Cluster 1, sesión 1

ICSE Academy, International Workshops Series

12 March, 2024

Sustainability and Socio-Scientific Issues (SSI)

in STEM education

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The privilege to be here….

From a narrow to an **expanded view** of possibilities for STEM teaching

The power of….

Exchanging resources, strategies, ideas, experiences

Don’t be afraid of barriers…

We are **here to help** and support

Moderators

Multimedia

Multiple ways of communication

Overview of the session

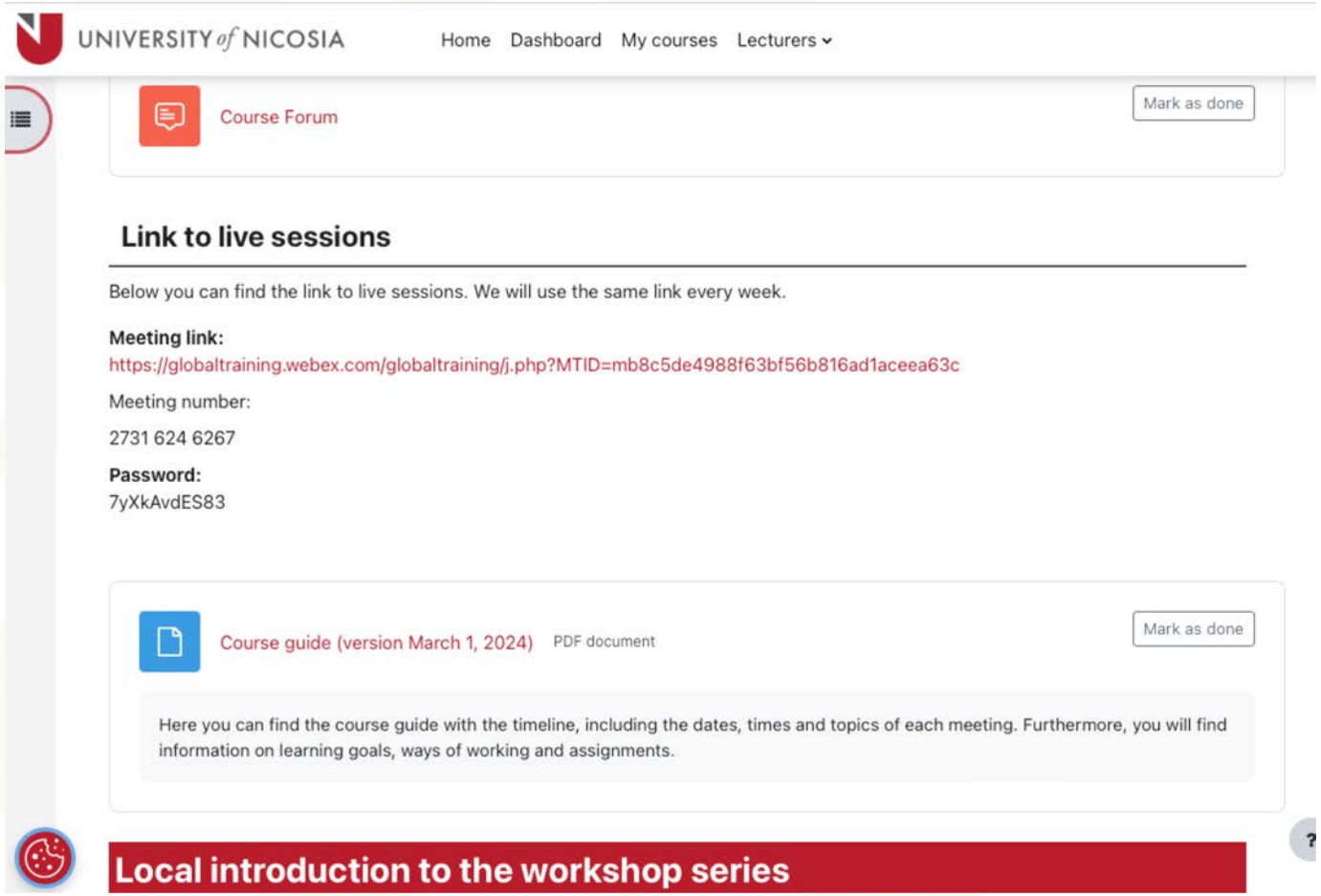
- Building a picture of the whole group.
- Basic information about how we are going to work.
- Why this cluster? Overview and connection of the different sessions
- Sustainability and STEM education through school community projects.
- A flavour from a concrete experience: exploring different examples
- Key features of effective activities for STEM sustainability education.
- Feedback from experience: sharing data from 30 case studies.
- Exploring potential contemporary contexts: Socio-scientific issues.
- Designing your own activities integrating input from the 3 sessions of cluster 1

Building a picture of the group

Join at menti.com | use code 4832 7905

Which country do you come from?

Access to Moodle



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Climate change, energy and materials crisis, sustainable development, inclusion…

Current challenges

Why?

Key role of Science & Technology

Need for

Highly qualified
Scientist and STEM professionals

Respond to

STEM-literate citizens
to make informed decisions

Cluster 1 ICSE Academy
Responding to societal needs

Sustainability & Socio-Scientific Issues

Inquiry-Based Learning

Argumentation

As powerful learning **contexts** to achieve the intended goals

To foster inquiry minds and **skills**
To collect evidence

As an **approach** to promote **critical thinking** and informed **decision-making**

Welcome to Cluster 1!

Tools and approaches for sustainability issues in STEM education

Session 1: Sustainability and SSI in STEM Education (12th March)

Session 2: Inquiry-based STEM learning (19th March)

Session 3: Argumentation and decision making in STEM education (9th April)

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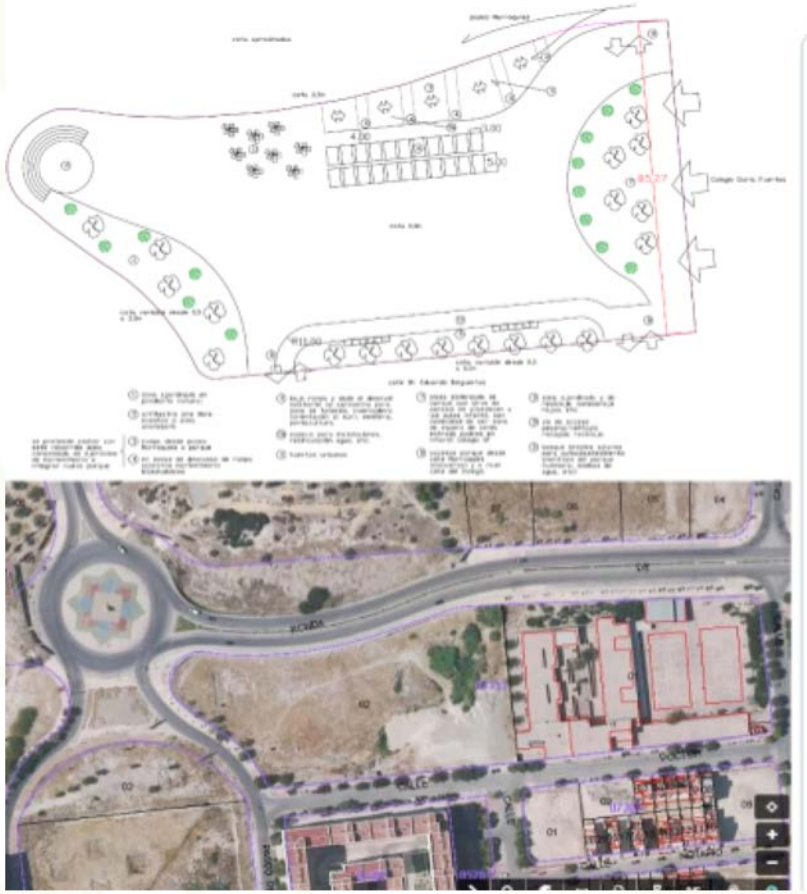
The problem, the context…



Building an ecologic park in a Primary School (Spain)

Students identified an area close to the school, only used to stored waste.

They suggested starting a project to build a part using waste to create playing grounds and a recreative stimulating area.

They contacted the City Hall to get support.

They engaged an architect and collaborated with him to start the park design.

Building an ecologic park

Early years students

Finding out how to grow a plant

- Building seedbeds
- What does a plant need?

Building sensory areas

- Exploring the properties of different waste materials.

Building an ecologic park

Students with special needs experiences different textures and reactions, when playing with the sensory panels created by other students.

Building an ecologic park – 4th grade students

Designing and creating a garden

- Which species grow?

How to bring birds?

- Designing and making nests

Planning and running an awareness campaign

Building an ecologic park – 5th and 6th grades

Running a survey to know about neighbours' attitudes and behaviours

Building a model of the park

Making measures and estimations

Using sensors

Building rain collectors

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Group work to discuss

20 minutes

1. What are the main pedagogical characteristics of this example?
2. What STEM learning outcomes can be achieved?
3. What other learning outcomes?
4. Which can be the benefits in comparison with other teaching strategies?

Join the break out rooms you are invited in and meet the moderator and the group

Include outcomes in
padlet/Analysisofanexample

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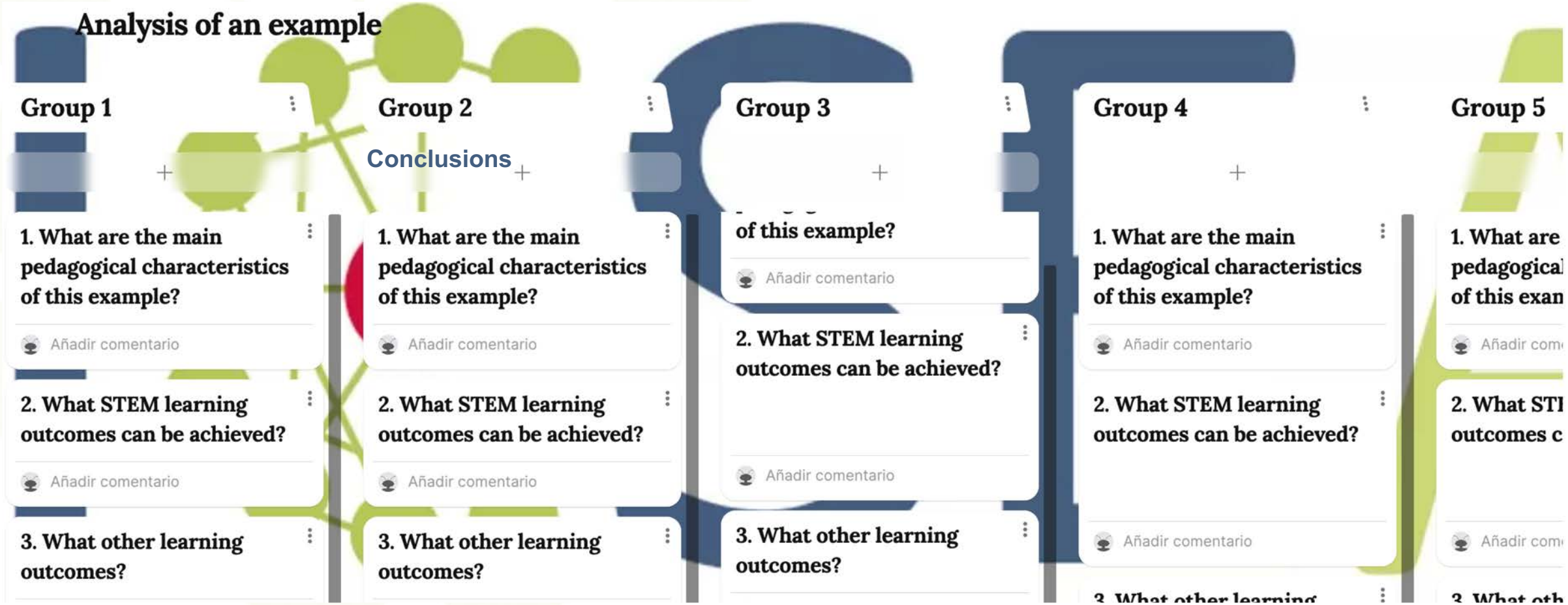
Write the Group Conclusions

Group number = Room number

https://padlet.com/jrm00067/analysis-of-an-example-slam0skez1ap44na



Sharing outcomes

1. What are the main pedagogical characteristics of this example?
2. What STEM learning outcomes can be achieved?
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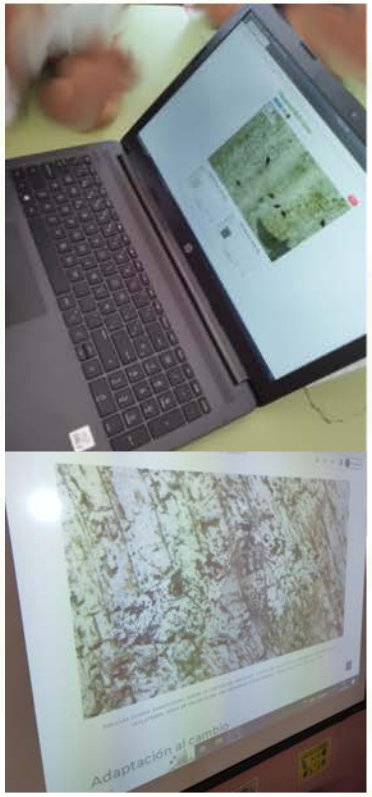
Learning about evolutionary biology and sustainability through school gardens

Sustainability **CURRÍCULUM** Biodiversity

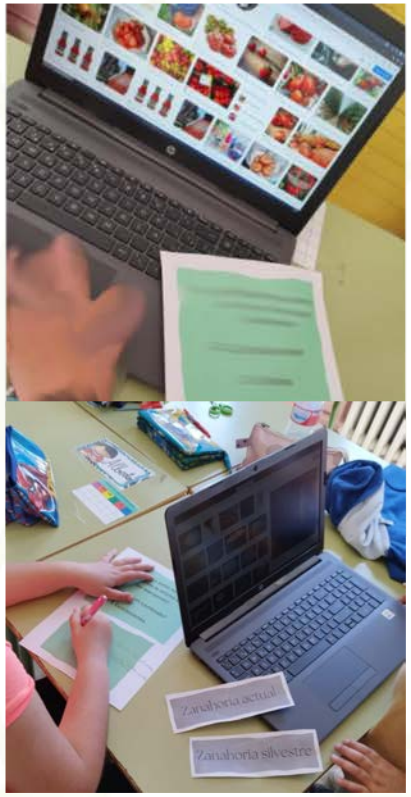
Sustainability and Evolutionary Biology through the School Garden

SESSIONS

The peppered moth



Crops domestication



A deep look into the school garden biodiversity

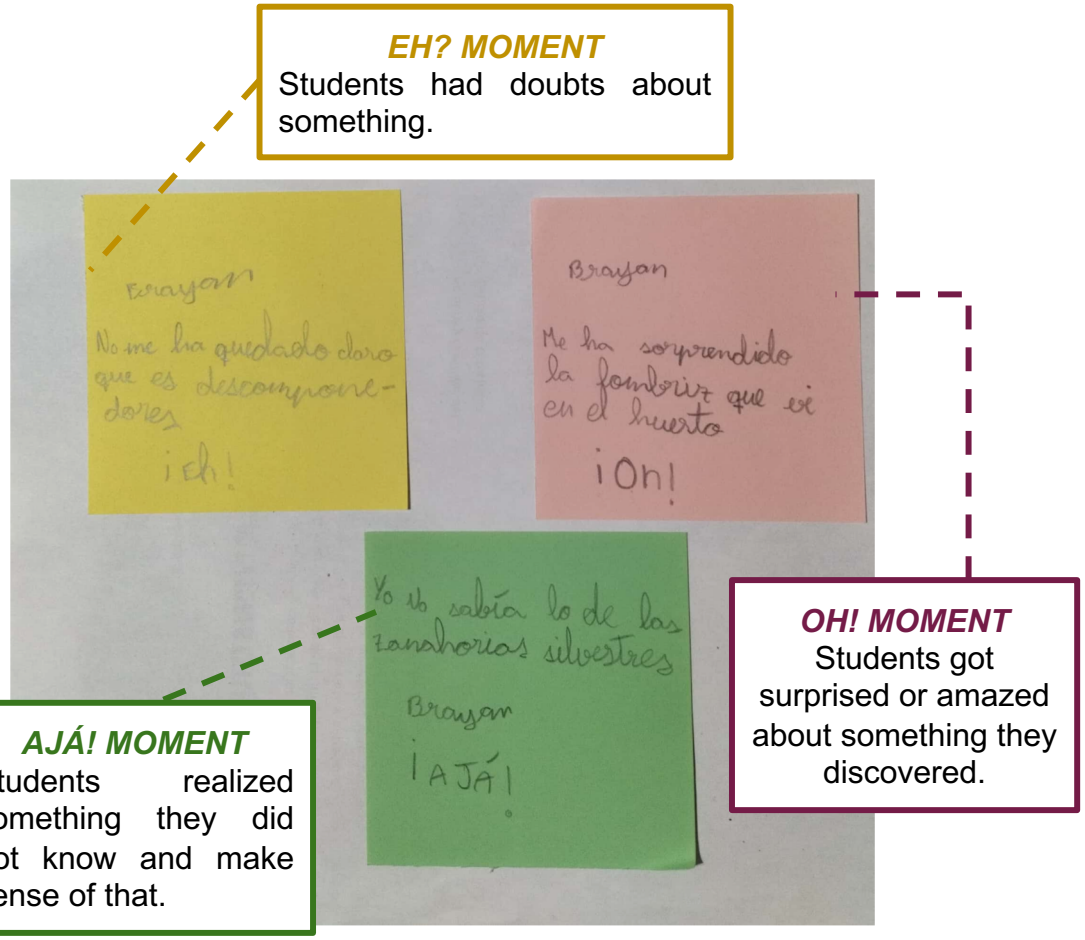
The role of insects in the school garden

Green spaces in the town

Impact evaluation: PRE/POST questionnaires and qualitative self-assessment

Table 1. Description of the questionnaire structure.

Dimension	Acronym	Number of items
Knowledge about evolution	KNW_BE	4
Evolution acceptance	ACC_BE	4
Sustainability consciousness	SUS_CON	3
Interest in science	SCI_INT	3
Science utility	SCI_UTI	3
Science literacy	SCI_LIT	3
Science self-efficacy	SCI_SEF	3



Impact on students and how they perceived the intervention

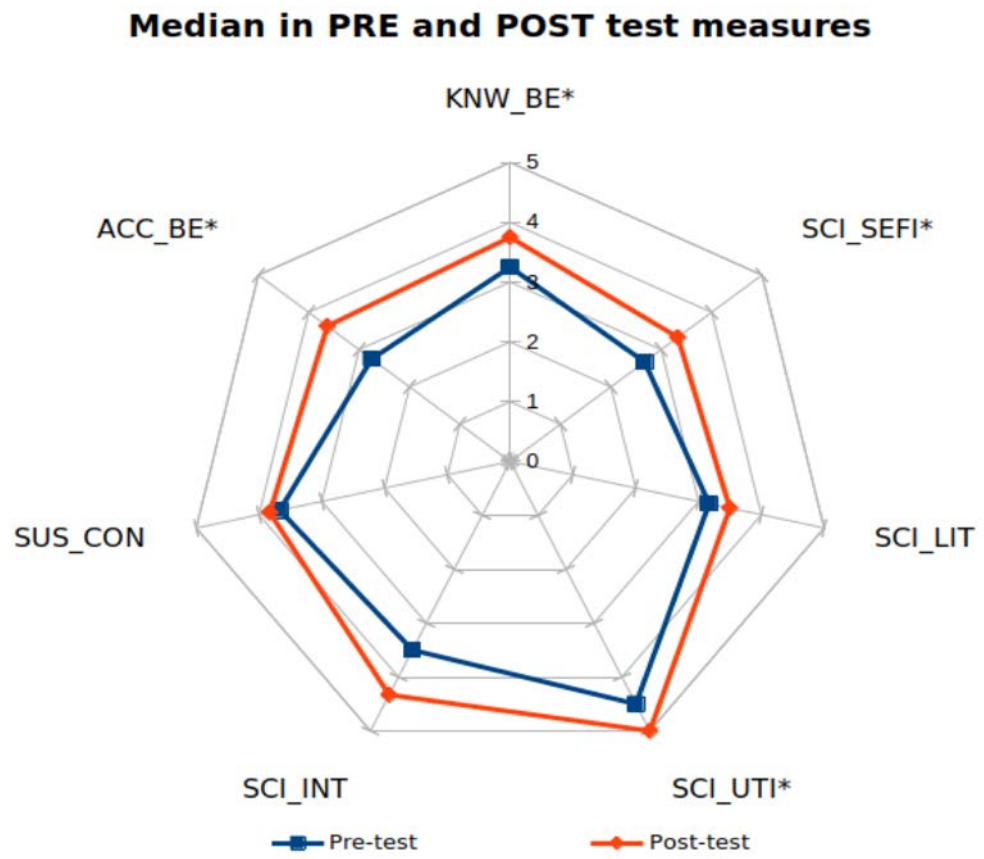


Figure 2. Median values for each dimension in pre (blue) and post (orange test). Dimension acronyms with an asterisk show significant gains after the intervention (p<0.05).

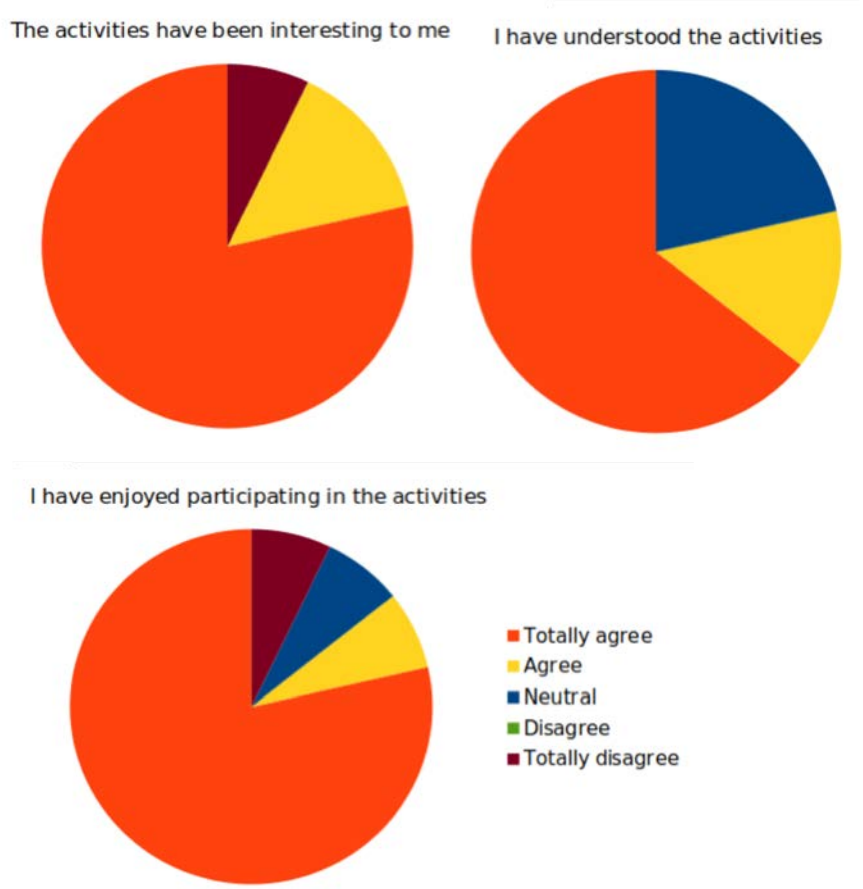


Figure 3. Students' assessment about the interest, understanding and enjoyment of the activities in which they participated through the intervention.

Impact on students and how they perceived the intervention

Table 3. Results from the qualitative analysis of the students' reported moments.

Moment	Number of cases indicating a moment related to a session					Written quotes*
	S1	S2	S3	S4	S5	
Oh!	5	2	10	1	0	*"The worm in the garden surprised me."; "I was surprised by the information on wild cucumbers."; "It was surprising when I went down to the school garden and I found a grasshopper there."*
Ajá!	10	4	3	0	0	*"I didn't know about wild carrots.", "I didn't know about moths but now I understand.", "I didn't know about the wild carrot, I didn't know it existed."*
Eh?	11	1	3	2	0	*"It is not clear to me what decomposers insects are."; "Everything has become clear to me."; "It hasn't been clear to me how to enter the moth game."*

**English translation from Spanish*

Impact on students and how they perceived the intervention

Positive impact on students

The students experienced nature in direct contact with living beings.

Connecting curricula with people's global priorities from an integrative and holistic approach that always includes scientific education for all.

"...to avoid the possible rejection of the teachers to implement cross-curricular teaching proposals in the classroom, it should be noted that, far from adding new blocks of content to be dealt with, an integrative proposal should be brought to the classroom with the reconfiguration of already existing content in a qualitative way…"

Rosales-López, 2015

From...

everyone does their part and tomorrow we'll put it all together

From...

everyone does their part and tomorrow we'll put it all together

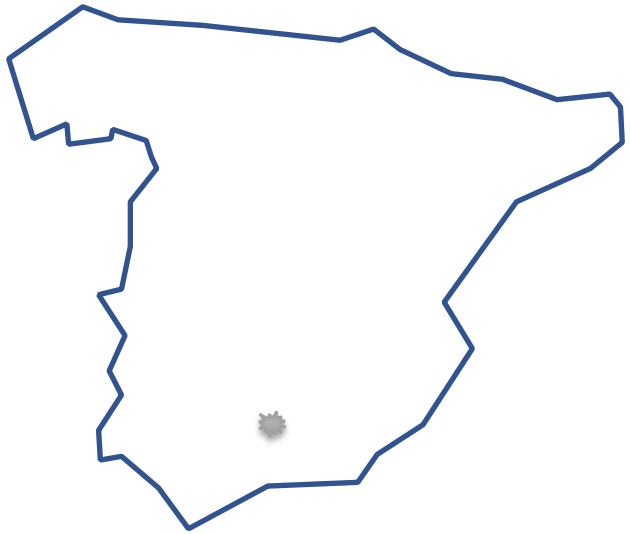
To...

CO-CREATION

Example of a school project in a Spanish primary school collaborating with other institutions and community members

Participants			
Total	Students (female)	Teachers (female)	From the community
215	180 (99)	25 (15)	10

Context



- Jamilena (Jaén, Spain):
  - Around 3300 habitants
  - Little town neglected by the neighbours
  - Short distances, but frequently car use within the town.
  - Different institutions/people involved: town authorities and police, students from a secondary school…

Linking to students' experience

What kind of environment/planet do we want to live in?
What can we do to create/preserve a nice/healthy place to live in?

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Moving to improve the situation: Creating a project

Starting to shape a project: **analyse, plan and act**.

Creating a title, a **logo and a slogan**: “Yohagomiparte” = “I do my part” meaning I take responsibility and make my own contribution.

Logo based on a story about a small bird contributing to extinguish a fire in a forest

(#IDOMYPART)

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Moving to improve the situation

Starting a social media campaign through social media

Raising funds:

- Designing and selling bracelets with logo.
- Running a solidary race.

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Fostering collaboration and co-creation

Intergenerational collaboration:
Representative from different class groups, proposing actions and co-creating solutions with adults.

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Actions proposed to improve the environment

Re-designing the schoolyard

Building a school garden

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Actions proposed to improve the environment

Reducing air pollution and mitigating climate change through sustainable transports
Going to school by bikes or roller skates

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Teachers' collaboration
Interdisciplinary planning and linking to the school curriculum

Maths: estimation, measurements
Building models
Cars and pollution
The quality of air, water and soil
The key role of plants
Building a school garden: What are the benefits?
Ecosystems, biodiversity and climate change…

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Feedback from participants

"We would like to tell other students to work like us because it helps the environment"

"We would tell them that they can help us so that more and more people participate."

Student

"A project is a blank sheet of paper and experience helps you become fluent in writing it."

"The students planted the seed and made it germinate."

School leader

"Finding yourself with a group of people who share your work approaches is comforting."

"Everything students learn is from emotion, there is no learning without emotion...They had to solve this, they were responsible for the action and it had an impact on them".

"I could see more critical thinking, and dynamic attitudes, students were deeply engaged."

Teacher

"It is very necessary to fit the project
into the curriculum because otherwise
it could be that we are just having fun
and entertaining the students."

Teacher advisor

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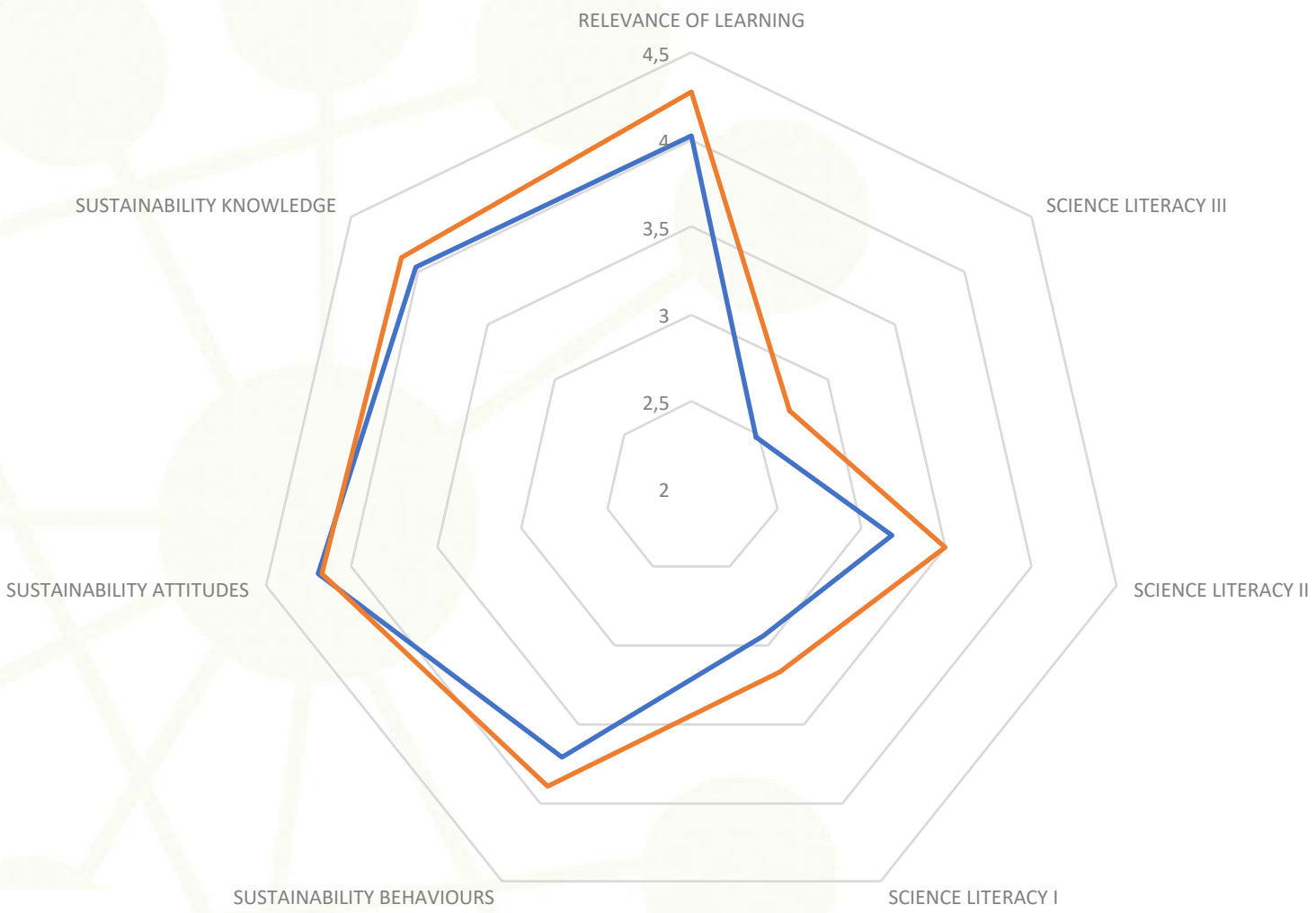
Measuring the impact on learning



N = 78 pre, 50 post
10 years old (mean)

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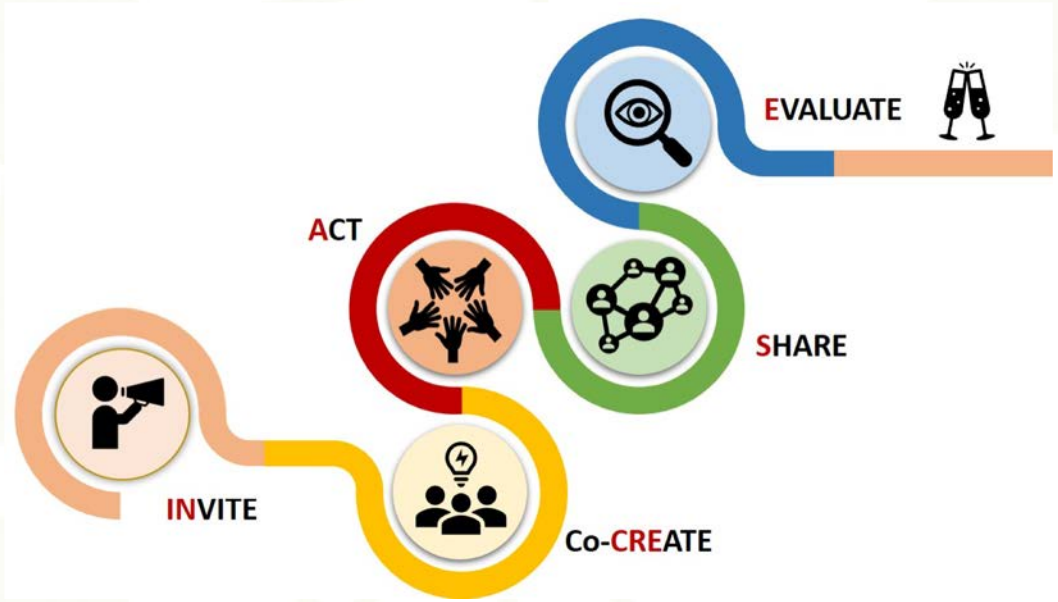
What are the main pedagogical features of these examples?

Comment on the following aspects:

- The topics addressed
- Students' role and agency
- The teacher's role
- Are there connections with the STEM curriculum?
- Which skills and attitudes might be developed?
- How can these activities been evaluated?

The approach



Which are the main features of these activities?

- Authentic and Co-created:
  - Shared ownership
  - Motivation
- Environmental issues
- Multiple possible solutions.
- Meaningful and relevant.
- Context-based mathematics and science learning (knowledge & skills).

The approach

Ways of working:

Within schools, between schools and local communities:

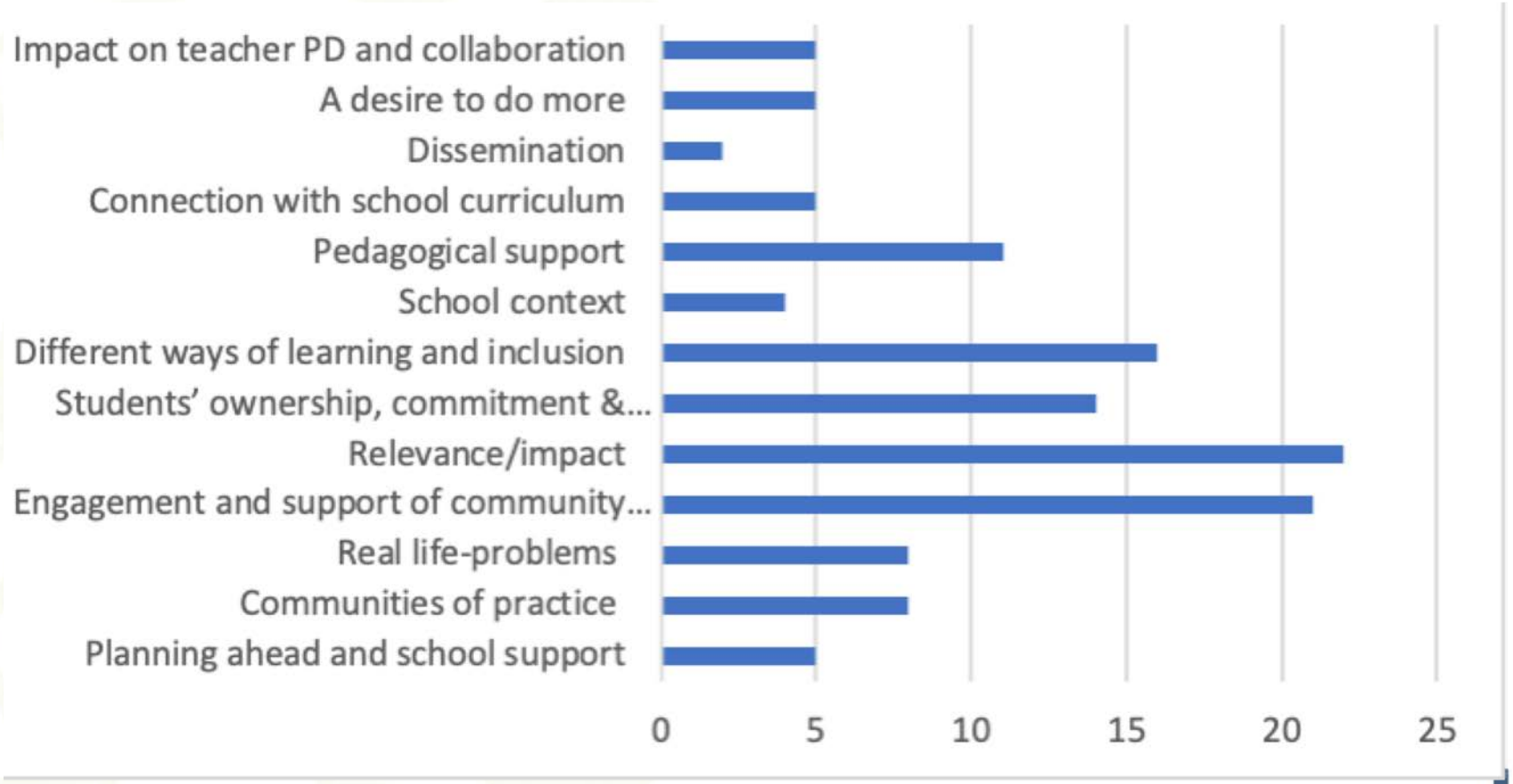
- Student-centred, teachers' guidance.
- Collaborative group work.
- Multi perspective approach to problem.
- Dialogic and interactive.
- Respectful; value mistakes as learning opportunity.
- Attentive to girls' interest and motivation

What are the potential learning outcomes

- Inquiring minds: critical and creative
- Understanding science & math in real-life environmental problems.
- Cross-cutting competencies for sustainability:
  - System thinking competency
  - Collaboration competency
  - Critical thinking competency
  - Self-awareness competency
  - Problem-solving competency
  - Anticipatory competency
  - Normative competency
  - Strategic competency
- Communication skills

What are the characteristics of good STEM sustainability projects

Data from a collection of 30 case studies from 10 countries



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What are the characteristics of good STEM sustainability projects

Data from a collection of 30 case studies from 10 countries

Real life problems

*"When students are presented with a **problem that is artificial or just for show**, they may become disengaged or feel that their time and efforts are not being valued"* (*Czech teacher*)

"… I like it because **I work on what will serve me in my life**" "This is the future!" "**All classes should be like this**" (Spanish student).

"This is for real, not only school!" (Norwagian student).

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What are the characteristics of good STEM sustainability projects

Data from a collection of 30 case studies from 10 countries

Relevance & impact

"They value how relevant was the project for people" (Czech student).

"…the belief that the thing they are doing will help their lives and those around them…" (Czech student).

"Students wants to grow more and to increase their impact in the community and raise the awareness people that could join their goals" (Norwegian observer).

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What are the characteristics of good STEM sustainability projects

Data from a collection of 30 case studies from 10 countries

Engagement and support of community members

"Educating young people is a joint project, not just of teachers and parents, but of all of us. "Outsiders" bring new impulses and different ways of seeing and thinking to the school, which is why such projects are important" (German stakeholder).

"*…their presentation on climate change to the city council was meaningful and the city council members liked it. That's why they supported the project financially*." (CZ teacher).

"They understand that the strong point of the SCP has been intergenerational collaboration and the opening of the SCP to society" (Spanish observer).

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What are the characteristics of good STEM sustainability projects

Communities of practice

"The *cooperation of more teachers at school is important. When teachers* ***work together on a community*** *project, they can pool their resources and share the workload, which can lead to a more efficient and productive implementation process. Of course, there's always a teacher who's not interested. But you need at least some of the same mindset as you…" (Czech teacher)*

"The ***collaboration between the different stages has been very enriching****, and we have seen how all the students from kindergarten to secondary education have collaborated. I believe that* ***programming*** *from children to high school can be* ***organized around these themes****" (Spanish school leader).*

"I found the ***teacher group quite engaged*** *and helpful in the learning process. I am not sure about its impact on teachers' professional development but can assume this project has had a* ***positive added effect on their collaboration skills*** *within the school environment and local community" (Norwegian teacher).*

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What are the characteristics of good STEM sustainability projects?

Commitment, ownership and empowerment

"…creating serious commitment to the SCP in initially unwilling students (Dutch teacher).

The students display a central role in the determining main questions of the SCP, doing research, collect data, reaching conclusions (Turkish teacher).

"The experience was very empowering for the students in fact two of the interviewees represented their school in a parliamentary session where school representatives (from ekoskola) share their environment-related concerns and recommendations with members of the Maltese parliament" (Maltese observer).

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What are the characteristics of good STEM sustainability projects

Different ways of learning and inclusion

All students are included and can contribute in some way. *As one student said, "everyone had some way of helping"* (Maltese teacher).

Awareness of **multiple interests/needs** involved (Dutch observer). *"…Projects enabling* ***different roles for students*** (*Czech observer*).

"The teaching staff has been able to detect skills in the ***students that they would not otherwise have perceived, they have realized that students are very capable*** *and very competent children, which has a very positive effect on their motivation"* (Spanish observer).

"SCP gave students "an opportunity to flourish" by allowing them the "opportunity to talk to each other, reach a compromise, see things, experience, make mistakes and ***learn from their mistakes"*** (Maltese teacher)

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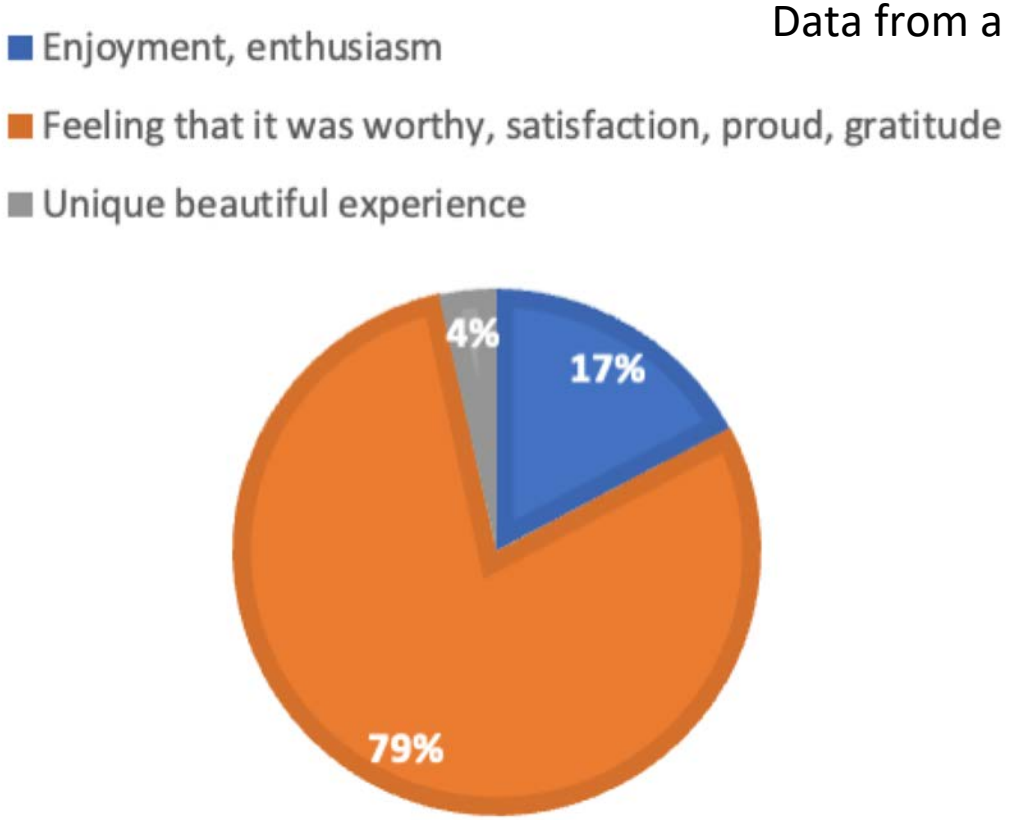
How are STEM sustainability projects experienced by participants?

Data from a collection of 30 case studies from 10 countries



*"It felt pretty good, because you know you do garden work, you **do something for school, for the environment and for yourselves and others**. So that felt really good"* (Austrian student).

"It is always wonderful to see how proud students can be of their sustainability projects. And not only them. After planting the shrubs and trees isolating the traffic one mother said: Thanks to the children there will be reduction of air and noise pollution and it enhances aesthetic appeal of the area. Every green brunch helps" (Czech teacher).

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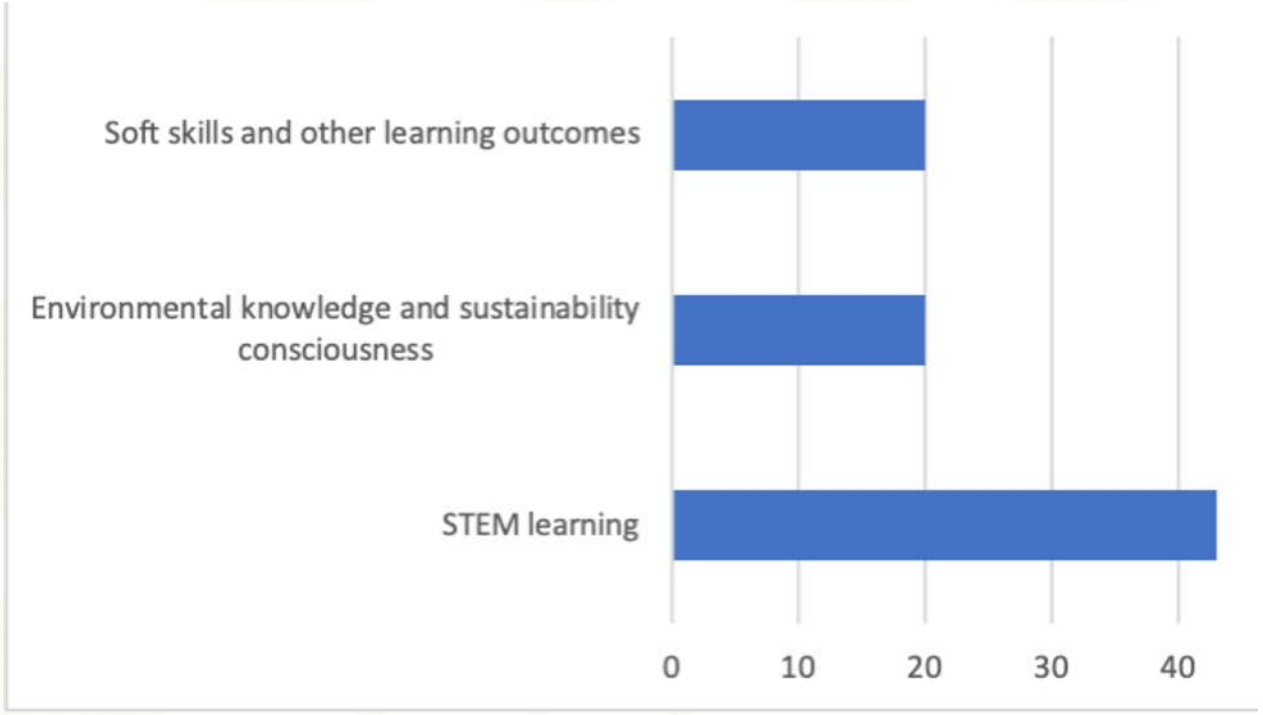
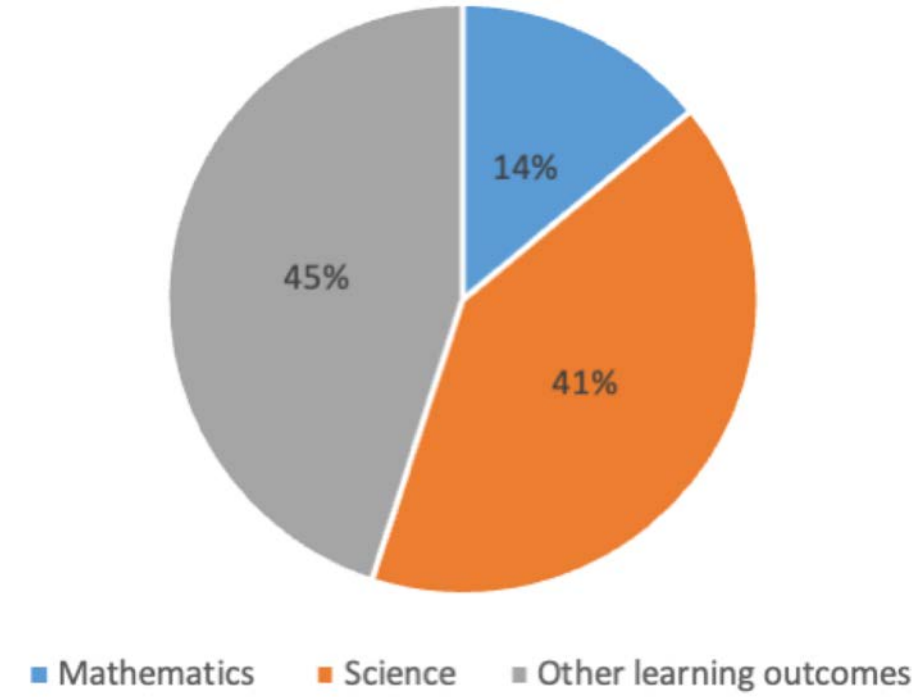
Students' learning through STEM sustainability projects

Data from a collection of 30 case studies from 10 countries



Quotations



Clustering

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Students learning through STEM sustainability projects

STEM learning

"In relation to maths and statistics: survey analysis - ***percentages, diagrams, average, area measurements/estimations****" (Norwegian observer).*

"They could recall and showed a deep understanding of ***warmth/energy Flo****w through materials" (Dutch observer).*

"They learned about ***chemistry elements*** *in the environment and the environmental impact of devices made of particular elements…"(Spanish observer).*

"Sometimes the science behind the project didn't amuse them, but when they could do something practical, they always got excited. However, at least scientific concepts, such as the importance of ***soil quality and water availability****…."* (Czech teacher).

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Students learning through STEM sustainability projects

Sustainability consciousness

"Students now understand better the statement "think globally and act locally". They think about wasting their food...they try to change their behavior and eating habits...They see a bigger picture of environmental problems (carbon footprint, etc.)." (Czech teacher).

"My daughter has become more conscious of human impact on climate change and how we can combat climate change by reducing energy consumption. I found other pupils quite engaged in the process, they seemed to know quite a lot about energy production and global warming, as well as being keen to teach parents about how to save energy and money spent on electricity bills" (Norwegian parent).

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Students learning through STEM sustainability projects

Other learning outcomes

"We learned different things in the SCPs, **things we wouldn't have learned in the normal classroom** setting. Research on how to build raised beds" (Austrian teacher).

"…one of the positive characteristics of the SCP was that it also taught the children **"life skills, how to cooperate, (and) critical thinking"** rather than "just how to recycle" (Maltese parent).

"Parents, teachers, school leaders value soft skills, critical thinking and the engagement they gain" (Norwegian observer).

"Being active citizens…be aware of what is happening around you. Do something about it!" (Maltese teacher).

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Defining SSI

What are socio-scientific issues?

a scientific component

arise as societal issues,

incorporate other disciplines and knowledge domains (political, financial, ethical and moral, religious etc).

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What characterises a socioscientific issue?

Controversial and contentious issues – for society and/or science

Require the use of evidence from science as well as other disciplines

Issues at the frontier of science; tentative status

Require judgement and decision-making

Require participation in discussion and debate about what to do (and possibly taking action)

Require a degree of moral reasoning and ethical evaluation

(Kolsto, 2000; Oulton, Dillon & Grace, 2004; Zeidler, 2003; Sadler, 2004; Albe, 2012; Benzce, Sperling & Carter, 2012; Salvato & Testa, 2012; Zeidler & Nichols, 2012; Nielsen, 2013; Zeidler, 2014; Nicolaou, Evagorou & Lymbouridou, 2015)

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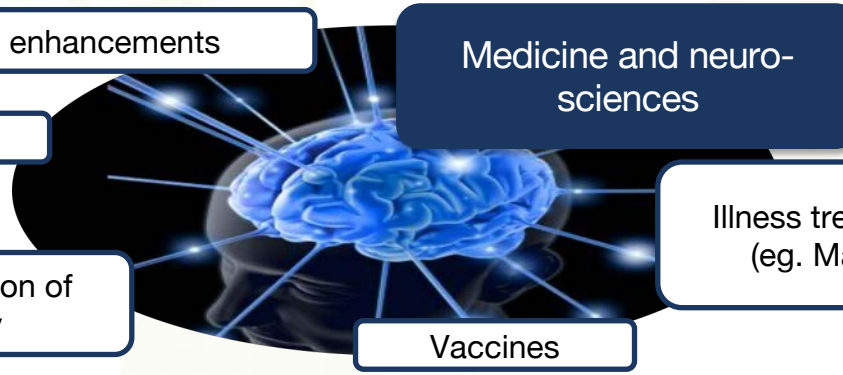
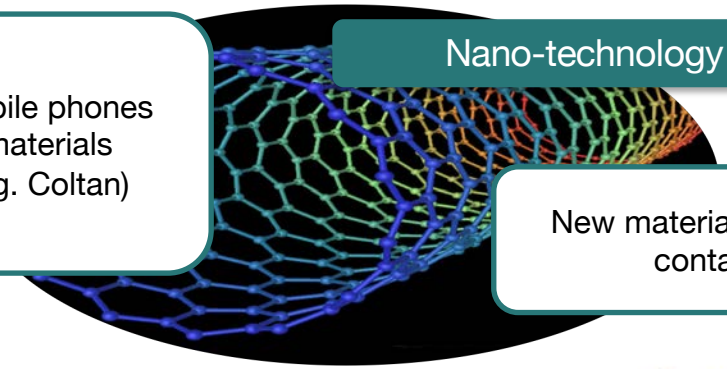
Examples of socioscientific issues



- Brain enhancements
- Medicine and neuro-sciences
- Doping
- Illness treatments (eg. Malària)
- Medicalization of society
- Vaccines

- Global Warming
- Energy resources
- Environment
- Nuclear plants
- Waste treatment
- Geological risks
- Food options

- Genetically Modified Organisms (GMO)
- Bio-technology
- Stem cells



- Mobile phones materials (eg. Coltan)
- Nano-technology
- New materials (eg. Edible containers)

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Issues to include in the curriculum (Wan & Bi, 2020)

Safety and Health:
Food safety, rationale use of antibiotics

Resources and Energy:
Development of clean energy, application of solar energy

Ecological system:
Biodiversity loss, destruction of rainforests and wetlands

Environmental Issues:
Water pollution, soil pollution, global warming

Biotechnology:
Gene therapy, GMO

New materials:
Nano-technology

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Wan, Y. & Bi, H. (2020). What major “socio-scientific topics” should the science curriculum focus on? A Delphi study of the expert community in China. International Journal of Science and Mathematics, 18, 61-77

What characterises socioscientific learning and teaching?

Recognising reliable evidence and data and making judgement calls

Understanding how to differentiate science from nonscience issues

Taking action on issues relevant to their everyday lives

Decision-making and practical argumentation

Collaborative learning

Situated learning contexts

Character formation

(Zeidler, et al., 2003; Sadler, 2009; Zeidler et al., 2009; Bencze & Carter, 2011; Evagorou, Jimenez-Aleixandre & Osborne, 2011; Nielsen, 2012; Evagorou & Osborne, 2013; Zeidler & Nichols, 2009)

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What do we know from previous studies?

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Students are more motivated to learn science after engaging with SSI (Bennett et al., 2004; Bulte et al., 2006), especially if the SSI they are studying is of personal or global interest.

SSI-teaching has been documented to improve conceptual understanding (Applebaum et al., 2006; Klosterman & Sadler, 2010; Sadler et al., 2016; Dori et al.; 2003; Venville & Dawson, 2010; Zohar & Nemet, 2002)

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SSI context can help students improve their argumentation skills (Dawson & Venville, 2010; Grace; 2009; Tal and Kedmi, 2006)

But this is highly dependent on the nature and quality of supports provided to students (Andriessen, Baker & Suthers, 2003; Bell, 2004; Evagorou & Avraamidou, 2008; Sadler & Dawson, 2012)

Limited studies on how SSI can promote activism and responsible citizenship (Benze et al. 2006) – most studies not linked to taking action

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How can we bring together SSI, sustainability and STEM?

What is the best solution to minimize the number of mosquitoes in our area?

Evagorou, M., Nicolaou, Chr. & Lymbouridou, C. (2020).

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Lesson 1: Introducing the problem

Lesson 2: learning about mosquitoes

Lesson 3: visiting the salt lake and data collection

Lesson 4: building models of the ecosystem

Lesson 5-6: using models to explore solutions

Lesson 7-8: presentation of decisions to stakeholders (local community)

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Study 2: The population of the bees worldwide is declining. Should we care, and why?

(Evagorou & Puig, 2017)

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Week	Activity	Scientific Practice
1	What do we know about bees? Honey tasters and pollen identification	Inquiry & argumentation
2	Building a model of a hive	Modeling
3 & 4	Redesigning and discussing a model of a hive	Modeling & argumentation
5 & 6	Using scenarios (varoa mites, pesticides, destruction of green areas)	Argumentation with the use of the model
7	Reflecting on the process and the practices	

SCAFFOLDING

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By engaging in SSI students and pre-service teachers:

improve their competences and practices,

improve their content knowledge, but also their attitudes and emotions towards science,

Understand the complexities of science and appreciate social aspects and responsibility.

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Assignment for cluster 1 – end of cluster

- Prepare an outline for a STEM lesson for your local curricula.
- Chose a topic that you would feel comfortable implementing with your students.
- The lesson should use an SSI as a context related to a sustainability problem, and focus on argumentation and Inquiry based learning (IBL).
- In the outline include the following information: level of students, duration of the lesson, participants' prior knowledge, methods to be applied, content, assessment methods, STEM theme, learning objectives, and description of the learning activities.

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