GENDER OPTIMIZING SOFTWARE PROGRAMMING FOR CHILDREN/TEENAGERS

INDUSTRY & RESEARCH

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 Ambassadresses
- 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 Ambassadresses
- Skill Game
- Speed Dating
- Your Role in Research: Inquiry into Chemical Reactions

GENDER OPTIMIZING SOFTWARE PROGRAMMING FOR CHILDREN/TEENAGERS

AT A GLANCE

Age Group	Adult trainers/teachers and educators
Format	Workshop
Duration	Between 2 and 6 hours

OVERVIEW

This activity aims to gender optimise and improve already existing workshops on software programming for children/teenagers. Most schools must teach software programming to middle school groups and quite a few industrial companies choose to offer workshops on programming for schools. This activity aims to reach out to developers, teachers and facilitators to gender optimise these workshops and ultimately target a broader group of girls and boys. In other words this workshop is about redesigning an activity in order to take gender into account.

This activity will in turn help prepare teachers and student teachers to work with and teach their students software programming. The activity will focus on a science and technology approach as well as a didactic approach in regards to teaching software programming to school students.

OBJECTIVES

The main objective is to create gender optimised activities that lead to a larger interest in STEM. The objective is to raise the interest in technology with regards to software programming. The

focus is specifically on engaging more young people to take an education within STEM (here specifically within technology). The engagement is reinforced through the tools and suggestions on gender inclusiveness.

SUGGESTED SCENARIO

The activity will relate mainly to mathematics and 'science and technology' and will focus on already developed workshops that could benefit from an adaption to motivate and reach a broader group of school students (girls and boys).

The following are the main topics and connections within software programming to the school curricula in relation to mathematics:

- Students can see the common language between everyday language and expressions with mathematical symbols (to get something (perhaps a robot) to do 'this and this' — we need to use a programming language).
- Students can use expressions with variables — here under with digital tools.

The following are the main topics and connections within software programming to the school curricula in relation to "Science and Technology" (which is a school subject in Denmark):

- Students can describe a process from a first resource to a final product.
- Students can develop and use steering and simple sensors in their programming and use these to handle robots.

TARGET AUDIENCE

Age	Adult trainers/teachers and educators who develop and host programming workshops for 12 — 15 years old.
N. participants	15 — 25
N. facilitators	2
Type of audience	Facilitators of software programming workshops — who might be school teachers, teacher trainers or in-training teachers as well as other kinds of educators or trainers.

TOPICS COVERED BY THE ACTIVITY

The scientific contents of such an activity are software programming as well as an understanding of how to translate everyday language into a programming language.

This activity will promote an understanding of a technology that isn't always visible and noted but used on a daily basis.

DURATION OF THE ACTIVITY

Suggested duration: 2 — 6 hours.

RESOURCES

Note that the following resources are suggestions that might be used in a software programming class and these can vary and will depend on the activity and available resources.

As this activity aims to gender optimize already existing classes/activities on software programming (such as MicroBot Technology, Lego MindStorm, etc) the resources mentioned below are not necessary to make the activity, rather it is suggestions for needed materials in a class setting, where the students would work within this workshop area.

MATERIALS

Lego Mindstorm sets (or MicroBot Technology or other programming sets)	1 set per 2 participants
Lego Mindstorm table for test	1 per 10 participants if possible – otherwise the floor can also be used for testing
Lego Mindstorm program	1

USEFUL LINKS, VIDEOS, ARTICLES

- Lego Mindstorms
- www.firstlegoleague.org
- Search on YouTube for Lego Mindstorm films – also in your own language.
- Gender guidelines for adapting activities:
  o *One size fits all?* is teacher training development programme developed in the framework of the TWIST project (Towards Women In Science and Technology – EU funded FP7 project).
  o Check out The Twist Project website for other suggestions.

SETTING

After identifying and contacting industrial partners or research institutions or others that develop and offer software programming workshops for school groups it will be necessary to see if the contacted partner is interested in adapting their workshop. Once this is established the next step will be to find a date and setting to meet up. Here it is important to discuss how the workshop targets a broad group of children taking different learning styles and preferences into account and discuss how the workshop could be improved taking these considerations into account.

The setting for the workshop will depend on the contacted partner and could be at the industrial partner that develops the workshops or at the school where the workshops take place. Following this initial meeting the workshop should be jointly adapted.

DESCRIPTION AND TIME SCALE

Here is an example of how a software programming class might be set up in a gender inclusive manner. You could even call this task 'Redesigning' an activity in order to take gender into account with the following considerations.

- Less competition and more structure.
- Greater focus on achieving a meaningful and creative outcome.
- Maintain time constraint but with no single correct response.
- Alleviate stress levels by promoting a more supportive, non-confrontational approach.

- Emphasise the mathematical and problem solving element by creating an algorithm as a sequence of instructions.
- Ensure the experience is more multidisciplinary in character.
- Promote a balance of study and application.
- Foster perceptual and symbolic learning and foster gross motor skills.
- Retain kinesthetic and experiential activities.

GROUP MANAGEMENT

A workshop will usually start with an introduction in plenum where after participants are divided into pairs for the remaining of the workshop.

INTRODUCTION

The teacher/facilitator briefly presents the workshop introducing the objective.

The teacher goes on to introducing the teaching/learning cycle to put the workshop into a relevant didactic context for the class. The workshop can also be put into science context by explaining which skills are developed in relation to science literacy, technological literacy and mathematics literacy. This is important to target a broad group of girls and boys and to put the science into context where more participants will realise the relevance of the workshop.

Mention that this activity aims to redesign a programming activity where gender is taken into account. The following are considerations that might be relevant to reflect on:

- Less competition and more structure.
- Greater focus on achieving a meaningful and creative outcome.
- Maintain time constraint but with no single correct response.
- Alleviate stress levels by promoting a more supportive, non-confrontational approach.
- Emphasise the mathematical and problem solving element by creating an algorithm as a sequence of instructions.
- Ensure the experience is more multidisciplinary in character.
- Promote a balance of study and application.
- Foster perceptual and symbolic learning and foster gross motor skills.
- Retain kinaesthetic and experiential activities.

DEVELOPMENT OF THE ACTIVITY

The pupils are then introduced to the element of programming via for example the "Learn to program" on the Lego Mindstorm site or via other software programming programs.

They work like this for ca. 30 minutes.

Once the pupils are introduced to the software programming they could receive an engineering challenge that they then solve with the Lego Mindstorm robot.

CONCLUSION AND FOLLOW-UP

The adapting of the workshop will involve a discussion with either the industrial partner or the teachers who develop this programme. The focus here will be of a didactic manner and focus on a teaching situation with a specific focus on how to involve

a broad group of students – hereunder girls (who often are not involved in software programming). Focus should be on putting the learning into context – where is this used in life? (for example for optimising robots in elder care – or in the medicinal industry – or in regards to sustainable development and energy efficiency).

This workshop example has looked at the concept of First Lego League, which focuses on reaching all the way around with a concept that is put into context and aims to solve a societal problem – often in collaboration with a company/industry.

There should always be a follow-up and evaluation of each workshop and this should in part focus on whether the workshop managed to involve a broad group of participants (girls and boys) and whether or not they alternated in the different roles – such as experimenting, testing, planning, etc. It is highly recommended that some success criteria are set up covering these areas. Read more below under "Gender inclusion criteria" on this.

GENDER INCLUSION CRITERIA

The "gender inclusion criteria" developed in the Hypatia project are relevant for the adaption of software programming classes 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

- Will encompass a variety of different ways of engaging students.
- Will involve activities that include a variety of problem solving and engineering methods such as planning, developing, building, testing and improving.
- Will use activities and approaches that incorporate a clear context so participants understand how, why and where their new knowledge may be put into practice.
- Will reflect on which previous knowledge and experience participants have.

INTERACTIONAL LEVEL

- Will alternate between presentations in plenum; work in pairs and discussions in plenum.
- Focus on changing roles/work areas (such as taking turns in planning, making notes, programming and building).
- Will note that all participants experience success in regards to solving the challenges.

INSTITUTIONAL LEVEL

- Should support the planned activities and this could include the physical learning environment and for example creating space in order to build and test the robot in an inspiring setting.
- Could be set up differently in the room – re-think where you plan – and why – re-think where you are creative – and why.

- Should include thinking of what kind of an impact the institution itself has – how do teachers present or speak of science or technology?

SOCIETAL/CULTURAL LEVEL

- Will put programming into context.
- Showcase and/or discuss some societal areas where programming offers solutions to societal challenges.
- Will invite participants to bring forward situations where they have seen results of programming.
- Will discuss the 'whys' and 'wheres' of society's use of programming.

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 developing the software programming activities should have knowledge of and/or be able to:
  - o Adapt the activity in relation to targeting a broader group of participants
  - o Reflect on how programming can be used in classroom teaching.
  - o Gain inspiration from technology and specifically ICT (Information and Communication Technologies).
  - o Have an awareness and understanding of how to motivate girls and boys to engage in the activity.

  - o Have an awareness and understanding of the cultural restraints that might be part of a classroom teaching in regards to gender.
  - o Realise 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:
  - o Program a (Lego Mindstorm) robot or other.
  - o Solve a challenge in relation to programming.
  - o Be aware of some example of what programming can be used for in society.
  - o If discussed – realize that gender stereotypes might influence our choices.

PARTNER DETAILS

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EXPERI MENT ARIUM

Cover image: the Danish Science Center Experimentarium, Hellerup, Denmark.

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.

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.