


Curious about

S **TE** **EM**

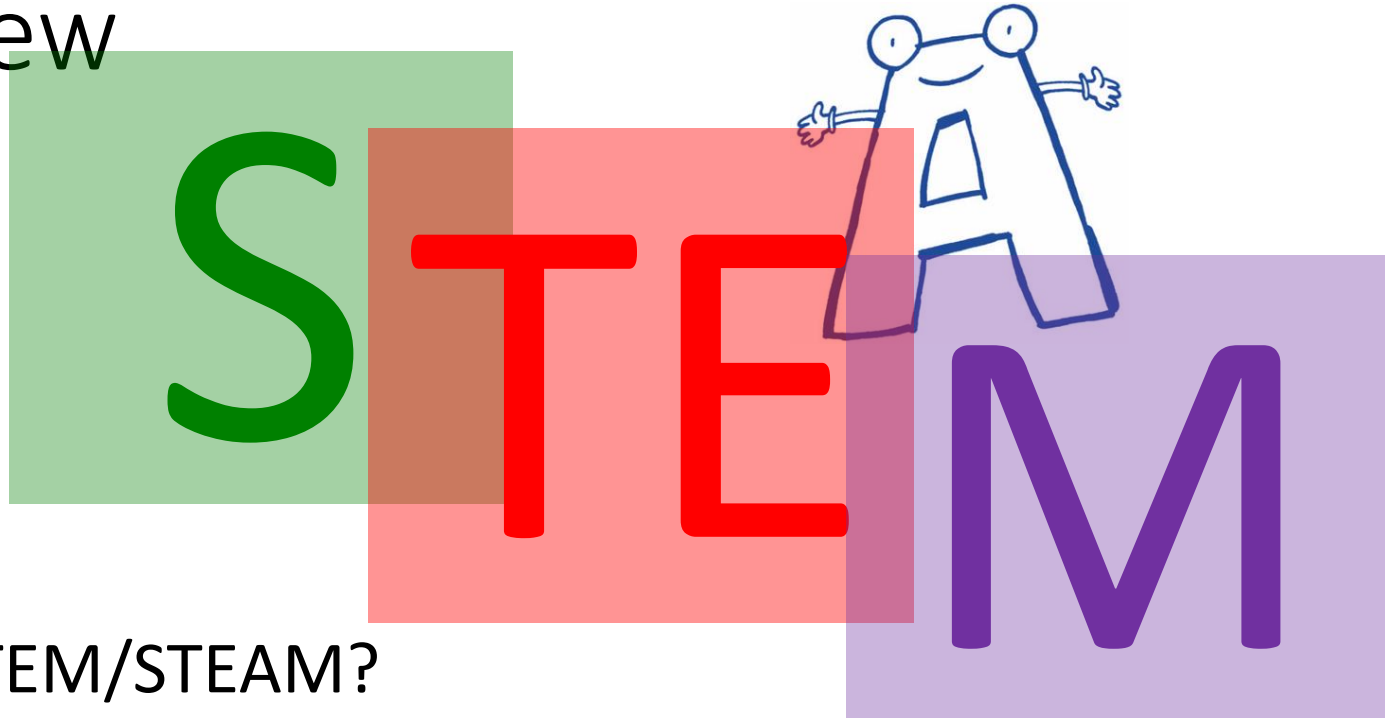


Ideas on why, how and what
of STEM education

Digna Couso (CRECIM Director), 30th November, 2021

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Overview



- What is STEM/STEAM?
- What for STEM/STEAM?
- What does it mean to be competent en STEM/STEAM?
- How to use and raise curiosity in STEM/STEAM?
- What sort of STEM/STEAM education do we need?



What is STEM?





forever
imagine
program
share



SCRATCH



What is STEM?

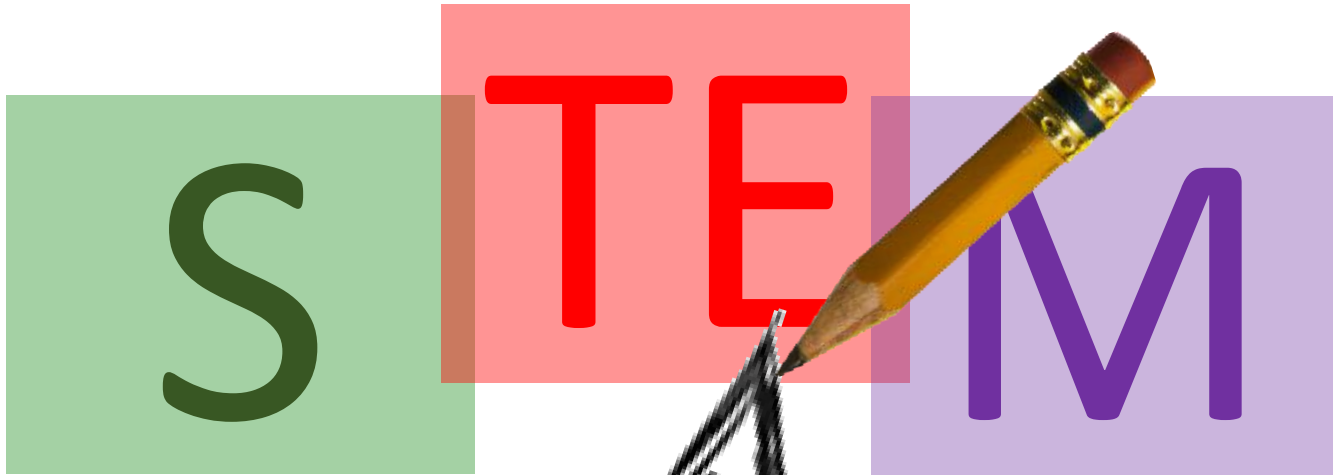


“STEM education is used to refer to something innovative and exciting”
(Kelley and Kowles 2016)



What is STE(A)M?

Science Technology Engineering Mathematics



Economy, environmental sciences, medicine,

(More than 70 disciplines!!!)

Visual Arts? All of the arts?
Desing? Creativity?
Humanities ?? (Liberal Arts)
Everything ??(All)



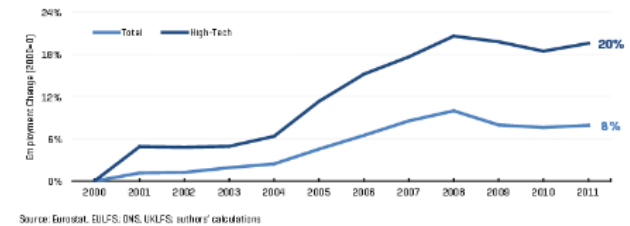
More important than what... *what for?*

Europe
needs
more
scientists

STEAMcat

Many different discourses /arguments in the STEM world (economical, political, professional, educational, ...)

EU-27 Employment Change versus 2000 by Sector (2000-2011)



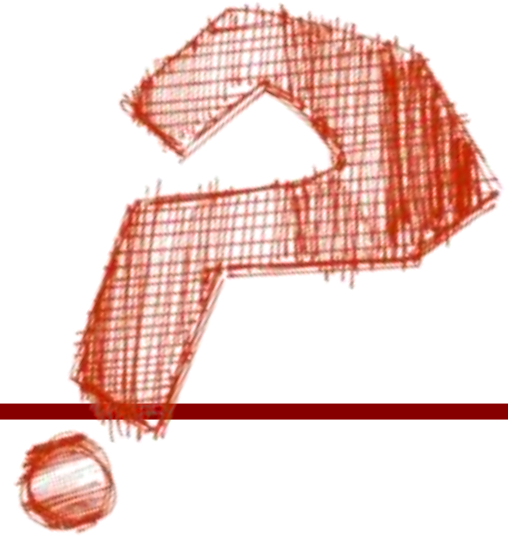
For us, STEM education should focus on developing:

- **competence in the STEM field** to positively transform our world
- **positive STEM identity** compatible with your other selves



What does it mean to be
competent in

S T E M



An attempt to define STEM competence

(Couso 2017, based on Balka 2011 and NRC 2012)

BE ABLE TO

Be able to **identify, apply and reflect** upon the way we **think, do and talk** in **Science, Engineering and Mathematics** in a more or less integrated fashion to **understand, decide and act** on complex problems and to **build** creative solutions

WITH
VALUES

using the appropriate technologies and collaborating with others

in a critical, reflective and value-driven way

STEM
PRACTICES

IN
CONTEXT

WITH
RESOURCES

An attempt to define STEM competence

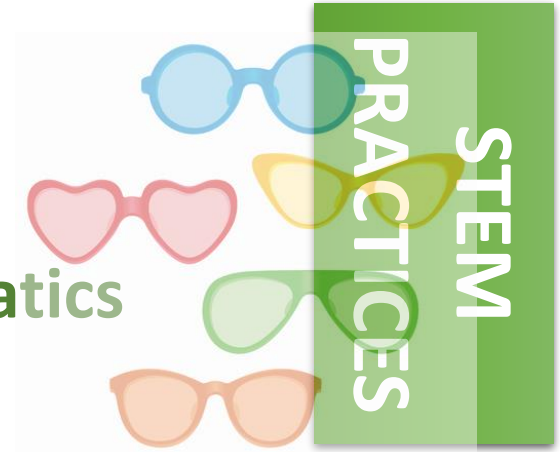
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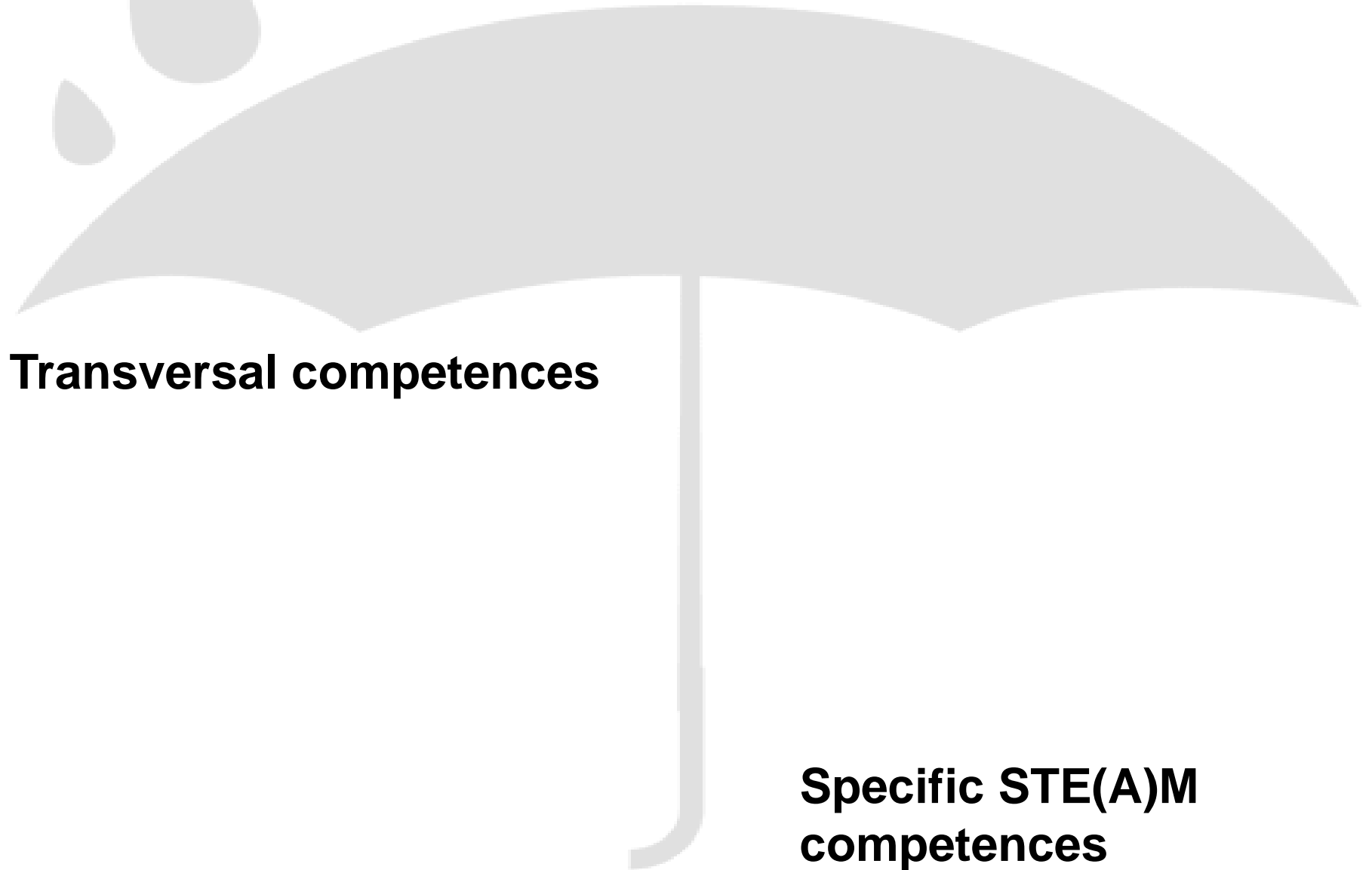
IN
CONTEXT

WITH
RESOURCES

WITH
VALUES

This implies a global competence...

(Surr et al, 2016)



Transversal competences

**Specific STE(A)M
competences**

This implies a global competence...

(Surr et al, 2016)

Transversal competences



DIGITAL COMPETENCE 2.0

Information search
Content creation
Digital security
Digital ethics
Cooperation and
digital communication

....



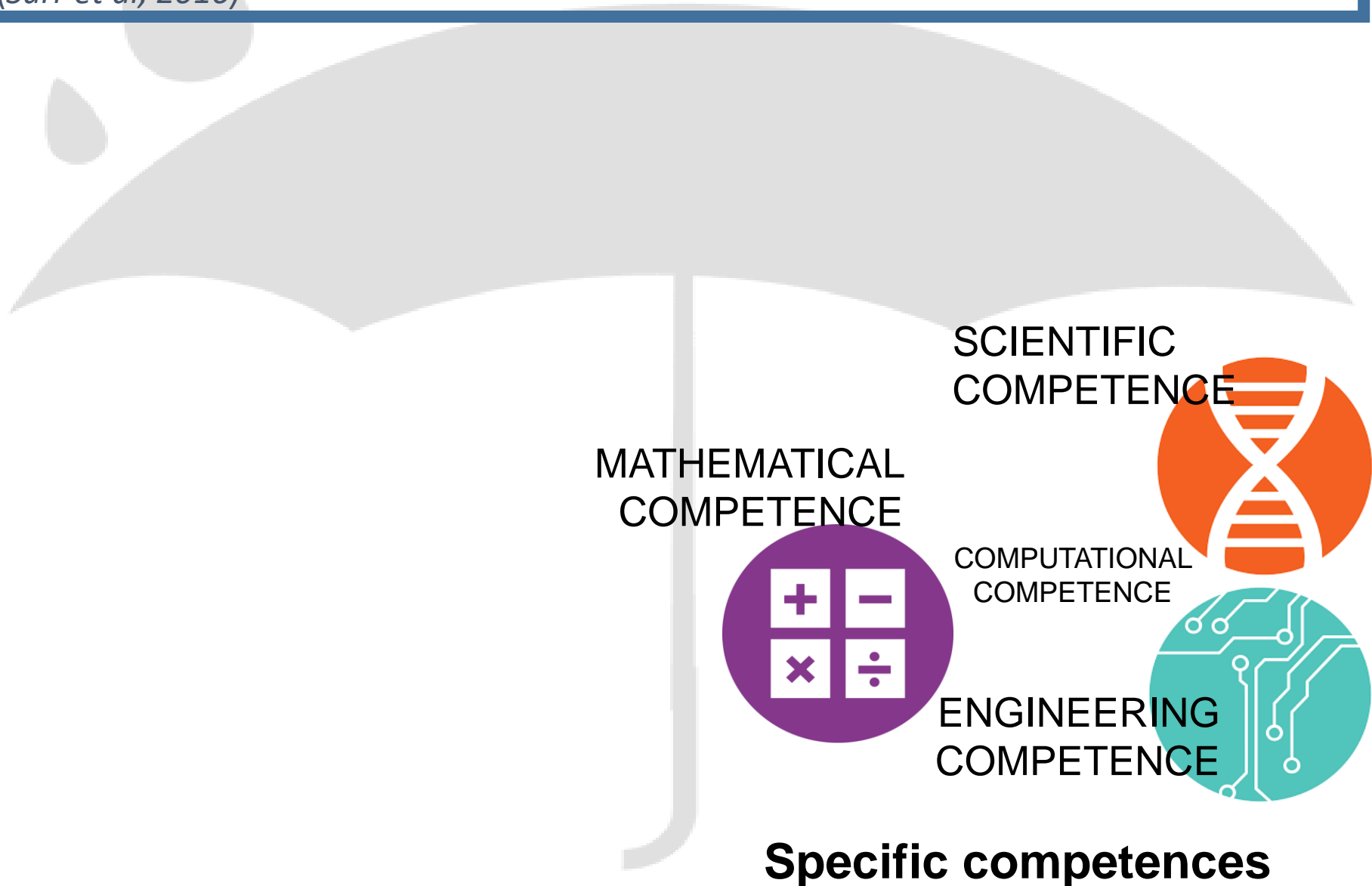
PARTICIPATORY COMPETENCE

S. XXI COMPETENCES (4Cs)

Critical thinking
Communication
Cooperation
Creativity

This implies a global competence...

(Surr et al, 2016)





Science practices

Observe and investigate phenomena to develop scientific models useful for describing, predicting and explaining the natural world in an evidence-based manner

- Asking scientific questions (researchable ones)
- Developing and using scientific models to describe, predict and/or explain natural phenomena
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking to explore natural phenomena
- Constructing explanations in an evidence-based manner
- Engaging in argument from evidence. ...
- Obtaining, evaluating, and communicating scientific information

(adapted from NCR 2012)



Engineering practices

Identifying and/or developing multiple solutions to be able to test, select and/or materialize the optimal one

- Developing and using prototypes and simulations
- Planning and carrying out tests
- Analyzing and interpreting data to identify points for improvement
- Using mathematics and computational thinking, scientific models and available technologies
- Identifying and/or developing multiple solutions and selecting the optimal one
- Materializing the solution
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information

(adapted from Simarro & Couso 2021)



Mathematical practices

Develop and use mathematical tools, strategies and concepts to solve real and ideal problems

- Identify mathematical concepts to generate problems
- Develop mathematical hypothesis, conjectures,
- Plan the mathematical solution of a problem and carry it out
- Test mathematical solutions to problems
- Use computational thinking, scientific models and available technologies
- Develop mathematical concepts useful in different situations
- ...

How can we develop such a global competence?

Transversal competences

S. XXI COMPETENCES (4Cs)

Critical thinking
Communication
Cooperation Creativity

COMPUTATIONAL COMPETENCE

SCIENTIFIC COMPETENCE

MATHEMATICAL COMPETENCE

ENGINEERING COMPETENCE

PARTICIPATORY COMPETENCE

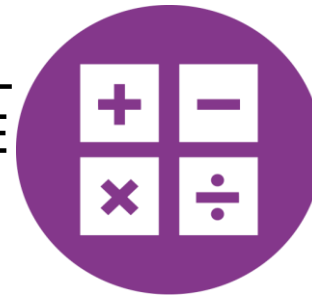
Specific competences



DIGITAL COMPETENCE 2.0

Information search
Content creation
Digital security
Digital ethics
Cooperation and
digital communication

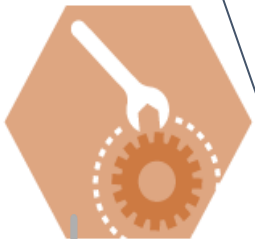
....



How to do
STEM?

To develop at the same time both specific and transversal competences





Tinkering



APPROPRIATE METHODOLOGIES

(problem-driven, context-based, cooperative)

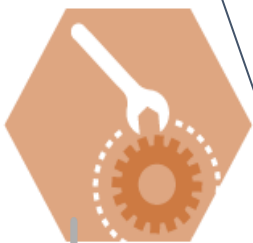
PBL, tinkering, making, gamificación, IBSE,...

How to do

STE(A)M?

To develop at the same time both specific and transversal competences





Tinkering



SSI, Citizen Science,
Environmental Education,
Social engineering,
STEAM,.....



AA

ADEQUATE
PERSPECTIVES

(critical, cross-disciplinary,
value-driven)

APPROPRIATE
METHODOLOGIES

(problem-driven, context-
based, cooperative)



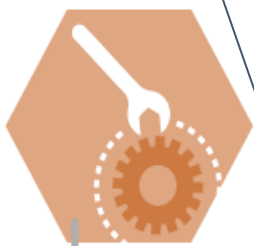
PBL, tinkering,
making,
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IBSE,...

How to do

STE(A)M?

To develop at the same time both specific and transversal competences





Tinkering



SSI, Citizen Science,
Environmental Education,
Social engineering,
STEAM,.....



AA



ADEQUATE
PERSPECTIVES

(critical, cross-disciplinary,
value-driven)

FAVOURABLE
TECHNOLOGIES

(creative, accessible,
sustainable)

Sensors, apps,
3D printing, ...

APPROPRIATE
METHODOLOGIES

(problem-driven, context-
based, cooperative)

How to do

STE(A)M?

To develop at the same time both specific and transversal competences

PBL, tinkering,
making,
gamificación,
IBSE,...

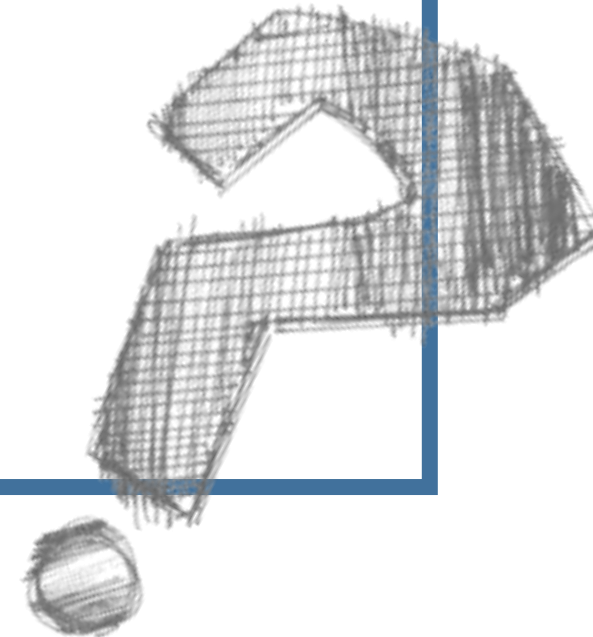


How to use and raise curiosity in/at

S

TE

M



Whatever the methodology, perspective, Technology,....
each STE(A)M project starts with and is guided thanks to
QUESTIONS



Students' questions,
teachers' questions,
global questions....

CURIOSITY IS NOT THE
ONLY DRIVER OF STEM
ACTIVITY... Willingness
to act, Love for truth,
moral imperatives,
values,....

STE(A)M project



Questions, or good questions?...

Read the text carefully:

Pinnimours are a type of munchis. Pinnimours live in the chunches and have four katris that help them to isportive. Pinnimour eat loviballs and cumuns.

Questions, or good questions?...

Read the text carefully:

Pinnimours are a type of munchis. Pinnimours live in the chunches and have four katris that help them to isportive. Pinnimour eat loviballs and cumuns.

Let's see if you understand it!

- What are pinnimours? What do pinnimours eat?
- Where do pinnimours life?
- How many katris do pinnimours have?
- Why are katris useful to pinnimours?

The power of good questions...

Pinnimours are a type of munchis.

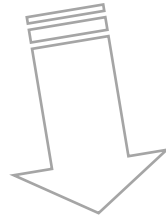
Pinnimours live in the chunches and have four katris that help them to isportive.

Let's see if you REALLY understand it!

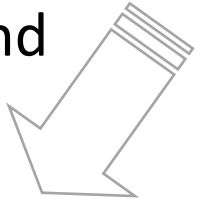
- What other munchis do you know, a part from Pinnimours? (INFERATIVE QUESTIONS)
- Why do you think pinnimours live in the chunches?
- Can you imagine other ways of insportive a part from the use of katris? (CREATIVE QUESTIONS)
- Are you in favour of the captivity of pinnimours for their survival? (EVALUATIVE QUESTIONS)

How are typical school questions?

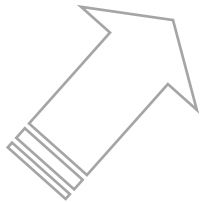
Either you know it or don't: they do not promote thinking or action



The Student can look for information in the computer, apply an algorithm automatically, etc (SIRI and ALEXA could also do it!)



What is the photosynthesis?
How much is the value of the speed?
How do you define a solid?



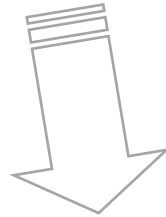
Only one answer is valid and expected

They do not promote more questions neither transfer



How are the *GOOD QUESTIONS*?

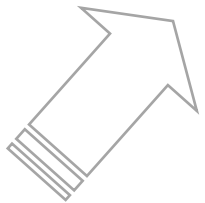
They connect with experience: everybody can say something



You can not look for the answer elsewhere: it needs your thinking, your inquiry, your opinion,...



What do you do at home to prevent your plants from dying?
Why do you think you do it and how would you test if it is a good strategy?



There are different valid answers and ways of answering

They promote more questions neither transfer





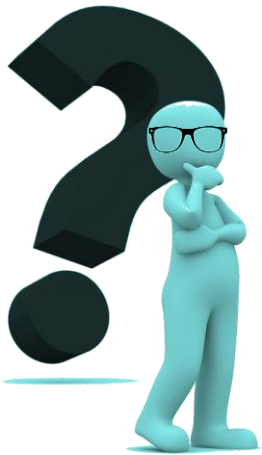
Typical questions to promote scientific practices

- How this is? *What do you think it is made of?*
- How does it happen? *How do you think it is made of so that it happens what it happens?*
- *Can you imagine ways of making it going further / quicker /...?*
- Can we represent what is happening in different ways? With drawings, words, arrows,...
- How is it now? *What do you think is going to happen in a while?*
- *What is /is happening now? What do we think it was/ it was happening before? What do we think it would be later?*
-





Typical questions to promote engineering practices



- How does this thing work, in particular? *What mechanism do we imagine is functioning here?*
- What other things (machines/programmes/protocols) that function similarly do we know? *What others things (machines/programmes/protocols) that function differently to do the same work can we imagine?*
- How can we assemble it or split it into parts? *Can we imagine something that would be able to do that thing?*
- How can we test that it works? What different ways of testing that it works *can we imagine?*

Typical questions to promote mathematical practices

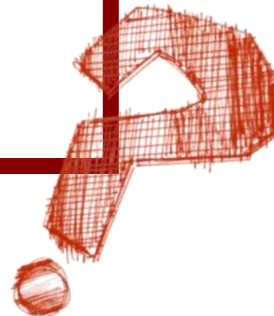


- How much is there? *What different ways do we have to know how much (smarties, WC paper,...) is there?*
- How can we calculate/approximate the amount of xxx to be able to YYY? How can we know we are right? *What other ways of knowing if we are right we can find?*
-

What sort of

S T E M

Education do we do /
do we need



What is STEM education for you?

RELATED TO
NEWNESS /
INNOVATION

A TECHNO-FRIENDLY/
TECHNOSOLUTIONISM
VIEW

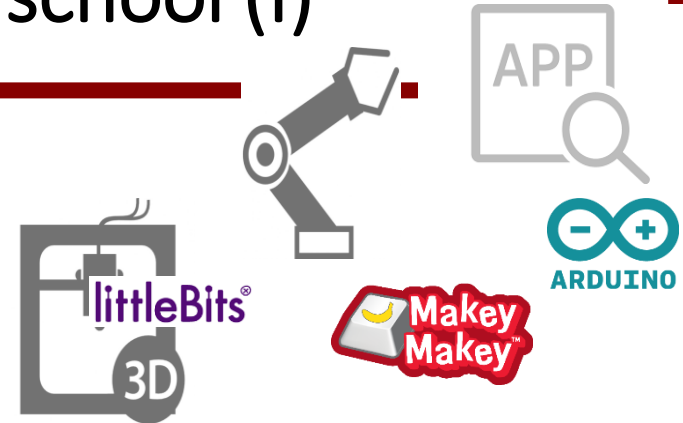
ASSUMES
INTEREST AND
MOTIVATION

IT NECESSARILY NEEDS TO BE
INTERDISCIPLINAR...



Common syndromes of the STEM school (I)

- *Shopping-syndrome* or the compulsive shopping for digital / creative/programable technologies.
- *Rainbow-syndrome* or the imperative need for everything to be beautiful and colorful (particularly with STEAM)
- *DIY-syndrome* or understanding of STEM as tinkering and making, instead of *talking to understand, understanding to solve, thinking to make, making to think...*

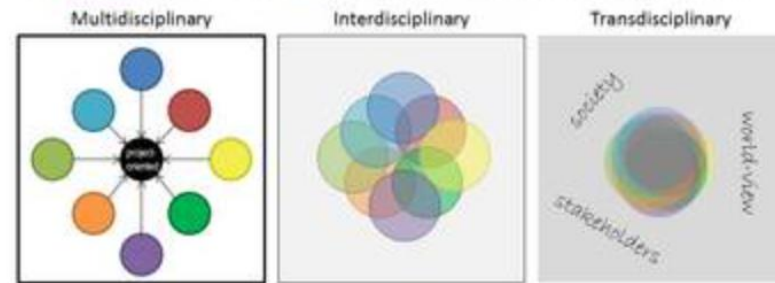


Common syndromes of the STEM school (II)

- *Syndrome “we already do scratch”*: STEM as tablets, computers, computational thinking, ...
- *Syndrome “as much as possible”*: introducing in every STEM Project all the disciplines possible, even if they are forced or deal with at superficial level
- *Syndrome “forgetting what we know, who we are”*: loosing what we already do right, it is part of our essence and we are proud of

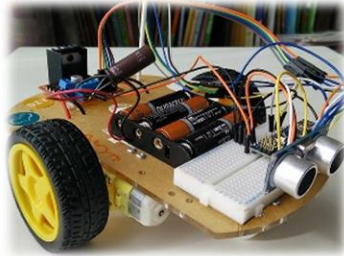


Multi- → Inter- → Transdisciplinary

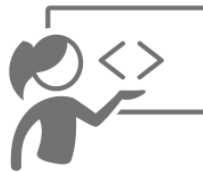




STEM education with values

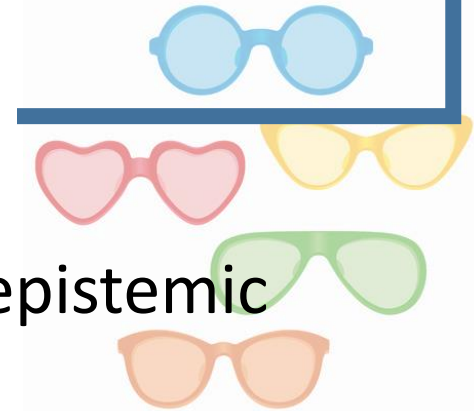


**Sustainability,
Equity and inclusion,
Social justice**



Some advice to “re-orient” STEM in your school

(Couso & Simarro, 2020; Simarro & Couso, 2021; Couso, Mora y Simarro 2021)



- Focus on STEM competence by prioritizing epistemic quality to interdisciplinarity:
 - Emphasise the way each discipline sees the world, experience the change of glasses
 - M in STEM is more than using the calculator. S in STEM is more than the definition of a scientific concept; E in STEM is more than building something; A is more than decorating
 - Use good (productive vs reproductive, inferative, creative, evaluative, open questions)
- Do not lose yourself in STEM
 - Environmental projects, SSI, IBSE, PBL,... what was working before Will work now and can be enriched
- Do not forget values in STEM
 - STEM with and for sustainability, social justice, equity and inclusion
- *Do not assume a positive stance from your pupils:*
 - *If they like it, enjoy it, take good marks, etc does not imply they identify with STEM neither they are developing aspirations in STEM or developing enough STEM competence*
 - *Girls, disadvantaged students and everyone else need to feel that you believe they are Good enough for STEM and that the STEM field would benefit from someone as special as them*
 - *Do not forget a gender and equity perspective: a participatory approach that welcomes all*

Gràcies!



S

The word 'STEM' is presented in a stylized, blocky font. Each letter is contained within a semi-transparent colored square that overlaps with the others. The 'S' is in a green square, the 'T' and 'E' are in a red square, and the 'M' is in a purple square. The letters are arranged horizontally from left to right.

TE

M

@dignacouso

digna.couso@uab.cat

What does it mean a
positive

S T E M

identity



A framework for students' stance on STEM

(Couso & Grimalt, 2019; Grimalt & Couso, 2019; Grimalt & Couso, in press).

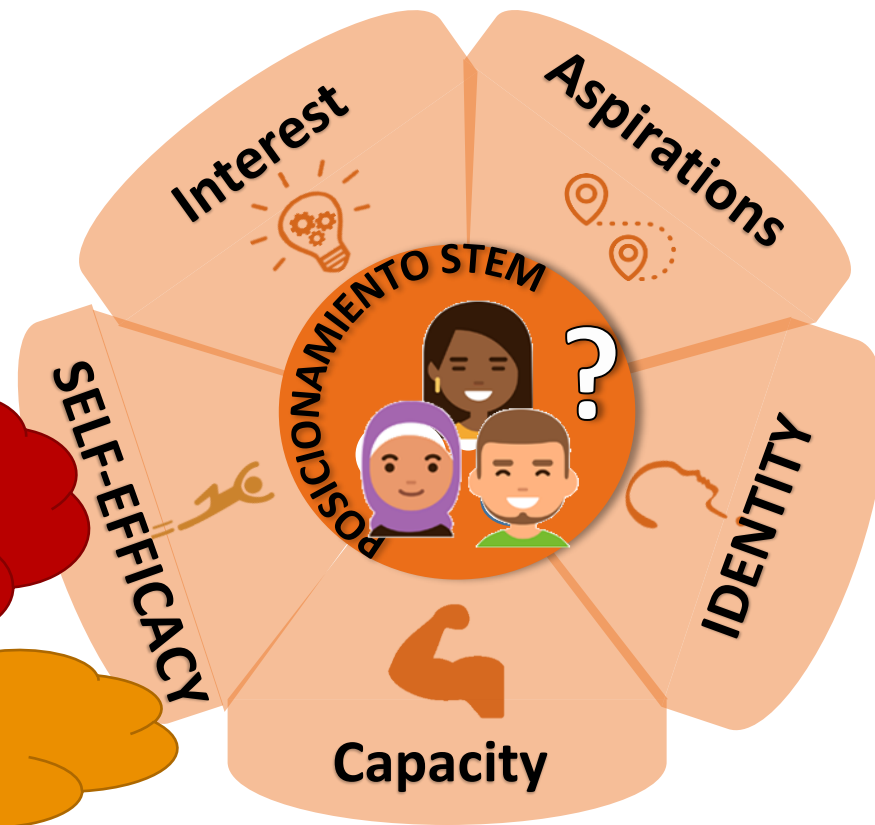
The way a person thinks, feels, speaks and acts in relation to the STEM field, that is, their position on STEM-related topics, agents and activities

Our stance on STEM is formed with the family, in the school and in society, and it is affected by a series of affective and cognitive variables:

- Interest
- Capacity
- Aspirations
- **SELF-EFFICACY**
- **IDENTITY**

I AM NOT GOOD ENOUGH FOR STEM

STEM IS NOT FOR PEOPLE LIKE ME

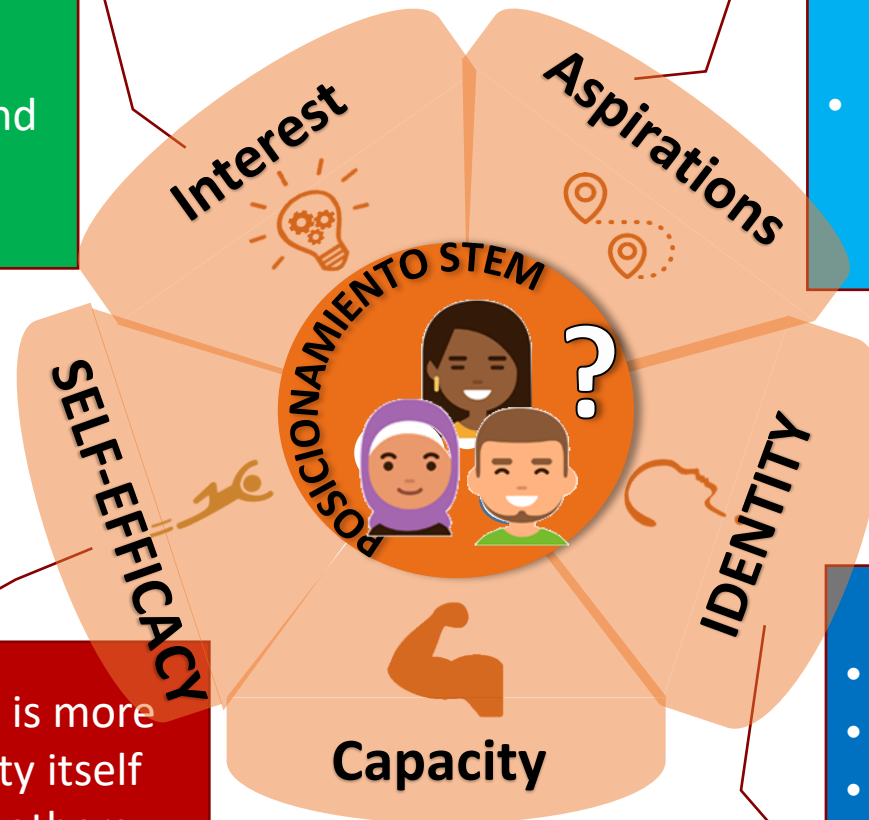


https://ddd.uab.cat/pub/l1ibres/2019/206832/steforyou_a2019iENG.pdf

What does research tells us?

- Interest is not so important!
- There is a gender effect
- topics with social and enviromental relevance

- Aspirations are very limiting factors: we become interested in what we aspire to
- Importance of family science capital
- Not enough orientation / vocational info provided



- Perception of capacity is more important than capacity itself
- Based on the views of others
- It is the most gender-oriented variable (together with fear of failure)

- More limiting variable
- Developed very early
- Need to reconcile who/how they are with who/how they think STEM people is



What is the STEM stance of our youngs.

