Model of STEM/STEAM seminar for trainers of secondary school teachers

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General description of the workshop

Aims of the workshop

On the Internet and many other media, we can currently find a wide range of so-called STEAM activities, but whose educational goals are very diverse, even contradictory sometimes. This ambiguity and lack of consensus in the field not only hampers the work of teachers who would like to design and implement STEAM projects in their lessons, but also makes it difficult to establish common guidelines for promoting equity through raising self-efficacy in STEM through this educational strategy.

In particular, this workshop pretends to create a first space for dialogue between teachers in order to:

- Have a perspective of the main characteristics of the different so-called STEAM activities that can be found in the network.
- Establish a basic consensus on the definition of STEAM area.
- Establish a basic consensus on the definition of the characteristics of good school STEAM projects through the exchange of experiences between the participants and the analysis of several given examples.

A second part of this training, more focused on identifying and analyzing different strategies for promoting self-efficacy in STEAM projects at school, and designing particular activities for promoting self-efficacy, can be found in the collection of artifacts (hackathon for teachers).

Description

Target audience	This workshop is addressed to all teachers from primary and secondary schools who are interested in designing and/or implementing STEAM projects in their schools, or are already designing and/or implementing STEAM projects. Scientific, technological or mathematical background is not needed for participant teachers.
Duration	2h 15 minutes
Outline of the workshop and temporization	The workshop is structured around 4 main activities: 1. Knowing each other (30 minutes) 2. What do we already know about STEAM? (40 minutes) 3. Identification of key elements of STEAM projects (45 minutes) 4. Establishing a consensus of STEAM projects (30 minutes) The detail of these activities can be found in the following pages.

Authorship of the workshop

- Centre de Recerca per a l'Educació Científica i Matemàtica (CRECIM) - Universitat Autònoma de Barcelona (UAB)
- Florida secundària
- SINS Cardener

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Activity 1: Knowing each other

Aims of the activity

- To know each other participant teachers and the workshop leaders

The activity at glance

Duration	**30 minutes**
Group dynamics	Whole group together
Material	List of contrasting statements to know participant teachers (professional experience and preliminary knowledge and experience with STEAM projects). Some examples are provided below.
Role of the workshop leaders and considerations about self-efficacy	The role of the workshop leaders is to motivate and engage participant teachers into the activity and the subsequent activities of the workshop. In this first activity, special attention should be given to promote the inclusion and engagement of teachers coming from different areas than STEM, who can exhibit a low self-efficacy in STEM, as well as teachers with no classroom experience in the implementation of STEAM projects.

Description of the activity

This first activity is similar to *Take Sides* or *Extremes* icebreakers.

In the middle of the room, create an imaginary line. All the way on the left side is one extreme, and all the way on the right side is the other extreme. The workshop leader calls out a pair of statements and designates a side of the room on which players should stand to indicate their preference. After participants take place, the workshop leaders ask participants to explain their preferences.

Examples of some of the contrasting statements.

- Teachers from primary school / teachers from secondary school
- Teachers from the same city in which the workshop is taking place / teaches from another city
- Teachers with STEM background / teachers with no STEM background
- Teachers with more than 5 years of teaching experience / teachers with less than 5 years of teaching experience
- Teachers with 1 year or more implementing STEAM projects / teachers with no experience implementing STEAM projects at school

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Activity 2: What do we already know about STEAM?

Aims of the activity

- To give some theoretical indications about STEAM and STEAM projects to ease the group work and the consensus building afterwards.

The activity at glance

Duration	**40 minutes**
Group dynamics	Whole group together
Material	Powepoint presentation (some slides are provided below as an example) Computer and projector
Role of the workshop leaders and considerations about self-efficacy	As far as possible, the workshop leaders should have into account the national educational situation regarding STEAM and STEAM projects and the background of the participant teachers when preparing and leading the activity. Although this activity is mainly conceived as a lecture, promoting the interaction of participant teachers will facilitate the inclusion of different realities and experiences.

Description of the activity

This Activity 2 is conceived as a lecture in which the workshop leaders provide some theoretical indications and hints to participant teachers about STEAM and STEAM projects. This lecture should be structured around two topics:

- Providing a general perspective of so-called STEAM projects or activities that can be found on the net and are relevant for the national context
- Outlining a first definition of STEAM

As we consider that this workshop should be embedded on the national educational reality and the expertise of the participant teachers, it makes little sense to provide detailed indications about the content to be delivered. For this reason, in the following lines we will only provide some indications about the two main topics that we consider should be covered.

General perspective of STEAM projects

- Promote the discussion about what participant teachers consider it is STEAM with a possible slide like the following one:

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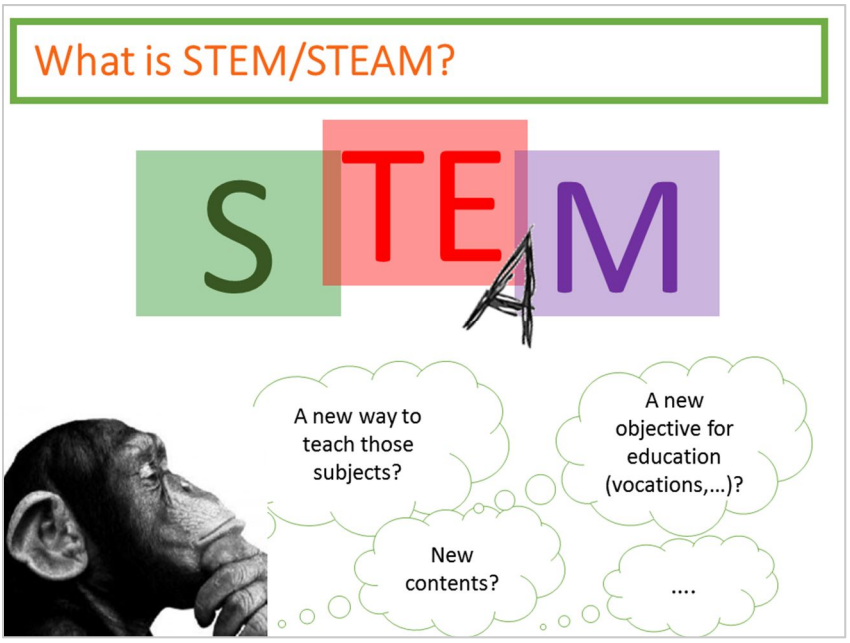

- Show different examples of so-called STEAM activities that can be found on the Internet. Ask participants which of those can be considered STEAM and why. It is recommended to show STEAM activities relevant for your educational context. Some examples…

  - Scratch
  - Arduino
  - Makey makey
  - Little bits

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    - STEAM Kids
- From the discussion, focus this preliminary analysis of different so-called STEAM activities on several aspects, like:
    - Does STEAM imply the use of new resources? (E.g. the introduction of new technologies in general, creative technologies, high-tech technologies, low cost tech…)
    - Does STEAM imply setting new educational objectives into the objectives? (E.g. orienting the action to the creation or design of objects, solving problems in an integrated way…) Does it imply a change into the classroom demands related with the activity?
    - Does STEAM imply the learning of new contents? (E.g. computational thinking)
    - Does STEAM imply the learning of new STEM contents) (E.g. programming, robotics…)
    - Does STEAM imply the learning of new transversal contents? (E.g. focus on creativity, solving problems, design thinking…)
    - Does STEAM imply the learning of new competencies? (E.g. develop the practice or way of thinking, doing and talking about engineering, science, mathematics in context…)
    - Does STEAM imply the learning of new methodologies? (E.g. Tinkering, Making, PBL, Learning by design…)
- It is important to consider with participant teachers how equity speaks in this preliminary analysis. In particular:
    - To which extent are these projects/activities multicultural, or offer a non-sexist perspective, respectful of different cultural and social background?
    - To which extent are these projects/activities targeting appropriately specific groups that are under-represented in the STEM field (e.g. women…)?
    - To which extent are these projects/activities inclusive in terms of taking into account learners that may have different mother tongues?

The aim of the discussion is trying to reach an agreement about what the participants think about these topics regarding STEAM

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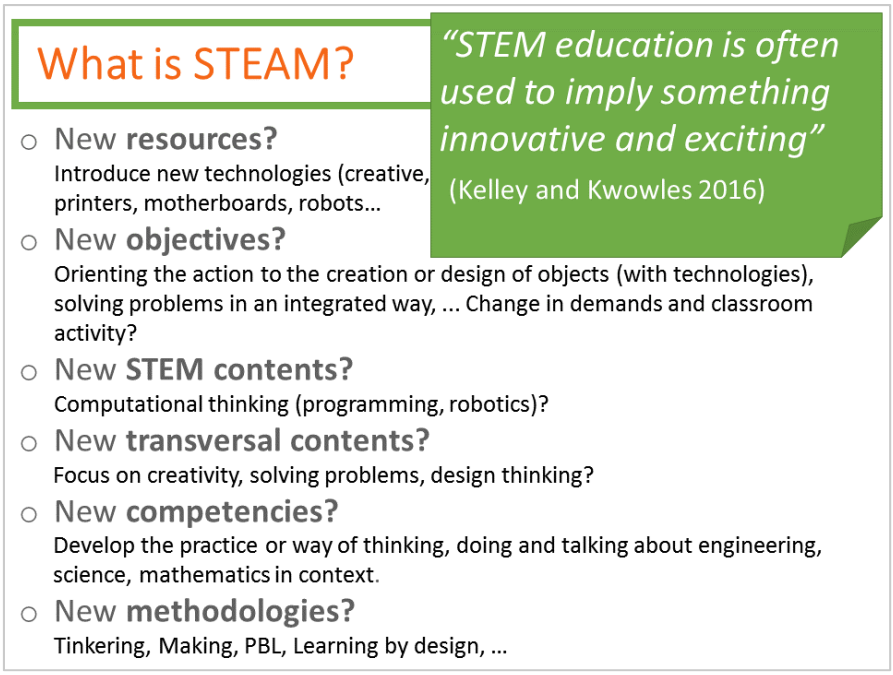
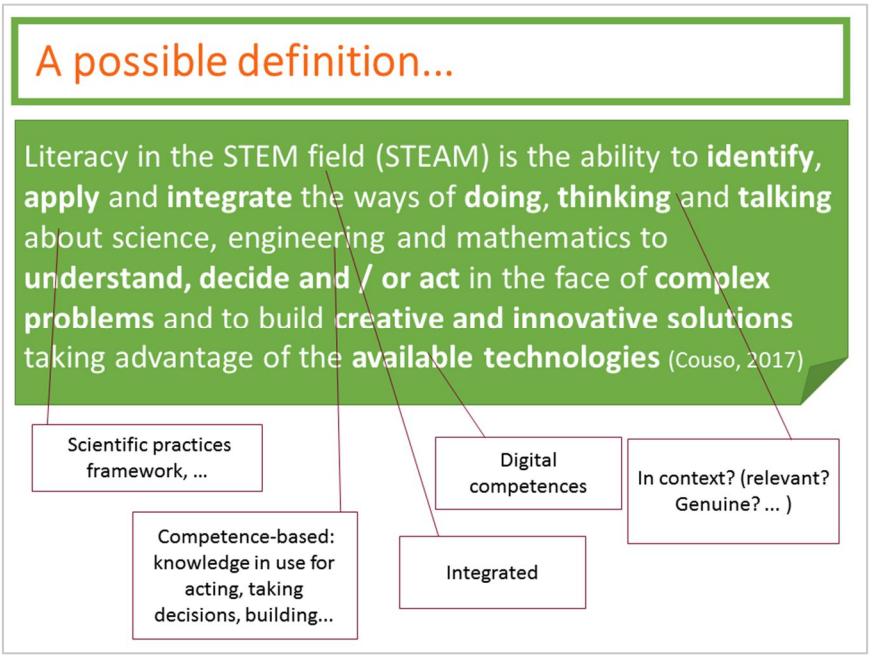


First definitions of STEAM

- From the discussion, a first definition of STEAM can be made. This definition setting can be carried out by identifying the characteristics in which there is a consensus and try to reach an agreement in those parts where there is a dissension. Another possibility is to project a possible definition and discuss with participants the main aspects of it, trying to refine it and build a first general definition of STEAM. In the implementation of this workshop we chose that last option, since we thought it would be faster than the first option and we wanted to prioritize the time for the activity 3.



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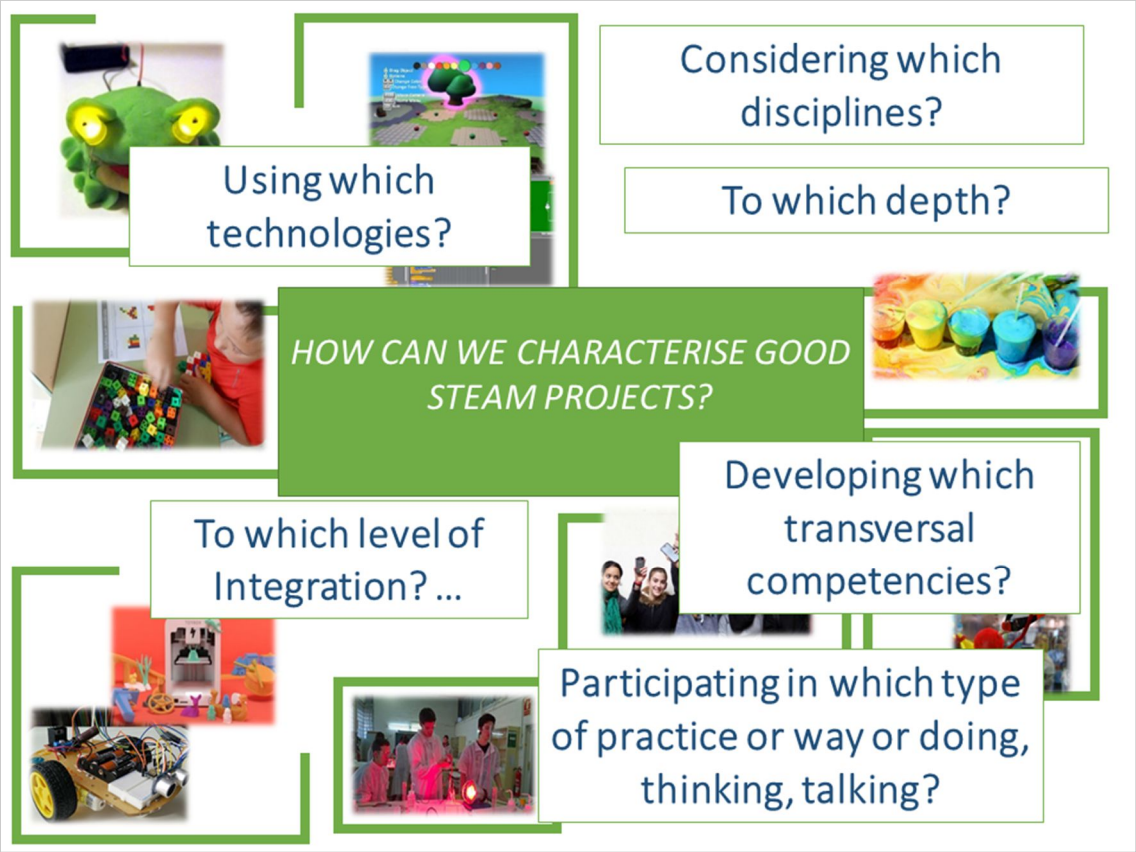
- Finally, as a second exploration, we suggest to revisit the different so-called activities STEAM with the first preliminary definition of STEAM in mind and refine the definition discussing with participant teachers different topics, like:
    - Which type of technologies have to be used in a STEAM activity? To which level of integration do they have to be within the activity?
    - Which disciplines/subjects have to be considered in a STEAM activity? To which depth do the subjects considered have to be tackled?
    - Is it necessary to develop transversal competencies in a STEAM activity? Which ones?
    - Are there any specific methodologies of work in a STEAM activity? Which type of practices, ways of doing, thinking or talking?
    - How this activities can offer a multicultural and non-sexist perspective? Which practices/technologies/competencies can target specific groups that are under-represented in the STEM fields? If STEAM activities makes use of high-tech technologies, how students of low socioeconomic background can participate in STEAM activities? Etc.



Activity 3: Identification of key elements of STEAM projects

Aims of the activity

The aim of this activity is to identify the elements that characterise a good STEAM project (for school context).

The activity at glance

Duration	**40 minutes**
Group dynamics	Work in little groups (5 people)
Material	Powepoint presentation (some slides are provided below as an example) Sheets with model of STEAM projects Computer and projector
Role of the workshop leaders	At the beginning of the activity, the workshop leaders will present the activity and lead the formation of groups. It is recommended to mix teachers with different professional experience, from different schools or having different background to promote a richer discussion. When the groups are working, the group leaders are expected to participate in each group, promote the dialogue among participant teachers and offer support to possible issues or doubts. Special attention to the diversity of the group members and the type of schools of origin should have to be paid.

Description of the activity

Presentation of the activity

The workshop leaders will propose to participants to analyse different STEAM projects in order to: (i) discuss the quality of the project; and (ii) discuss which characteristics do the group considers the project should have to be considered a good project.

To guide the discussion, several dimensions are proposed:

- **Educational objectives**: What do we think about the purpose or learning objectives? Which are they? Should they be these? What others could be?
- **Assignment**: What do we think about the assignment given to the students? What type is it this assignment? What skills/practices does it promote? What degree of experimentation does it allow?
- **Contents**: What do we think about the contents? Which contents appear? How are the contents delivered? (or how should be delivered?) Which contents are missing? At what level are the contents delivered?
- **Degree of interdisciplinary**: What level of interdisciplinary is the project promoting? What discipline or disciplines "lead" or guide the project? What others are used? To what degree are they integrated?

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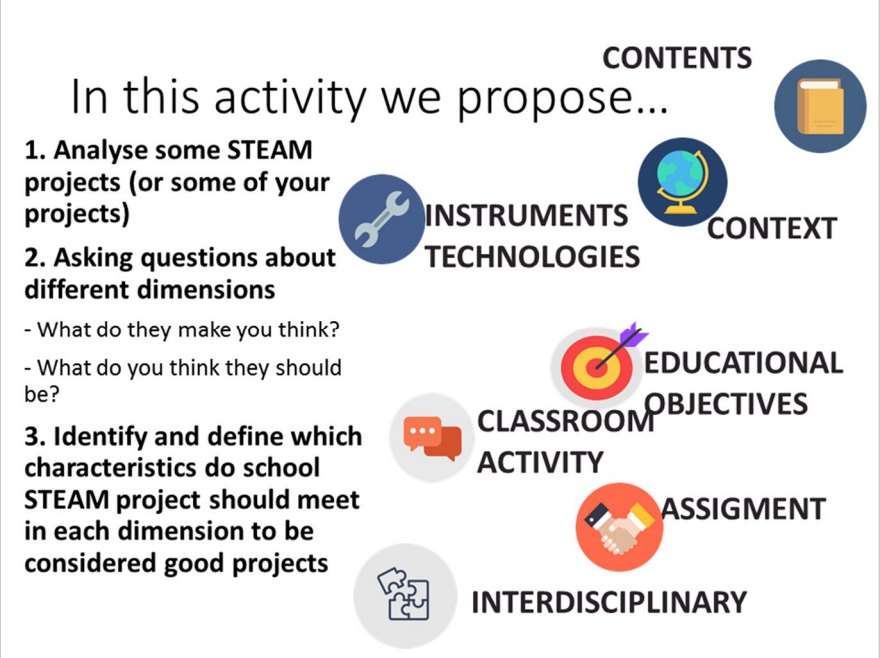
- **Context**: What do we think about the context? Which is it? How is it? What role does it play in the activity/project? What degree of authenticity does it allow?
- **Classroom activity**: What do we think of the classroom activity promoted? What ways of thinking, doing or speaking will be important in the classroom? Which kind of reasoning (scientific, engineering, mathematician) will the students use? Will you use S, TE or M techniques and procedures? In what ways?
- **Instruments/technologies**: What do we think of the technologies used in the project? What are they used for? Why are they used? What do they bring? What do they limit?
- **Other:** (how to evaluate? how to manage the class? How long is it necessary to finish the project?)



Analysis of STEAM projects

The aim of this activity is that the groups analyze STEAM projects that are relevant in their own educational context. In this sheet some examples are provided, though the analysis of school projects that are already being implemented is more recommended.

To ease the analysis of the projects, we recommend to prepare a sheet in which each group will pour the results of their discussion. An example is provided below:

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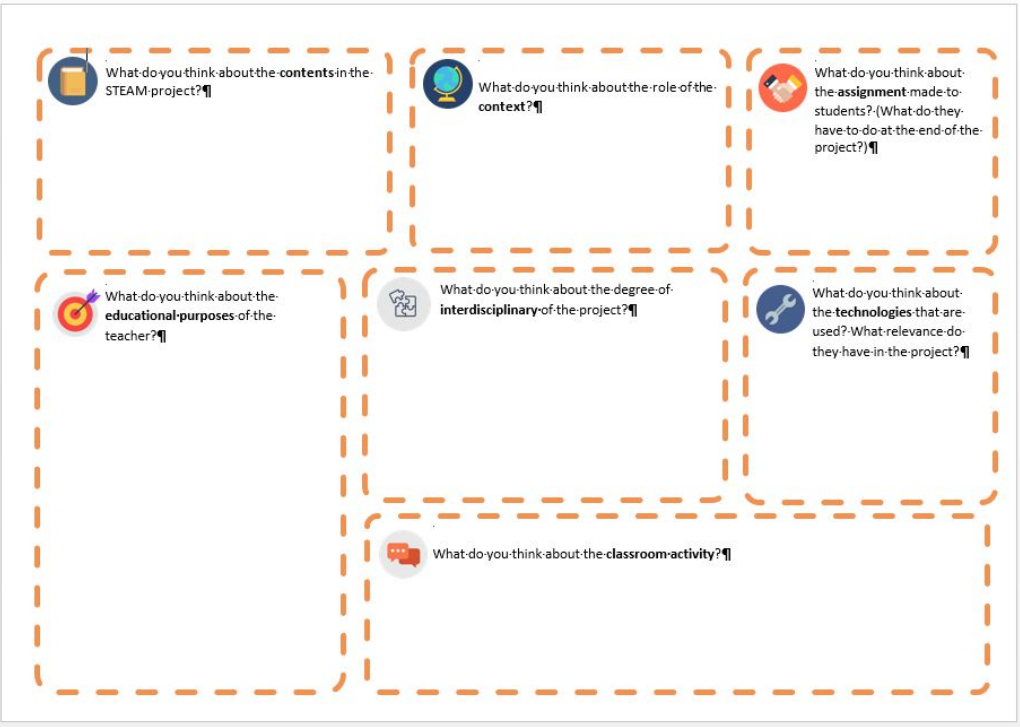

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Examples of projects to analyse

"Heat Loss" project

https://www.teachingchannel.org/videos/stem-lesson-ideas-heat-loss-project

In this project the students build and test a **model of a house** to study the energy losses. The goal is to determine the places in the designed structure where more heat is lost and establish strategies to improve the prototype to avoid these heat losses. In order to find out where these losses occur, they use thermometers and thermal imaging. As they apply changes (putting windows, different construction materials), they test them and verify their effectiveness. Students talk about energy transfer, for example they say "energy goes out faster ..." during their project.

Students' work is based on collecting data and organizing it in a data table. Reflection among students is based on the data gathered and is triggered at the end of the session with questions such as: "What do your data suggest about how heat energy moves?"; "How do you think that you benefit from energy conservation in your family?"

QUESTIONS TO GUIDE THE GROUP DISCUSSION

- ❑ **What do we think about the purpose or learning objectives?** Which are they? Should they be these? What others could be?
- ❑ **What do we think about the assignment given to the students?** What type is it this assignment? What skills/practices does it promote? What degree of experimentation does it allow?
- ❑ **What do we think about the contents?** Which contents appear? How are the contents delivered? (or how should be delivered?) Which contents are missing? At what level are the contents delivered?
- ❑ **What level of interdisciplinary is the project promoting?** What discipline or disciplines "lead" or guide the project? What others are used? To what degree are they integrated?
- ❑ **What do we think about the context?** Which is it? How is it? What role does it play in the activity/project? What degree of authenticity does it allow?
- ❑ **What do we think of the classroom activity promoted?** What ways of thinking, doing or speaking will be important in the classroom? Which kind of reasoning (scientific, engineering, mathematician) will the students use? Will you use S, TE or M techniques and procedures? In what ways?
- ❑ **What do we think of the technologies used in the project?** What are they used for? Why are they used? What do they bring? What do they limit?

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- ❑ **Other:** (how to evaluate? how to manage the class? How long is it necessary to finish the project?).

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"Materials Science" project

http://lsg.ucy.ac.cy/MaterialsScience/

During this project, students analyze phenomena related to sound and certain materials in order to make decisions to acoustically condition different spaces in a disco. To do this, students design different experiments and use sensors (sound level meters) and digital magnifiers. Based on the data gathered, the acoustic behavior of different materials and other properties are studied. As well, data gathered allow students to differentiate and to imagine the internal structure of absorbent and acoustic reflectors.

Students are encouraged to discuss in a group work and reach an agreement about the ideas they consider important to explain different observed phenomena, and about the structure and explanation of properties of different materials. Some of the questions that must be answered are: "How do you imagine this material on the inside to behave an acoustic reflector on the outside? And an acoustic absorber?"; "How can we explain that the properties of a material influence their acoustic behavior?" Finally, from this theoretical construction they can address questions about which materials are better or worse to isolate an establishment based on scientific evidences.

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Caminalcules project
https://sites.google.com/a/xtec.cat/caminalcules/

In this project, students are expected to work collaboratively to establish the taxonomy and phylogeny of diverse invented animals (so-called *Caminalcules*). Evidence, such as images, fossils and other information on how other scientists have built their theories about the process of evolution are provided to students so they can establish their own hypotheses. At some point, students are expected to explain and defend their theories about the creation of *Caminalcules* through evolution against their peers and establish a basic consensus on the knowledge they reach. During the process, students should continuously rethink their ideas, challenging the security they have in their hypotheses and defend very well the criteria they use based on the reasoning's' similarity with the scientific community.
Some of the questions to which the students are exposed are: "how sure are you that this species is located here?"; "On what basis do you use this classification criterion rather than this other one?"


QUESTIONS TO GUIDE THE GROUP DISCUSSION

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- ❑ **Other:** (how to evaluate? how to manage the class? How long is it necessary to finish the project?).

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Math in Fashion

http://www.thirteen.org/get-the-math/teachers/math-in-fashion-lesson-plan/overview/74/

Using video segments and web interactives from *Get the Math*, students engage in an exploration of mathematics, specifically proportional reasoning and sense making, to solve real world problems. In the Introductory Activity, students view a brief profile of a young professional who shares her passion for fashion design and who presents a fashion-related math challenge. In Learning Activity 1, students work in small groups to calculate the wholesale price of the garment and to determine what changes could be made to the garment to meet the target retail price point. (Students can solve the problem using handouts provided in the lesson and/or by using an online simulation.) Students summarize how they solved the problem and view the strategies and solutions used by the *Get the Math* teams. In Learning Activity 2, students explore an online simulation on the *Get the Math* website to tackle other similar fashion-related challenges. In the Culminating Activity, students reflect upon and discuss their reasoning and talk about the ways in which algebra can be used in the world of fashion and beyond.

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- ❑ **Other:** (how to evaluate? how to manage the class? How long is it necessary to finish the project?).

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"Mosquito Alert" project
https://www.cdc.gov/zika/public-health-partners/cdc-zika-interim-response-plan.html

In this project, students are asked to become members of the Disease Control Centre where they have to work with the case of an infection of mosquito-borne viruses and provide proposals for their control. Some of the topics in which the students can focus are: the mosquito habitat, its life cycle, prevention technologies, the environmental impact of its reduction or elimination, virus transmission efficiency, economic impact, etc. Students choose how they want to address the problem, search for information, etc. Final students' proposal to tackle the problem has to reflect that different alternatives have been studied and the best option has been chosen for the majority of the population.

QUESTIONS TO GUIDE THE GROUP DISCUSSION

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Project…

[Write a description of your project here]

QUESTIONS TO GUIDE THE GROUP DISCUSSION

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- ❑ **Other:** (how to evaluate? how to manage the class? How long is it necessary to finish the project?).

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Activity 4: Establishing a consensus of STEAM projects

Aims of the activity

This final activity is aimed at sharing the results of the group work and establishing a consensus about the characteristics of good STEAM projects among participants

The activity at glance

Duration	**30 minutes**
Group dynamics	Whole group together
Material	PowerPoint presentation Computer and projector
Role of the workshop leaders	Workshop leaders will act mainly as moderators, trying to group together participants' considerations to reach an agreement.

Description of the activity

First round: Each group explains to the rest of the groups the results of their work:

- How do they have characterized the STEAM project? Which strengths have they identified? Which weaknesses?
- Which of the projects' characteristics should be requisite features of good STEAM projects?

While each group is talking, the workshops leaders act as a recorder, writing the exact words of participants in a PowerPoint presentation, so everyone can see them. The rest of the groups take notes about things they agree, disagree and have doubts.

Second round: Discussion of the ideas exposed

If necessary, each group at least jot down their participants' ideas in 1–2 minutes before sharing orally and discussing; this ensures that everyone has had an opportunity to get their ideas down.

After this moment, each group shares their considerations about other groups' analysis of a STEAM project. The aim of this part, and the role of the workshop leaders, is to try to merge the discussion to a particular proposal in order to reach a consensus.

Final: at the end of the discussion, the workshop leaders will read the statements in which there have been a consensus.

A slide is presented as an example of the agreements reached in the STEAM seminar conducted the 30th of June 2017.

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Sharing orally

- ABOUT THE **CONTENTS**
  - Importance of making clear which content to work (few, but in depth).
  - Contents are better to be learnt during the project rather than before or after.
- ABOUT THE **CONTEXT**
  - We say motivating, relevant, near... But it depends on who we are talking about! The key: creating the need for students
  - Importance of ever choosing a genuine / authentic context
- ABOUT THE **INTERDISCIPLINARITY**
  - Integrate only those disciplines/subjects which are relevant to solve the proposed problem.
  - Usually there is one discipline/subjects acting as leader.
  - Not all disciplines/subjects are expected to be studied in-depth.
- ABOUT THE **DEMAND** MADE TO THE STUDENTS
  - We need to set a challenge with different modes of success (but we need to inform students about what they have achieved and what not).
  - The demand must be clear
  - The demand should be functional (useful), and better for someone of the outside
- ABOUT TECHNOLOGIES
  - They must be the vehicle, not the purpose of the STEAM project

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