inquiry process
- Know what kind of skills you need to have to be a scientist.
- Know the different kind of roles you can have within research
- Be aware of some examples of what science can be used for in society.

## PARTNER DETAILS



This module was originally developed by NEMO Science Museum in Amsterdam, the Netherlands. Contact: Meie van Laar, [vanlaar@nemo.nl](mailto:vanlaar@nemo.nl)

Cover image: NEMO Science Museum, Amsterdam.

## GUIDELINES ON GENDER BALANCE

### **WHY IS IT IMPORTANT FOR PEOPLE OF ALL GENDERS TO STUDY AND WORK IN STEM AREAS?**

In the coming years, with Europe's knowledge economy developing and new technologies on the rise, skills in science, technology, engineering and mathematics (STEM) are becoming increasingly necessary in order to guarantee an adequate & professional workforce in a broad range of careers. It is therefore imperative to attract and recruit more youth to STEM study programs and ensure the diversity of STEM-trained professionals. The Vision of Hypatia is of a European society that communicates science to youth in a gender inclusive way in order to realize the full potential of girls and boys around Europe to follow STEM related careers.

Institutions and facilitators responsible for implementing science education activities, such as schools, museums and industries have a key role in this. They may influence the ways in which learners construct and negotiate their gender and their attitude towards STEM. This is why it is important to reflect on the gender and science biases we have, to acknowledge the stereotypes and make sure we do not perpetuate them in our interactions with the participants.

### **FACILITATING GENDER INCLUSION**

In facilitating gender inclusive activities it is important to be aware of a few significant concepts.

## **GENDER AND SEX**

Sex refers to biological characteristics and functions which distinguish between males and females: chromosomal sex, gonadal sex, morphological sex.

Gender refers to the social construction of men and women, of masculinity and femininity, which differs across time and space, and across cultures. It is a hierarchical and hierarchizing system of masculine and feminine norms.

## **GENDER STEREOTYPES AND SKILLS**

A gender stereotype is our social perception regarding the attributes of males and females (character, abilities, tendencies, preferences, external appearance, types of behavior, roles, career paths etc.) and our tendency to relate such attributes to individuals of each sex, prior to meeting them (example of stereotype: male are more rational and female more emotional).

When we talk about gender stereotypes and science we refer to roles and abilities that are supposed to be "suitable" for males and for females in science (for example engineering and building are associated more with males than with females).

## **GENDER AND SCIENCE**

STEM are fields of inquiry and knowledge. Like other forms of knowledge, they may include gendered dimensions. When the gender variable is not taken into account by researchers, this can influence the results: for example when medicines are not tested on both male and female. Furthermore, there is a persistent gender gap in the production system of scientific and technological knowledge and in many European countries women are over represented in biology and medical sciences while they are

under-represented in mathematics or informatics. Besides, women are less likely to reach a high level of responsibilities in sciences.

They are depicted as rational, intellectual and independent, and these characteristics are often associated with masculinity. This means that boys or girls who do not identify with such characteristics will think that STEM studies and occupations are “not for them” and avoid STEM completely. This is why it is important to present a complex and diverse image of science.

### **SUGGESTIONS FOR THE IMPLEMENTATION OF THE ACTIVITY**

Defining, recognizing and implementing gender inclusive activities is complex and challenging and requires a constant auto reflexivity of the facilitator about his/her own gender stereotype and bias. Here are some practical indications and reflection questions to assist the facilitator in being inclusive.

### **INTERACTING WITH THE GROUP**

- **Neutrality in assigning tasks and roles**

*How will I assign tasks? What responsibilities will I assign and to whom?*

Avoid assigning stereotypical gendered roles to participants that may contribute to the internalization of ‘female’ or ‘male’ identities, for example asking boys to build things and girls to take notes. Ensure that the different roles required by the activity are rotated between participants.

- **Attribution of success and failure, overcoming stereotypical responses**

*Do male students who have failed link their failure to themselves or to external factors?*

*Do female students who have succeeded link their success to themselves or to external factors?*

Set a high level of expectations for both sexes. Avoid over indulging with the girls (this leads to dependency rather than independence). Encourage both girls and boys to take risks.

- **Adopt a “Wait Time” to encourage girls to speak in an environment of risk-taking boys who might respond faster than they do**

*How attentive was I to the students’ responses? How long did I let them speak for?*

Wait 4–5 second before calling on a student to answer a question. Delaying the answer enables all the students to respond, thus giving everyone the opportunity to come up with it.

- **Interaction with the sexes to overcome the tendency to engage with male students more than with females:**

*Did I direct questions to boys more than to girls?*

Be aware whether the questions are directed more to boys or to girls.

- **Unaware expression of stereotypes**

*Did I pay attention to the students’ behaviour in relation to their expression of gender stereotypes?*

Teenagers often reproduce gender stereotypes unconsciously or in a subtle way. This might be taken as the chance to underline it and use it as a point of reflection.

#### **DURING A DISCUSSION**

- *Are boys more interested in building things and girls in decorating the things produced? Can you switch these roles in the activities?*

Challenge learners to depart from their preferred interests and widen their engagement in science (many children have gender stereotypic interests that might be challenged).

- *Do you think it could be useful to introduce and discuss the concept of gender or stereotype before or after the activity?*

Consider if a forgoing explanation of the main concepts about gender and about the terminology/concept connected could enrich the discussion.

- **While facilitating a discussion**

Acknowledge that different learners have different kinds of prior knowledge that may be relevant in different ways. Discussion can take its point of departure in what learners already know about the subject matter.

#### **MEETING A STEM PROFESSIONAL**

Role models are effective in stimulating girls' and boys' interest in STEM. Many activities have STEM professionals as protagonist or give examples of STEM professionals. It is important that these role models do not reinforce gender stereotypes.

- *How many men and how many women appear in the example of STEM professionals I give in the activity? Are they stereotypical?*

Keep a balance between the number of females and males as speakers or examples. Where possible ask them to talk not just about the scientific content but also about their personal life.

Ensure that the involved science educators and scientists reflect a broad variety of personalities. Girls and boys are most inspired by role models they feel psychologically similar to themselves (as regards to origin, culture, age, etc.). Otherwise, the standards set by the other person can be seen as contrasting, and girls and boys may react against them.

- *In the activities, do I present the variety of STEM – from computer games to engineering?*

While choosing STEM professionals and examples involved in the activity, ensure that the diversity of science is represented to the largest extent possible.

## **FACILITATING AN EXPERIMENTAL SITUATION**

While dealing with a specific scientific content participants might not see clearly how this is related with gender balance in STEM. Hypatia activities aim to propose unexpected ways to approach science and scientific content (like chemistry, robotics or making), breaking the stereotypical perception of STEM. This serves to introduce and disseminate a different view of the world of science, unveiling different aspects with which more people – girls and boys – can identify. You can emphasize this aspect while facilitating an activity focused on scientific content rather than on gender.

- For example, an activity framing technology such as the one on wearable technologies could attract more girls than one on transport or missiles.
- Many girls feel more comfortable in a situation based on cooperation, and others even avoid competitive activities. The facilitator could present a challenge with a “story” behind and not just as a competition, or pay attention in balancing competition and cooperation in the same activity.
- Many studies show that girls learn better in an environment that is esthetically pleasing. This is why it is important to create a pleasant and esthetic environment for the activities.

## **USEFUL LINKS ABOUT GENDER INCLUSION IN THE CLASSROOM**

### **HYPATIA’S THEORETICAL FRAMEWORK**

The present document proposes a framework to address gender inclusion in STEM activities. It gives rise to a set of criteria for the analysis of the gender inclusiveness of existing STEM education activities, or for the design of new, gender-inclusive activities.

[Theoretical Framework](#)

### **GENDER EQUALITY IN THE CLASSROOM**

We are frequently unaware of the manner in which we relate to boys and girls. School classrooms are no exceptions. Here is a list of points of attention and suggestions aimed at improving the degree of equality in the class in order to encourage girls and boys to pursue the fields of STEM.

[Gender Equality in the Classroom](#)

## GUIDELINES ON FACILITATION

### **A BIT OF ADVICE FOR GOOD FACILITATION**

A key element for good facilitation is the active involvement of the participants every time a concept or content is presented.

Involvement means for example:

- Considering participants' personal experience as a starting point of the engagement.
- Building on their own point of view or prior knowledge.
- Embedding continuously the contributions of the participants in the process.

Facilitation is not easy; it takes practice, time and reflection! In order to transfer these concepts into practical situations – and thus to foster engagement, interaction and discussion – you can find a brief list of suggestions below. They can be helpful in developing good facilitation.

### **INTERACTING WITH THE GROUP**

- Prepare the environment where the activity will take place in advance, organize the space according to the needs of the activity, even changing its usual structure if needed (i.e. you can move tables and chairs around).
- Make sure that all participants can see and hear well.
- Keep eye contact with the participants.
- Address participants as peers rather than as passive spectators or ignorant individuals.
- Listen to people and use their own terms.
- Use questions as much as possible – they can be a useful tool to encourage interaction among the group.
- Stimulate reflections among participants.

- If possible, ask and build on information or elements that can be discovered through direct observation.
- Engage people by linking to their personal experience.
- Encourage participants to express their opinion and elaborate their own considerations.
- During an activity, you might want to organise different group settings – work in smaller groups or in pairs, create plenary moments – to help engagement and better interaction with the experience.
- Before interacting with the participants in plenary, you might want to ask participants to discuss in small groups as a “warm up”. This helps involving the shiest people or helps everybody to feel more comfortable about the topic before sharing any consideration in plenary.
- When the discussion is set in small groups, move around the groups checking on work and discussion, and intervene – only in case of difficulties!
- In plenary, try to address everyone as much as possible, encouraging everybody to participate and engage.

### **FACILITATING AN EXPERIMENTAL SITUATION**

- Try to make the activity as participatory as possible: every participant should have the possibility to engage directly with the experiment; avoid demonstrations.
- Do not reveal the results of the experience before the participants' own discoveries and considerations.
- Encourage participants to make initial hypotheses/descriptions/comments about what they think would happen.
- Keep the experiment at the centre of attention and of the discussion.

- Engage learners through an alternation of manual activity, questions and discussion.

### **DURING A DISCUSSION**

- Engage learners through a balance of open-ended questions, closed questions, discussion and exchange of opinions, etc.
- You might want to use provocative dilemmas as tools for debate. Disagreements can be valuable for analysing notions and negotiating views, use them constructively.
- Stimulate and build not only on participants' already-acquired knowledge but also on emotions and imagination.
- Challenge the participants at a suitable level.
- Avoid:
  - A didactic approach and the assessment of participants' knowledge.
  - Monologue.
  - Specialized terms with no reference to real objects.
  - Seeking and dealing only with the correct answers or, even worse, with the correct questions.
  - Not listening.

### **HOSTING A STEM PROFESSIONAL**

- You might suggest to the speaker to alternate between questions and speech allowing participants to take up a more active role and prevent long talks.
- Before introducing a STEM professional, you can ask participants to share their perception about the particular profession, and then discuss it with the speaker.

- Young participants, when they have the possibility to ask free questions, often seem to be interested in the speaker's daily personal lives, in their career path and about what they were like when they were students. You can suggest that speakers use these topics as "hooks" during speeches and conversations.

It helps if speakers bring tools or objects from their daily work with them as examples from their daily practice.

### **QUESTIONS: A FUNDAMENTAL TOOL FOR LEARNING**

Building a relationship with an object is like 'getting to know a new person'. Indeed, this kind of comparison can help understand a possible way of developing questions to be used in learning experiences. In the process of getting to know a person or starting a conversation we move from the basic and concrete to the abstract and more complex. Using questions in a learning situation involves similar steps: starting from basic information (usually elements that could be discovered through observation) working at levels where there is compatibility (i.e. levels where the pupils can become involved and engage through their knowledge, experiences and views), in order to proceed to the discovery of more complex information and concepts. Such an approach invites learners to search within their own repertoire of knowledge and experience for the necessary elements that would help them discover new insights, while at the same time it can operate as the foundation for the development of questions by the learners themselves.

In fact, we are not arguing here for a linear process of 'facilitator-asks – learners-answer'; rather, we argue for a two-way-contribution process, in which both facilitator and

learners are in the position to ask and answer questions. In this sense, questions are the stimulus for initiating dialogue, the tool and *not* the objective. They help new knowledge to be elicited and information to be added within a free flow of ideas, leading to the broadening of understanding.

What are the types of questions that would operate as the method for eliciting information and interpretation, for initiating constructive dialogue, for developing skills and self-confidence in learners – and facilitators themselves?

First of all the basic categories:

- Closed questions – the ones that have only one correct answer.
- Open questions – those that accept more than one correct answer.

Closed questions are usually used when we seek specific information about the phenomenon/topic/exhibit/object etc. and can be further divided to:

- Questions for examination: Answering those questions requires careful examination. The answers offer the first information on the basis of which we construct more detailed knowledge.
- Questions for explanation: The answers offer an explanation – how something works, how it was created, etc. and are closely related to the information derived from the examination questions.
- Questions for comparison: These stimulate comparisons with other situations of the same type, materials, dimensions, etc. and encourage the identification of similarities, differences and connections with the learners' personal knowledge and experience.

On the other hand, open questions encourage the expression of personal views, the employment of pre-existing knowledge of the learners, and the search for personal meanings. Discussion and open-ended questions offer learners the opportunity to pool ideas and share insights in the group followed by opportunities to develop understandings further through deploying and defending insights and opinions.

Open questions can be divided into the following categories:

- Questions for problem-solving: Those demand the use of critical thinking, imaginative thinking, hypothesis and analysis skills and ability for using knowledge for problem solving.
- Questions for prediction: The answers to those questions offer predictions in instances of changes of parameters.
- Judgement questions: Answers to those can be very personal and unique. They demand choices, evaluation of a situation, justification, etc.

You should be seeking a balance between closed and open questions. Asking only closed questions might create a feeling of ignorance among those learners who find it difficult to answer them, since they require relatively minor use of skills and more of specialised knowledge. Closed questions should be used for exploring the object and the new knowledge around it, and, in addition, offer the basis on which to ask the open questions. For any learner, answering open questions implies using their personal context to find the new information. It also enables them to use their own personal experiences, emotion, imagination and skills for meaning-making and personal interpretations.



In the philosophy of an interactive, constructivist approach to learning, the asking-answering of questions means not only the acceptance of more than one correct answer (through open questions), but also 'allowing learners to get things wrong', that is, not allowing a learning situation to be limited by seeking only 'correct' answers, or by the expectation of pre-determined outcomes. It is important that the facilitator does not jump in too quickly to correct learners, but rather uses the conflicts that arise between their different perspectives helping them to see that there are standards and that their own interpretations are not necessarily the same or as good as those held by other learners. Learning results from reference to, and drawing from, learners' own understanding of situations, and opportunities for exploration through trial and error.

# Hypatia PROJECT

Hypatia is an EU Horizon 2020 funded project that addresses the challenge of gathering different societal actors around bringing more teenagers, especially girls, into STEM careers both in school and as a choice of learning and career in the future. It aims at changing the ways sciences are communicated to young people in and out of school to make them more gender inclusive.

This project has received funding from the European Union's Horizon 2020 Framework Programme for Research and Innovation (H2020-GERI-2014-1) under the grant agreement No. 665566.

