



# REINFORCE

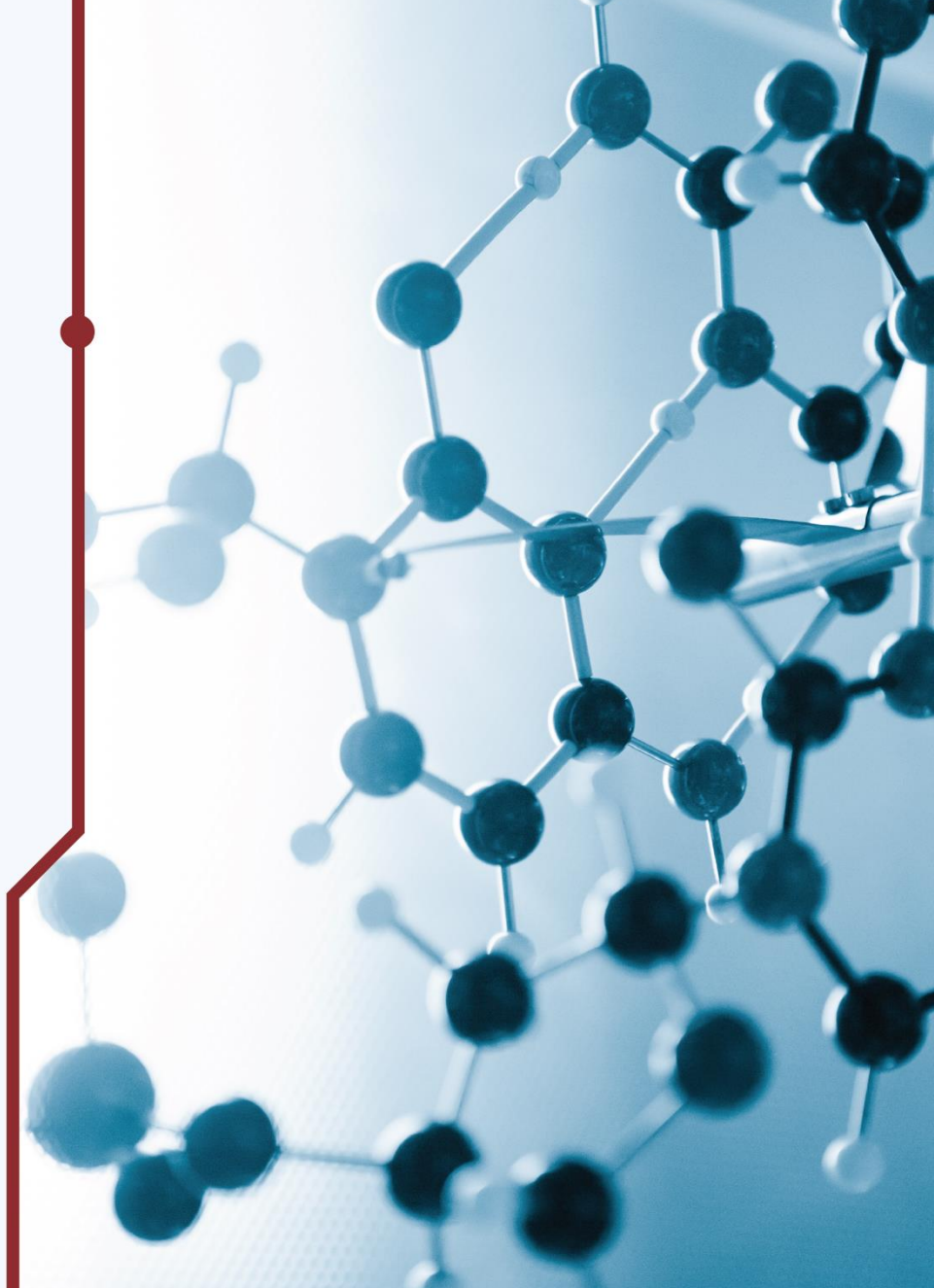
REsearch INfrastructures FOR Citizens in Europe

## Gravitational Waves and Citizen Science for Education

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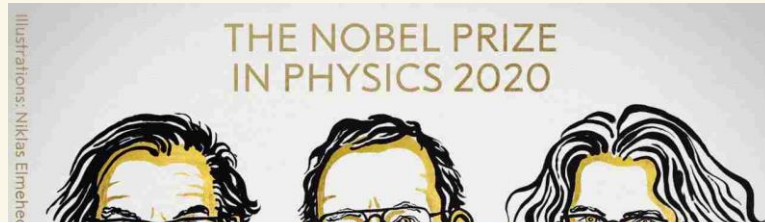
ELLINOGERMANIKI AGOGI





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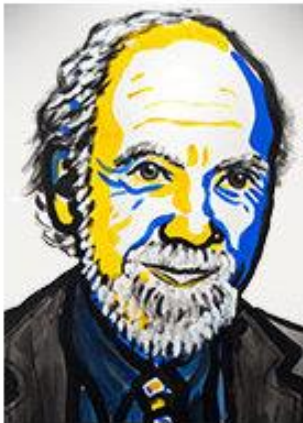
## Game Changing Discoveries in Physics with great media coverage



### The Nobel Prize in Physics 2017



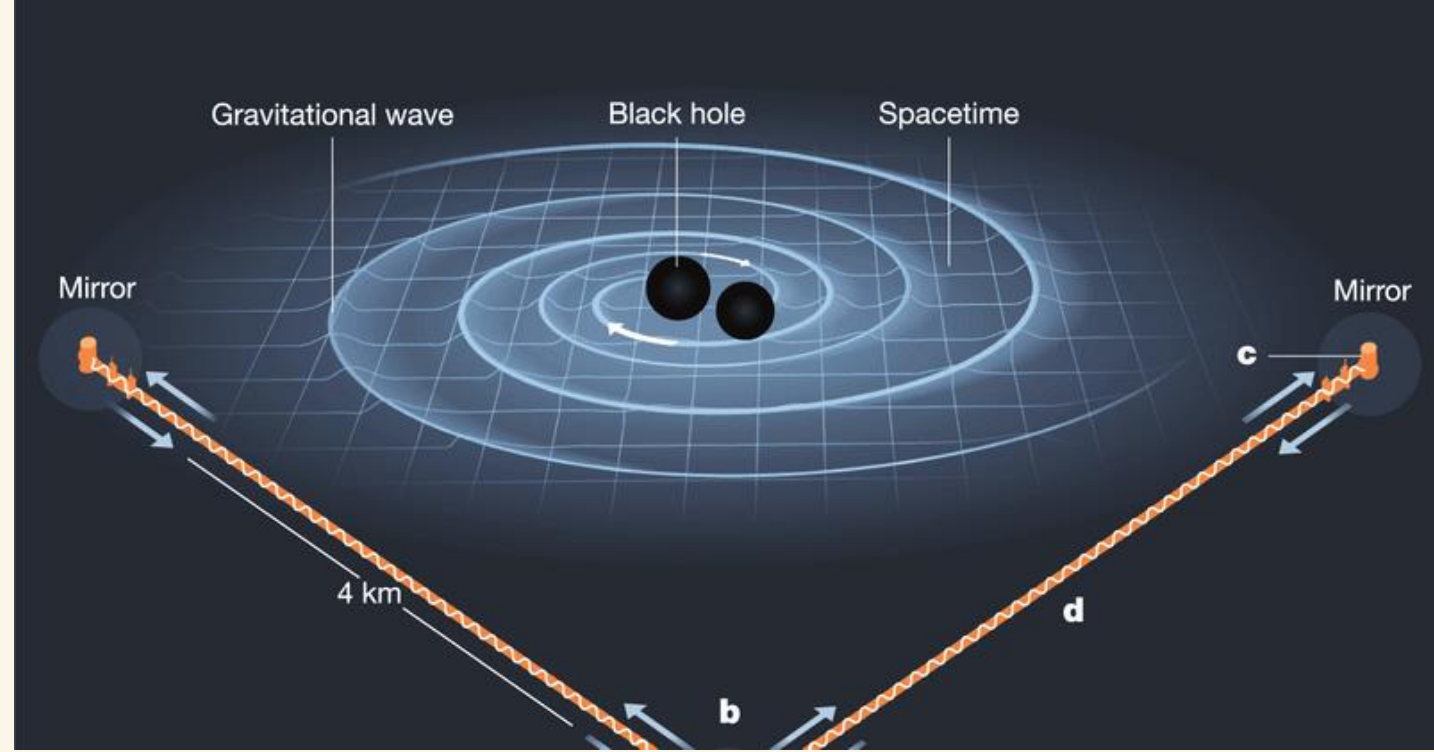
© Nobel Media. Ill. N. Elmehed  
**Rainer Weiss**  
Prize share: 1/2



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**Barry C. Barish**  
Prize share: 1/4



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**Kip S. Thorne**  
Prize share: 1/4



# And unprecedented impact in humankind



Feb



# Yet if you browse the web..



YouTube search: flat earth

**FLAT EARTH**  
*International Conference*  
[crowd cheers]

0:24 / 4:00

RALEIGH  
People From Around The Globe Met For The First Flat Earth Conference (HBO)

1.420.281 προβολές

13 ΧΙΛ. 5,2 ΧΙΛ. ΚΟΙΝΟΠΟΙΗΣΗ ΑΠΟΘΗΚΕΥΣΗ

VICE News  
Δημοσιεύθηκε στις 28 Νοε 2017

Conspiracy theories are nothing new, but in the age of the internet, they spread like "chemtrails" in the wind. The theory that the world is flat, for example, gained so much popularity online that this year 500 people gathered for the first ever International Flat Earth Conference.

ΕΓΓΡΑΦΗ 3,4 Ε

ΑΠΟΘΗΚΕΥΣΗ

I'm a Physicist At CERN We've D

6.584.342 προβολές • 30 Ιουν 2016

And this goes beyond hard science as well...

Or investigate school curricula you will identify a gap between frontier scientific research with society and education

20<sup>th</sup> – 21<sup>st</sup> Century Physics not systematically integrated in K12 formal education!

Teachers don't feel confident to address students' questions regarding newest discoveries in modern science






**To address the gap between frontier scientific research and school education we go beyond outreach and connect schools with Large Research Infrastructures through citizen science**



# The interplay of Large Research Infrastructures, Citizen Science and School education in REINFORCE

- Offering authentic research experiences for students
- Helping increase relevance and meaning of school science
- Supporting the increase of students' science literacy



**LARGE RESEARCH  
INFRASTRUCTURES  
IN FRONTIER PHYSICS**

**CITIZEN  
SCIENCE**

**SCHOOL EDUCATION**



- Contributing in the production of new knowledge
- Supporting the Optimization of Large Research Infrastructures
- Helping raise awareness acting as multipliers



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# Goals

Students are envisioned to..

- contribute in the optimization of Large Research Infrastructures in Physics
- become partners in the research enterprise
- increase sense of meaning in school science
- increase disciplinary knowledge and overall science literacy
- increase science motivation









# Challenges: The doors we need to open

- ❌ Introducing new topics beyond school curriculum.
- ❌ Balancing Scientific Goals and Learning outcomes.
- ❌ Lack of teacher training and support.
- ❌ Curriculum pressure and lack of classroom time

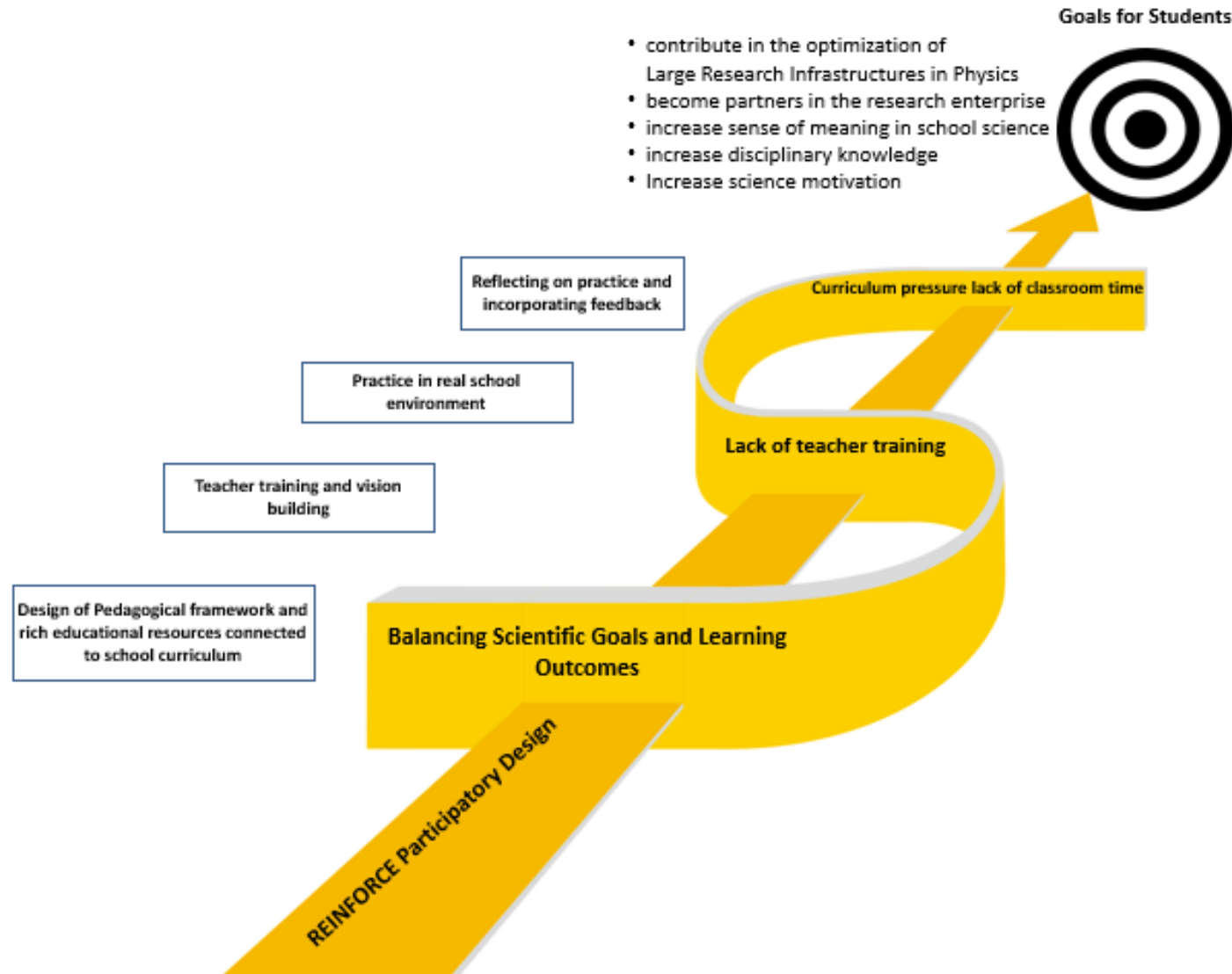


# The REINFORCE participatory methodology: the key to overcome the challenges

-  Design of Pedagogical framework and rich educational resources connected to school curriculum
-  Teacher training and vision building
-  Practice in real school environment
-  Reflecting on practice and incorporating feedback



# REINFORCE for education in a nutshell



# Example: Gravitational Wave Noise Hunting for schools





# Pedagogical Design



Orientation



Hypothesis generation



Planning investigation



Investigation and Analysis



Communication



Emmanuel Chan...

Dr. Sofoklis Soti...

Prof. Stavros Ka...

vincenzo napola...



Dr. Valerio B...



Dr. Rosa Dor...



Recording...

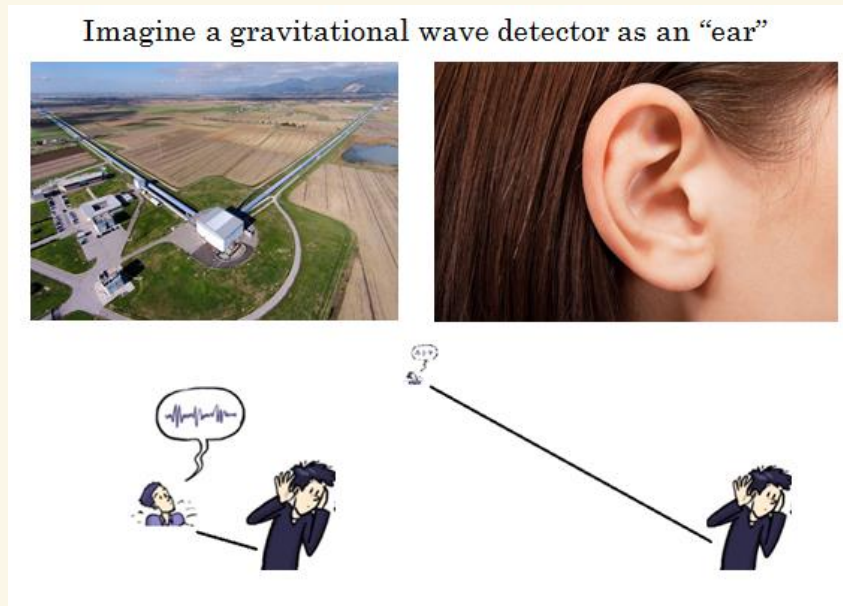
LIVE

on Facebook



# Pedagogical Design: Hypothesis generation and design

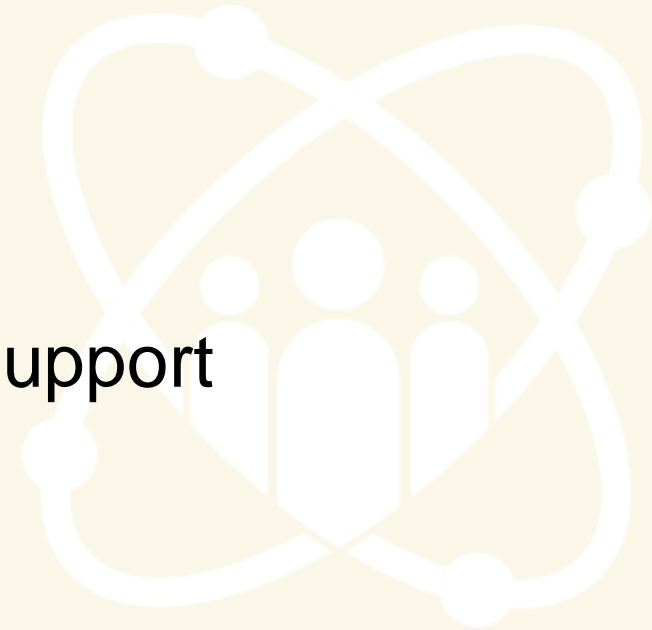
## Using analogies and bridging GW detection principles to school science



“more sensitive ears” → “can identify signals from larger distances”. Similarly, a gravitational wave detector’s sensitivity corresponds to how far in the universe it can reach and thus to its discovery potential! Sources of noise need to be controlled in order to maximize our detector’s sensitivity.

# Pedagogical Design: Planning Investigation

- Explaining the Signal and Noise Characteristics in GW- Detectors
- Identifying sources of noise: Environmental-Detector noise and transient noise (Glitches)
- Discussing how noise affects detector sensitivity
- Introducing the tools to identify noise patterns and support scientists in the optimization of their detector
- Describing the challenge



# Different sources of “noise” affect the gravitational wave detector’s sensitivity

Adapted from : Laser Labs’ Spacetime Quest: <https://www.laserlabs.org/spacetimequest.php>

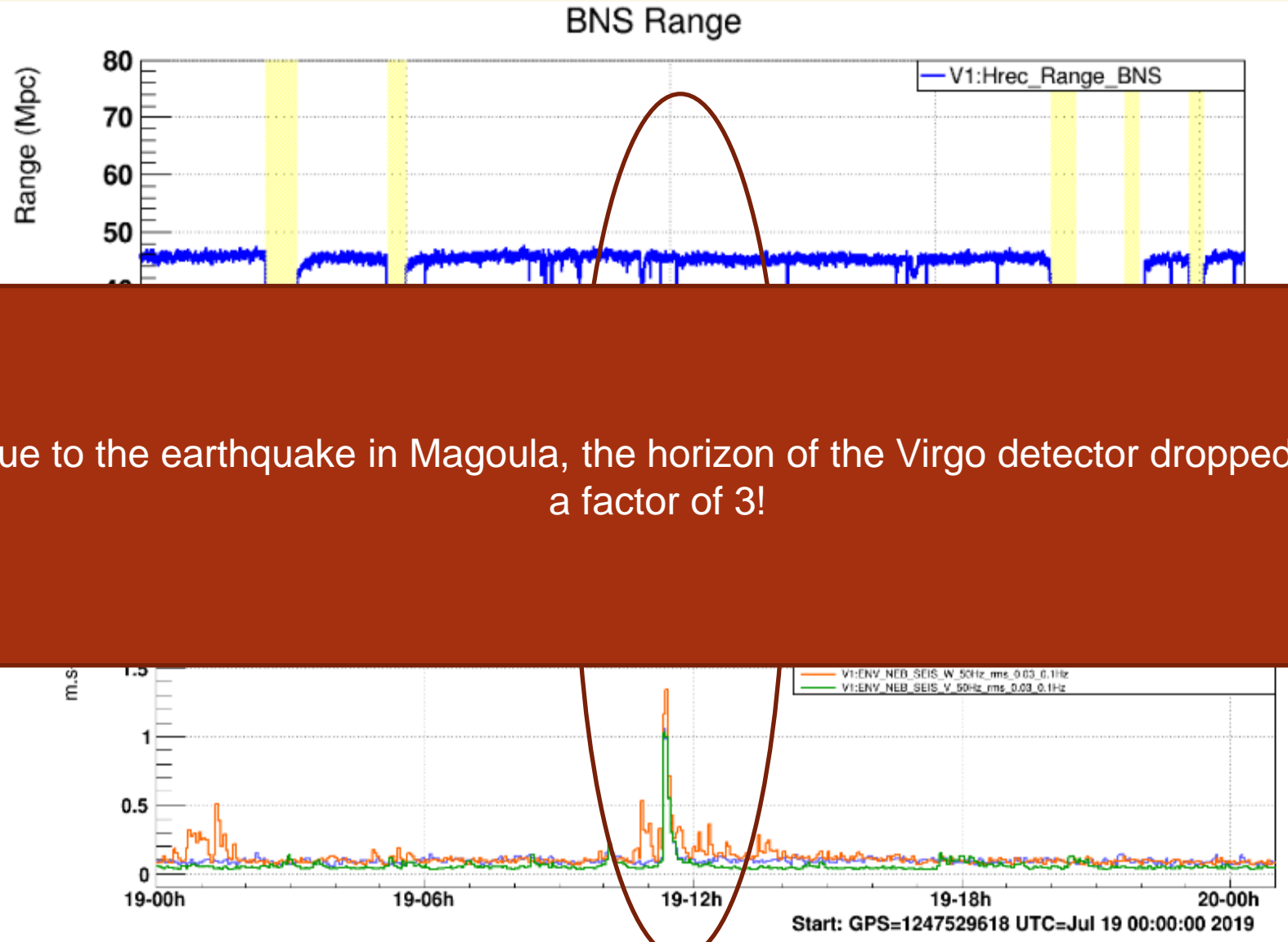


# A few examples of environmental noise..



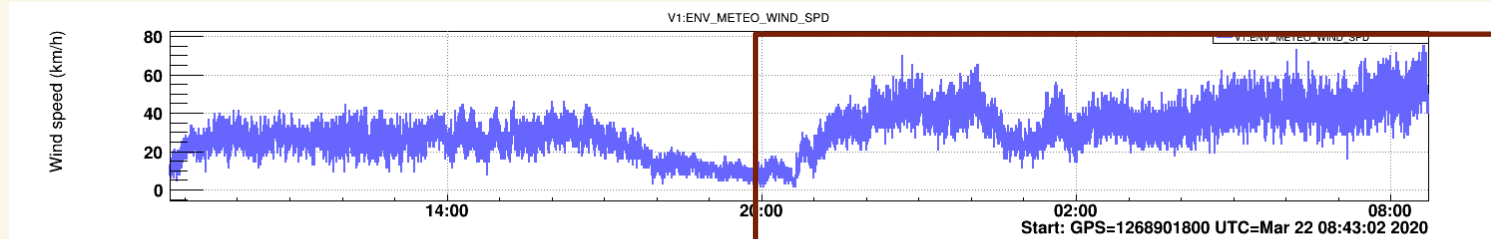


\* A measure of How far in the detector "hear"



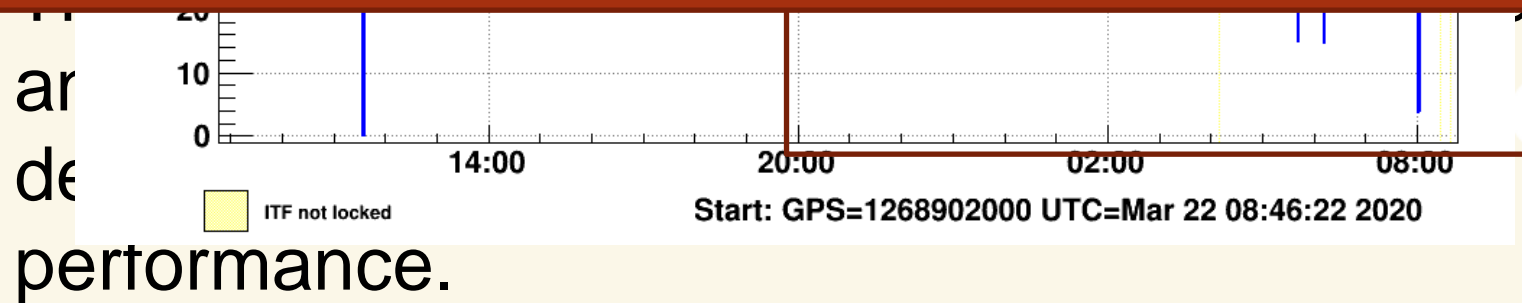
\* BNS range is defined as the distance up to which a single detector could observe the coalescence of a pair of 1.4 solar masses neutron stars with signal to noise ratio of 8.

# Does the wind blowing, affect a gravitational wave detector?




What does this plot tell us?

"If two neutron stars with mass equal to 1.4 solar masses merged in distance higher than 50 MPc and a signal arrived to our detector around 08.00 A.M, we wouldn't be able to detect it because the wind was blowing furiously!"



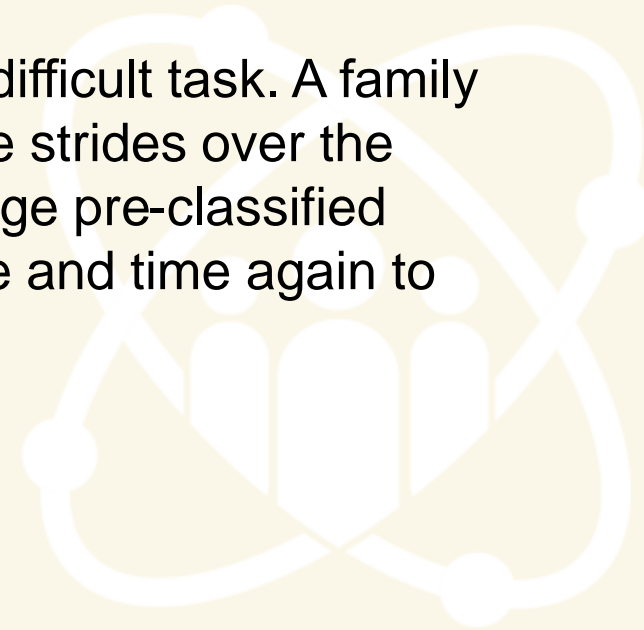
ar  
de  
performance.

 There are sources of “noise” in Gravitational Wave detectors that are poorly understood.. The so called “Glitches”!

 Description of the challenge:

“Classifying glitches using computers has proven to be an exceedingly difficult task. A family of data analysis algorithms known as *machine learning* have made huge strides over the past decade in classification problems, though they usually require a large pre-classified dataset to operate effectively. However, human intuition has proven time and time again to be a useful tool in pattern recognition problems such as this.

**This is where citizen science comes to the rescue!”**





# Familiarization with the tools

The frequency spectrum of a class of glitches

How far in the Universe can a Gravitational Wave Detector “reach”

Mpc

40

20

0

Frequency (Hz)

1024  
512  
256  
128  
64  
32  
16  
-0.25

Frequency (Hz)

Strain ( $\times 10^{-20}$ )

Time (seconds)

Hanford - O2a

Time (seconds)

LIGO-Livingston raw data

Normalized amplitude

Window amplitude

Normalized energy

Glitch in LIGO L1 detector  
during GW170817  
Abbott et al 2017

# Pedagogical Design: Investigation and Analysis

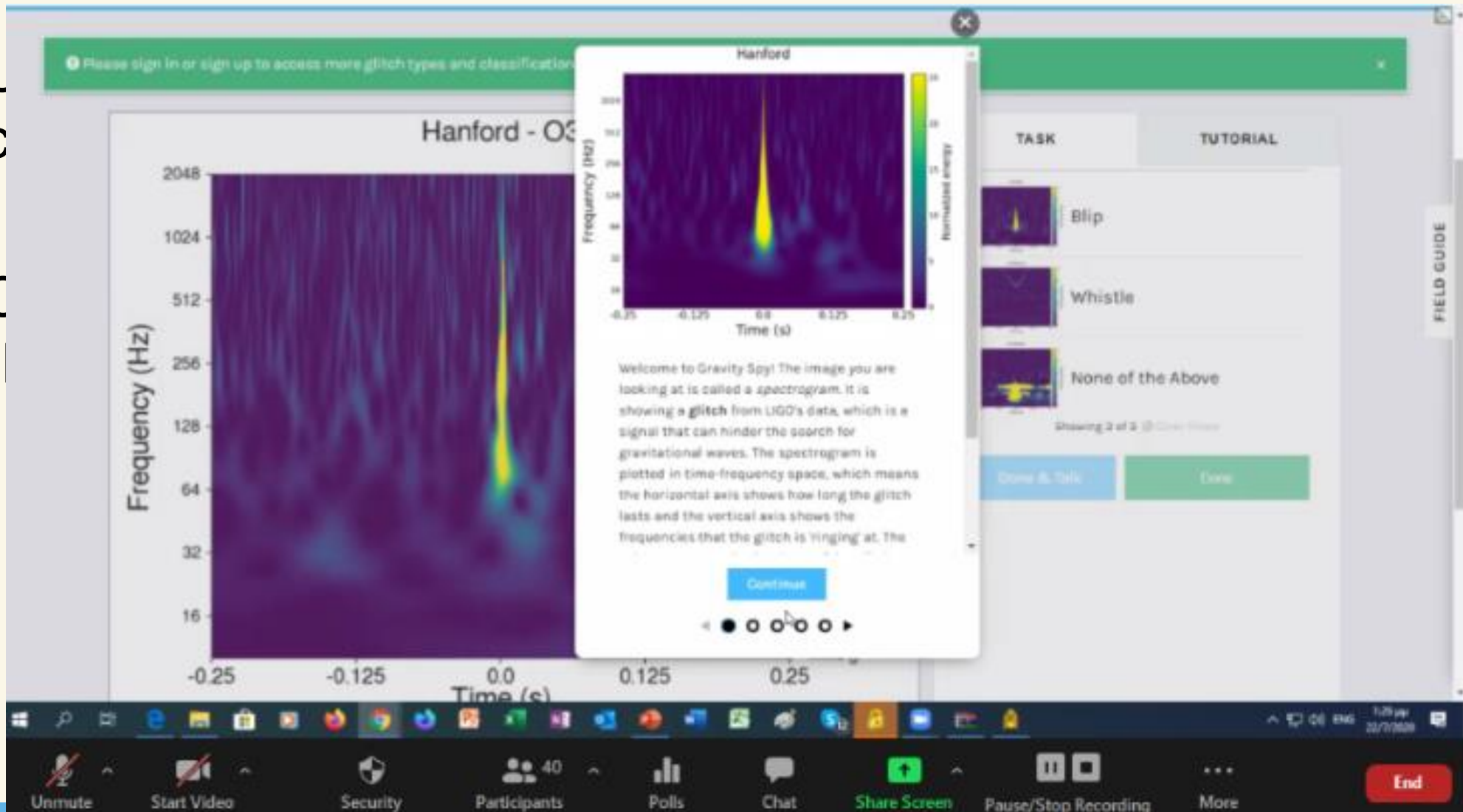


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Gravity Spy

ABOUT

CLASSIFY

TALK

COLLECT

The newest member of the gravitational wave family has been announced! LIGO-Virgo discovered a merger with one object in the mysterious "mass gap" between the heaviest neutron stars and lightest black holes. We aren't able to tell what it is because it was swallowed whole by its black hole companion. Find out more about this enigma in [discovery paper](#), check out some out-of-this-world [media here](#), and read about the major contributions to this discovery made by members of the Gravity Spy from [Northwestern](#) and [CSU Fullerton](#)!

## Gravity Spy Talk

Search or enter a #tag



## Subjects tagged with paireddoves



Talk is a place for Zooniverse volunteers and researchers to discuss their projects, collect and share data, and work together to make new discoveries.

# Preliminary findings from a visionary workshop with teachers about Gravitational Wave Noise Hunting





<https://www.reinforceeu.eu/events/training-workshop/vision-building-workshop-citizen-science>



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# Programme

- ☒ Citizen science in education (+mentimeter session) – 1hr
- ☒ Citizen science and REINFORCE – 20 mins
- ☒ Hands on session: GW noise hunting in the classroom (1 hr)
- ☒ Final mentimeter session and teacher feedback (20mins)



## THE REINFORCE CITIZEN SCIENCE ACTIVITIES WILL

positively alter attitudes towards science in general

be enjoyed by my students

increase students' collaboration skills

increase students' communication skills

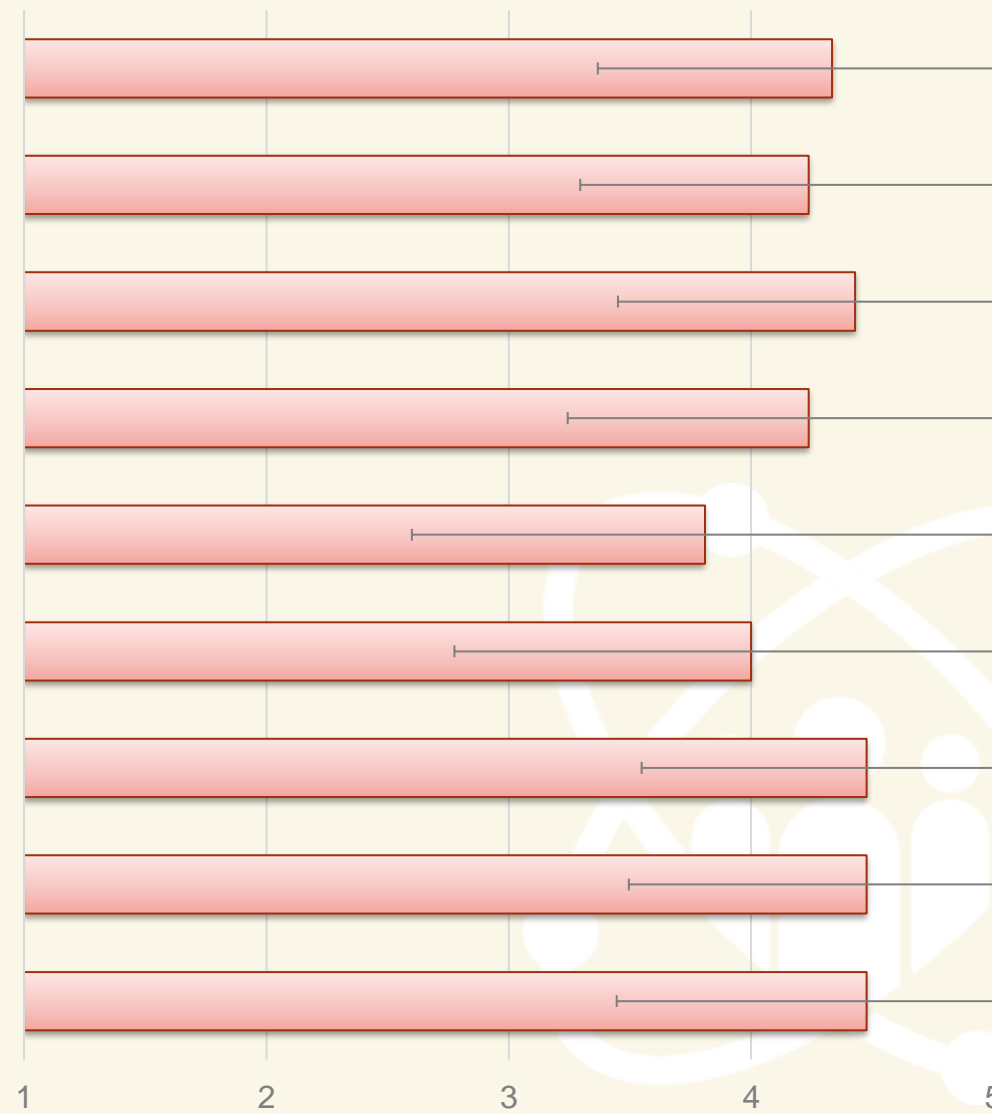
be relevant to students' life.

contribute to their personal development

increase students' sense of meaning of learning and science courses

motivate students to learn more about the specific topics

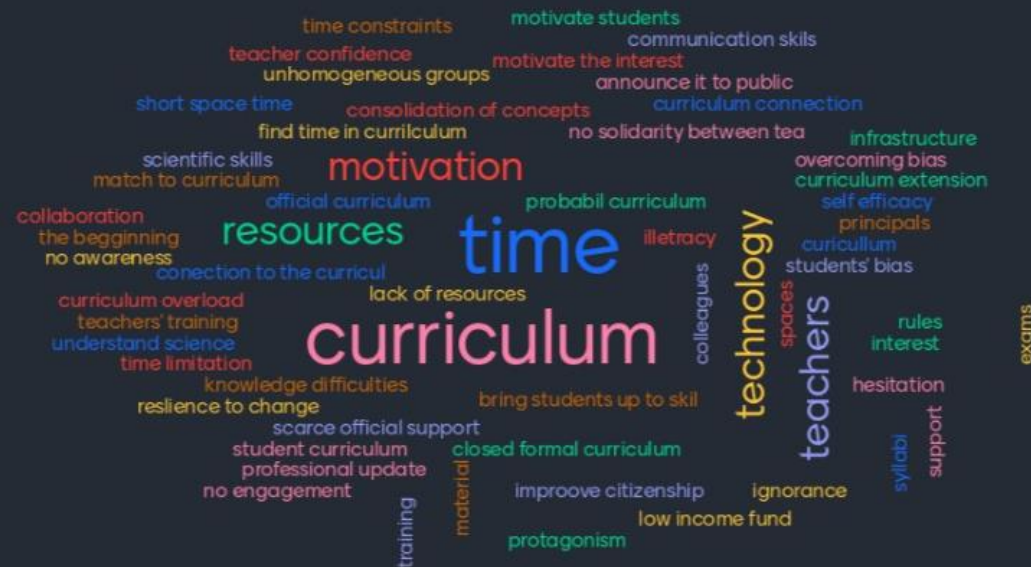
increase my students' motivation to be engaged in STEM



## Main challenges (N=26)

“Curriculum”; “Lack of resources”; “Time”; “Lack of Training”; “infrastructures (PC’s)”

What are the main challenges to overcome to integrate CS in formal school education?



**Desired Learning outcomes**  
**“Scientific way of thinking”; “Cooperation”**

**What are desired learning outcomes that you would intend for your students?**

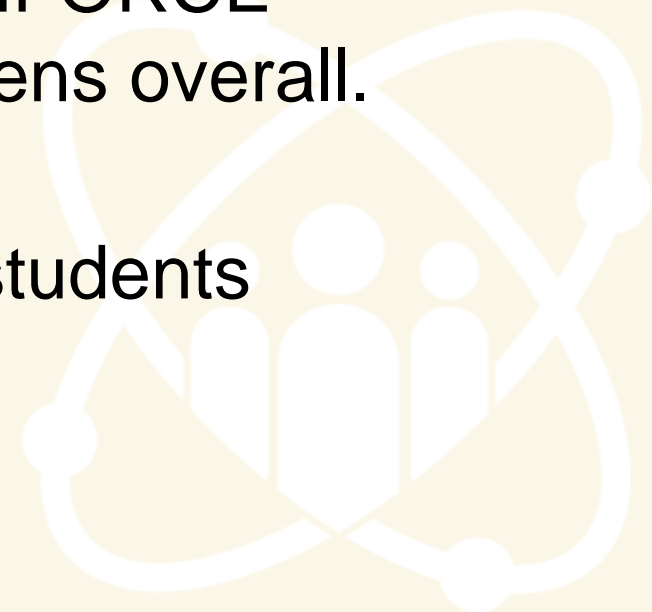




# Future steps

- 🚀 Launching the REINFORCE projects.
- 🚀 Initiating a series of 2 year long participatory engagement activities to support the implementation of the REINFORCE Citizen Science projects with schools and with citizens overall.
- 🚀 Engaging 100,000 citizens out of which 5,000 are students

Looking forward to working with you!





# REINFORCE

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