

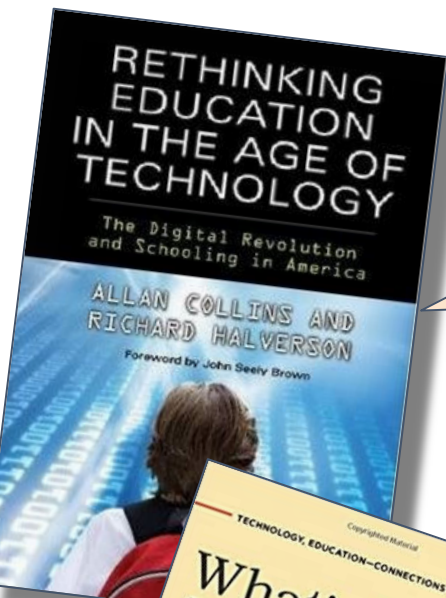
Reasoning with Data in School-Based Citizen Science

A presentation at the Paderborn Colloquium (ProDaBi)
by Prof. Dani Ben-Zvi
17 May, 2023

Part I.

School-Based Citizen Science

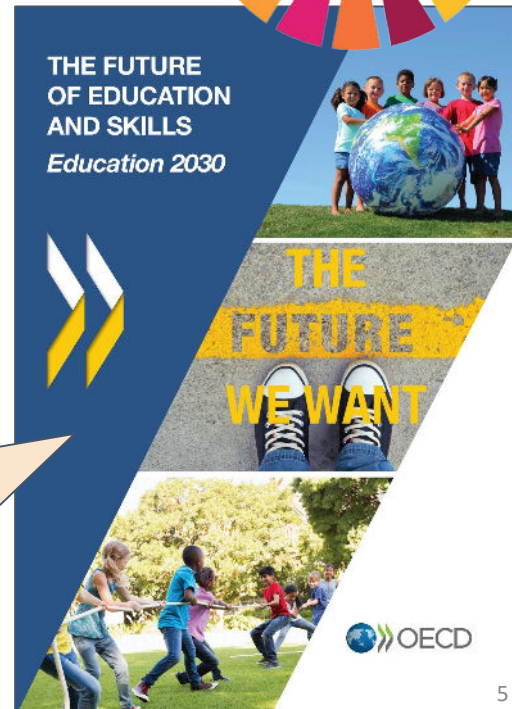
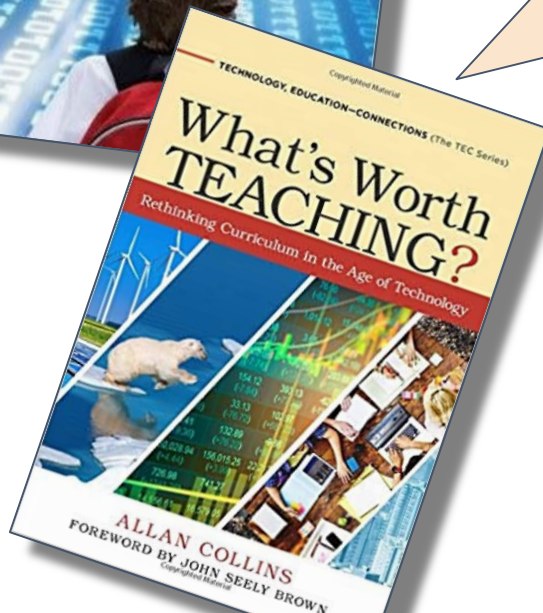




“Schools everywhere are anchored in the past... [schools] aren't preparing youth for the complexity of today's world.”

“What a student should learn is to be a knowledgeable person, a good citizen, a thoughtful worker, a reflective thinker, and a valuable friend in a complex dynamic society.”

“Education needs to ...equip students with the skills they need to become active, responsible and engaged citizens...”



Citizen science projects **actively involve citizens in scientific endeavors** in meaningful roles: contributors, collaborators or project leaders.

Citizen science projects have a **genuine scientific outcome**: Answering a research question, informing policy.

Both the professional scientists and the citizen scientists **mutually benefit** participation: Research publication, social benefits, personal enjoyment.

Citizen scientists are **acknowledged** in project results and publications.

Citizen scientists may, if they wish, **participate in multiple stages** of the scientific process: Design methods, gather data, analyze data.

Citizen science project data and metadata are **made publicly available** and where possible, results are published in an **open-access** format

Citizen science **is considered a research approach** like any other, with limitations and biases that should be considered and controlled for.

Citizen scientists **receive feedback** from the project: How their data are being used and what the research, policy or societal outcomes are.



Credit to Foldit players

Published in final edited form as:

Nature. 2010 Aug 5; 466(7307): 756–760.

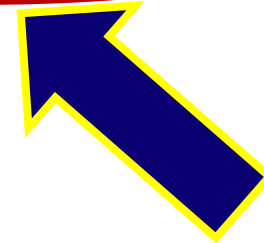
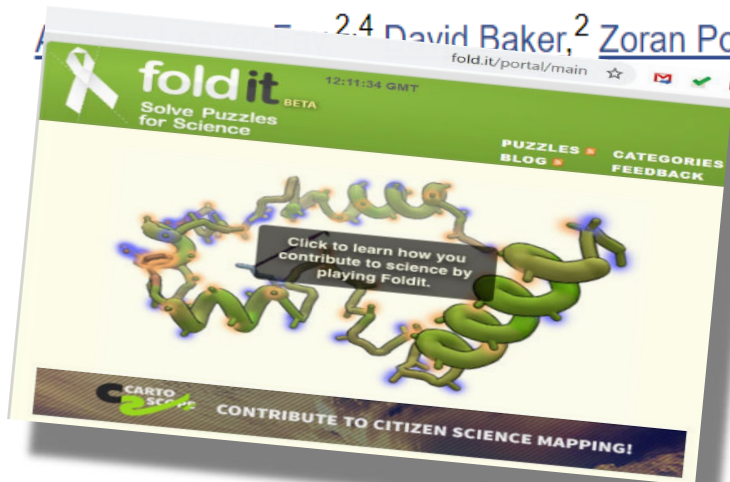
doi: 10.1038/nature09304

HHMIMSID: HHMIMS218516

PMID: 20686574

Predicting protein structures with a multiplayer online game

Seth Cooper,¹ Firas Khatib,² Adrien Treuille,^{1,3} Janos Barbero,¹ Jeehyung Lee,³ Michael Beenen,¹
— 2.4 David Baker,² Zoran Popovic,¹ and >57,000 Foldit players⁵





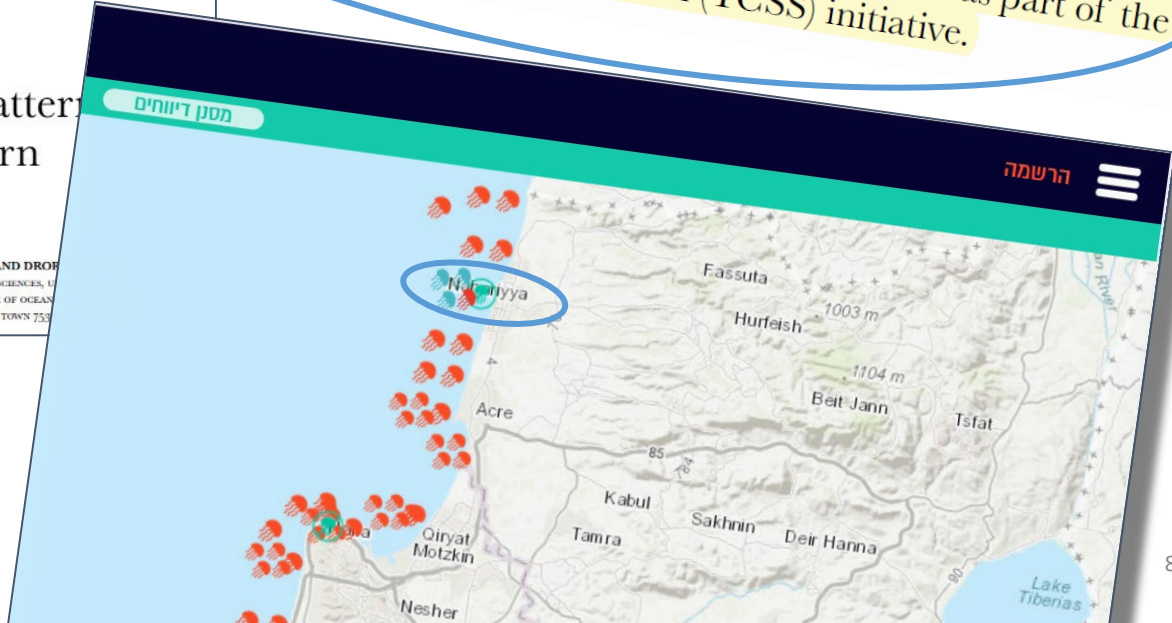
ORIGINAL ARTICLE

Phenological shift in swarming pattern of *Rhopilema nomadica* in the Eastern Mediterranean Sea

DOR EDELIST^{1,*}, TAMAR GUY-HAIM², ZAFRIR KUPLIK^{1,3}, NOA ZUCKERMAN¹, PHILIP NEMOY¹ AND DROF
¹RECANATI INSTITUTE FOR MARITIME STUDIES AND DEPARTMENT OF MARITIME CIVILIZATIONS, CHARNEY SCHOOL OF MARINE SCIENCES, U
HAIFA, MOUNT CARMEL, HAIFA 31905, ISRAEL ²ISRAEL OCEANOGRAPHIC AND LIMNOLOGICAL RESEARCH, NATIONAL INSTITUTE OF OCEAN
31080, ISRAEL AND ³DEPARTMENT OF BIODIVERSITY AND CONSERVATION BIOLOGY, UNIVERSITY OF THE WESTERN CAPE, CAPE TOWN 753

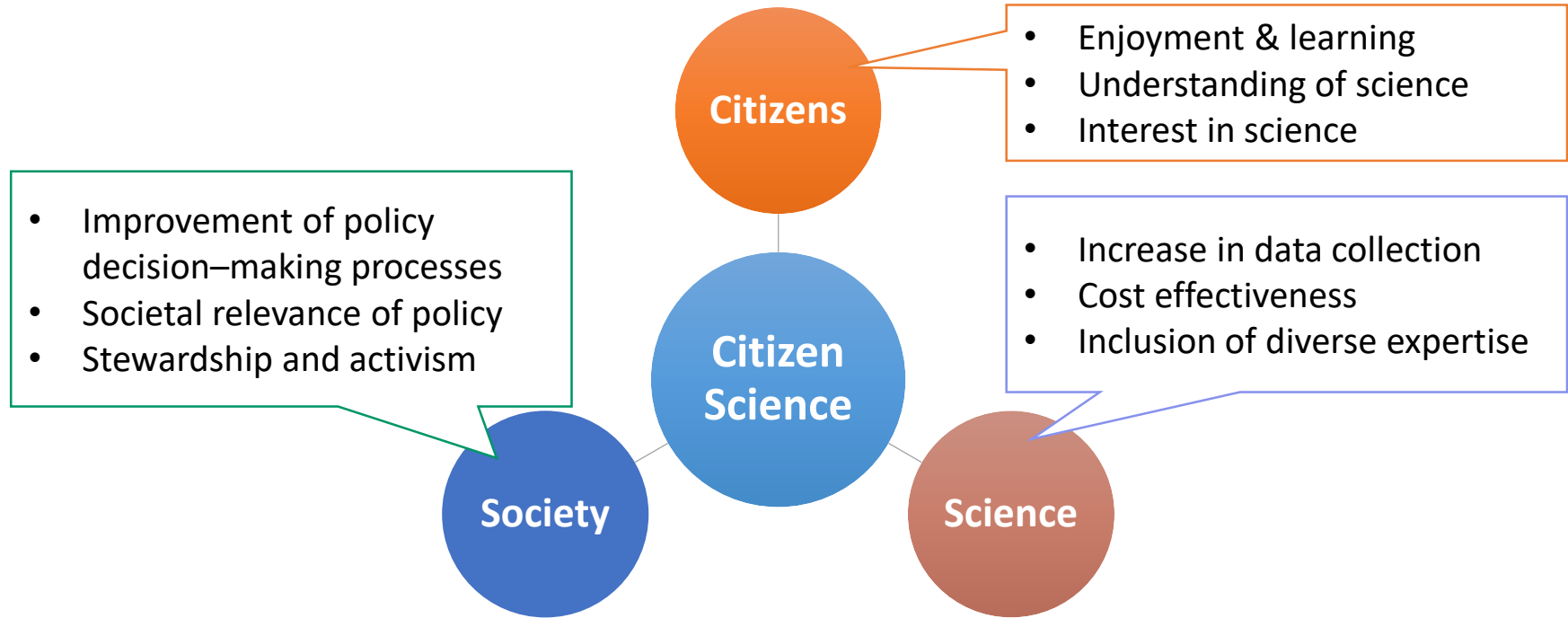
ACKNOWLEDGEMENTS

We would like to thank all the citizens who have contributed jellyfish observations to our website and especially to students in the Rambam School, Nahariya, Israel who did so as part of the Taking Citizen Science to School (TCSS) initiative.



Why citizen science?

Win, win, win...



Hecker, S., Wicke, N., Haklay, M., & Bonn, A. (2019). How does policy conceptualise citizen science? A qualitative content analysis of international policy documents. *Citizen Science Theory and Practice*, 4(1).

Shirk, J. L., Ballard, H. L., Wilderman, C. C., Phillips, T., Wiggins, A., Jordan, R., ... Bonney, R. (2012). Public participation in scientific research: a framework for intentional design. *Ecology and Society*, 17(2), 29.

The screenshot displays the Zooniverse.org homepage. At the top, there is a navigation bar with a teal 'ALL DISCIPLINES' button and icons for various fields: ARTS, BIOLOGY, CLIMATE, HISTORY, LANGUAGE, LITERATURE, MEDICINE, and NAT. Below this, a search bar contains the text 'Most Recently Launched' and a filter icon. To the right of the search bar, it says 'Showing 1-20 of 97 projects found.' and there is a 'Name:' search input field. The main content area features a large, prominent project card for 'Join the hunt for solar jets – enigmatic bursts of energy from our own star – the Sun!'. This card has a dark red background with a solar image and a 'Learn more' button. To the left of this card, a partial view of another project card is visible, titled 'Help us understand patterns of...'. Below the main card, a row of five smaller project cards is shown: 'GWITCHHUNTERS', 'SCARLETS AND BLUES', 'METEORORUM AD EXTREMUM TERRAE', 'NODE CODE BREAKERS: LOOKING FOR PATTERNS IN LYMPH NODES', and 'SUPERWASP: BLACK HOLE HUNTERS'.

ALL DISCIPLINES

ARTS

BIOLOGY

CLIMATE

HISTORY

LANGUAGE

LITERATURE

MEDICINE

NAT

Most Recently Launched

Showing 1-20 of 97 projects found.

Name:

Join the hunt for solar jets –
enigmatic bursts of energy from
our own star – the Sun!

Learn more

Help us understand
patterns of...

GWITCHHUNTERS

SCARLETS AND BLUES

METEORORUM AD EXTREMUM
TERRAE

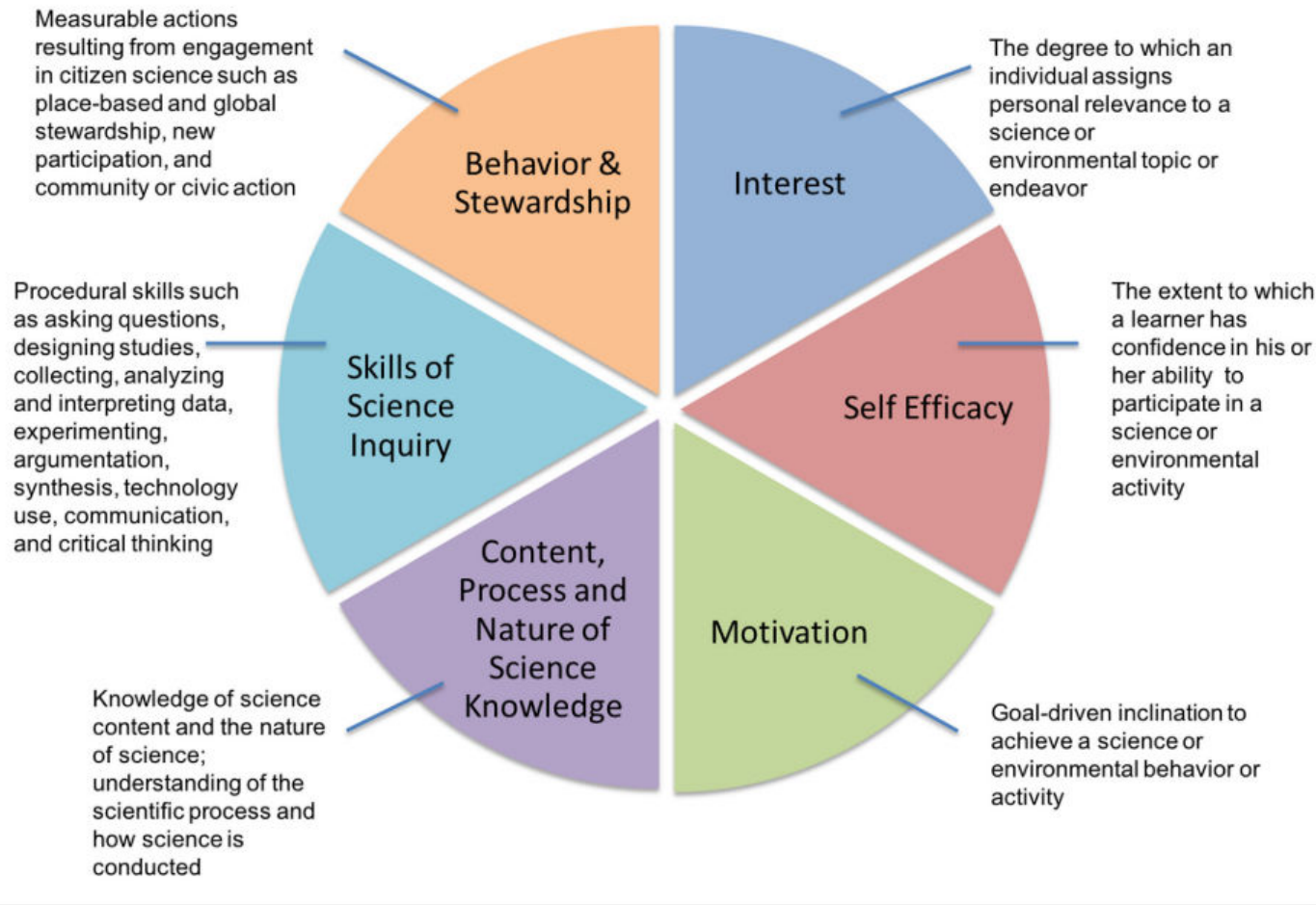
NODE CODE BREAKERS:
LOOKING FOR PATTERNS IN
LYMPH NODES

SUPERWASP: BLACK HOLE
HUNTERS

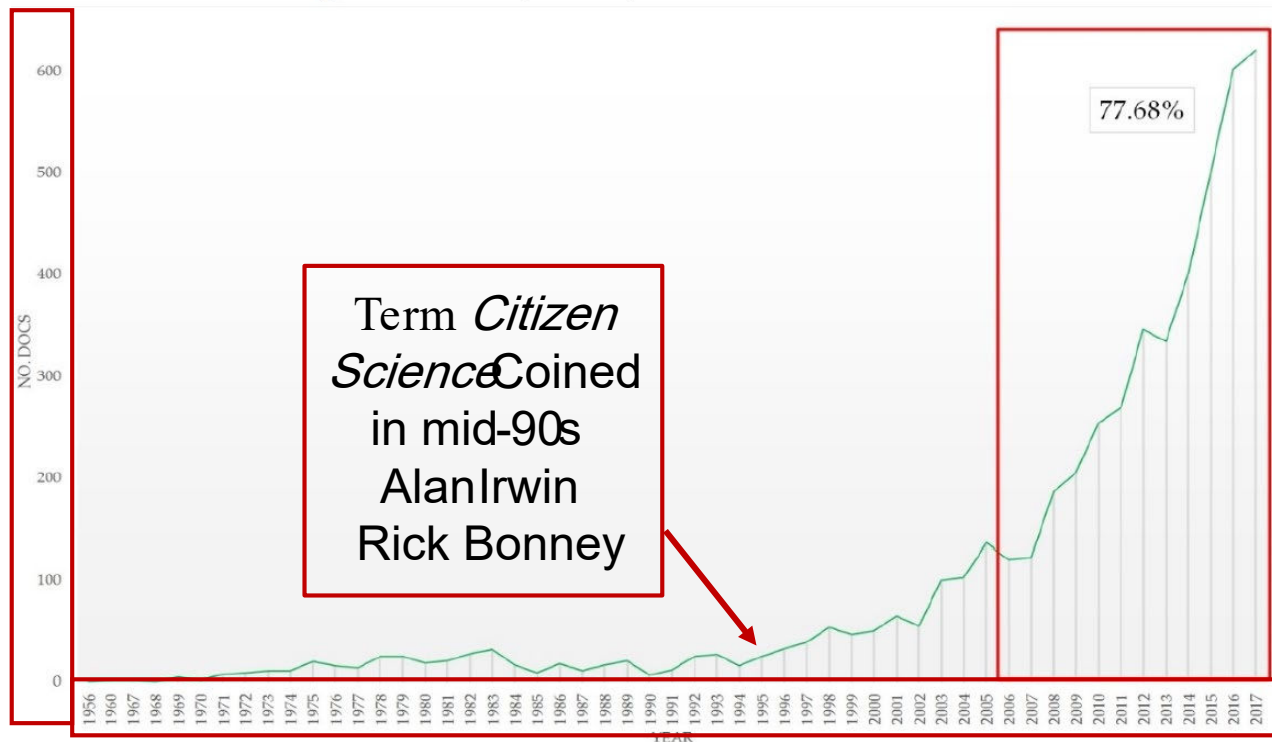
Myriad projects
enabling
anyone to
become a
citizen scientist

Examples from
Zooniverse.org

Potential for learning in citizen science – typically unrealized

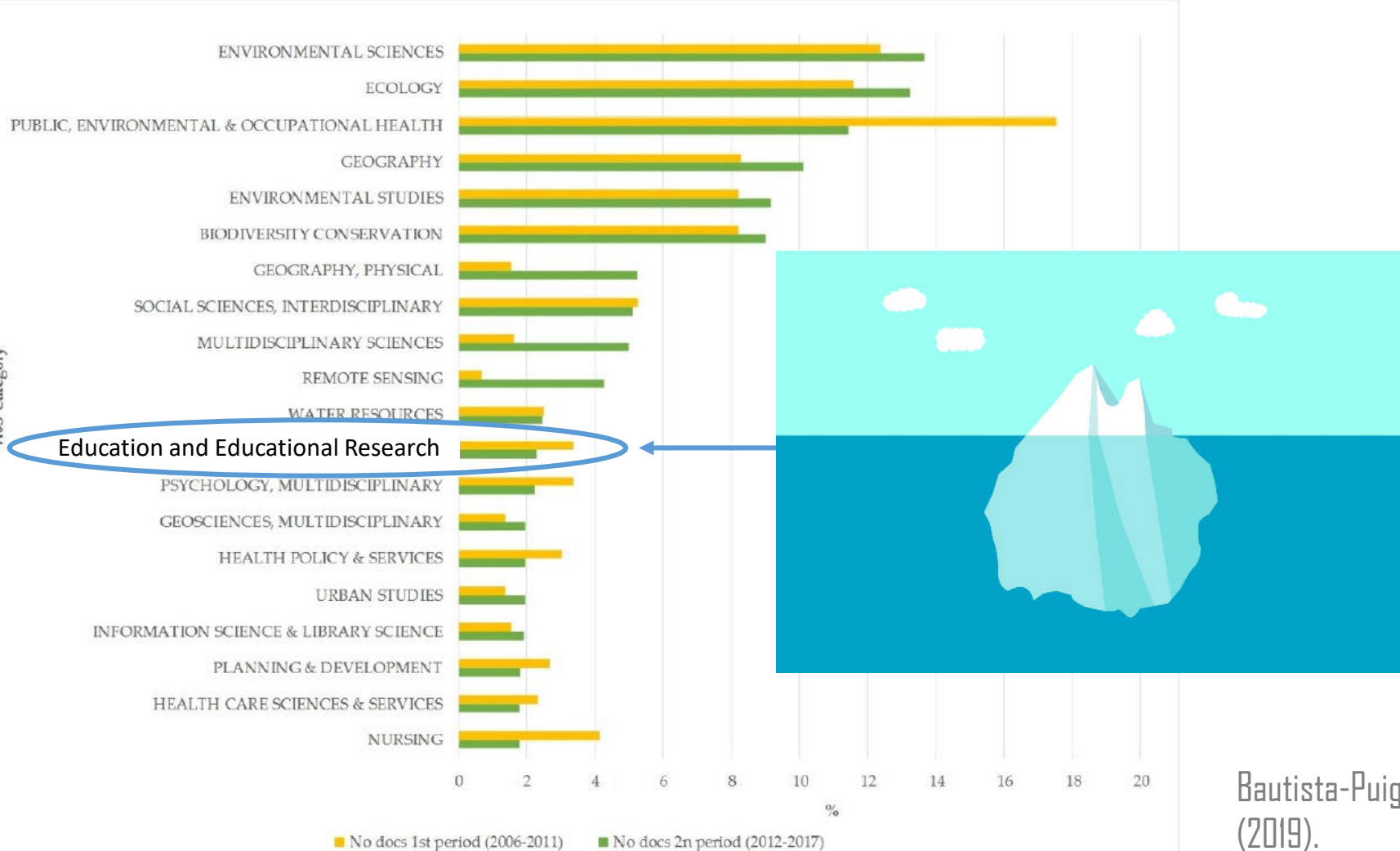


Scientific landscape of citizen science publications



Bibliometric study using the terms:

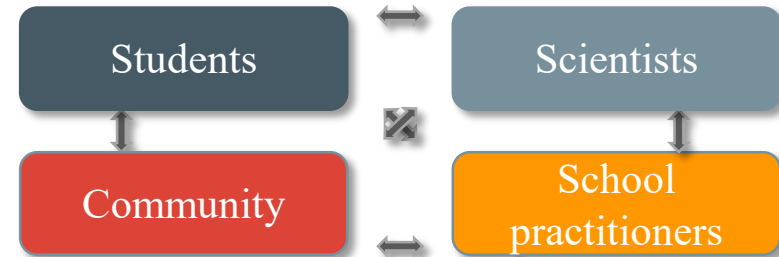
“crowd science”,
“community science”,
“participatory research”,
“community-based research”,
“citizen research”,
“science shop”,
“public-participation”,
“citizen observatory”,
“citizen science”, etc.





Challenges involved in school participation in citizen science

- How to maintain the excitement and authentic learning when incorporating CS into schools?
- How to cultivate the development of a learning ecology that fosters mutual benefits for students, school practitioners, scientists, and sometimes the community?
- How to support teachers in adapting the CS curriculum materials to suit their specific educational context?

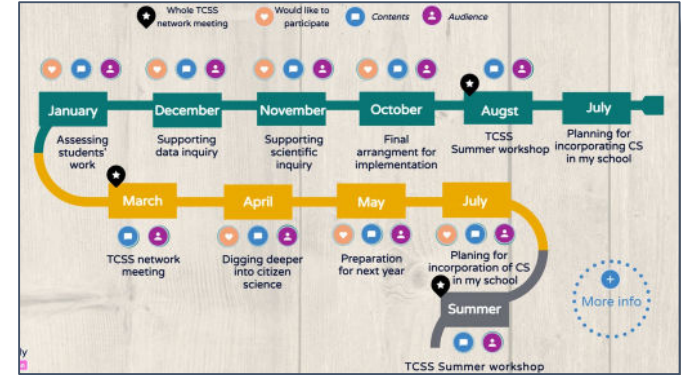


Network of research-practice partnerships (RPPs)



The TCSS modus operandi

Modular support system for teachers



Citizen science projects: Co-designed



Insights:

Co-creating design knowledge

All stories

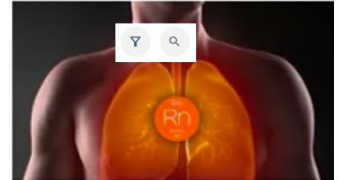


Landmarks for accessibility: How to start the project?
Contributed by Dalit Lan

Students at Leo Baeck school won first prize at the Haifa inquiry fair presenting their work in the Wild Boar CS project

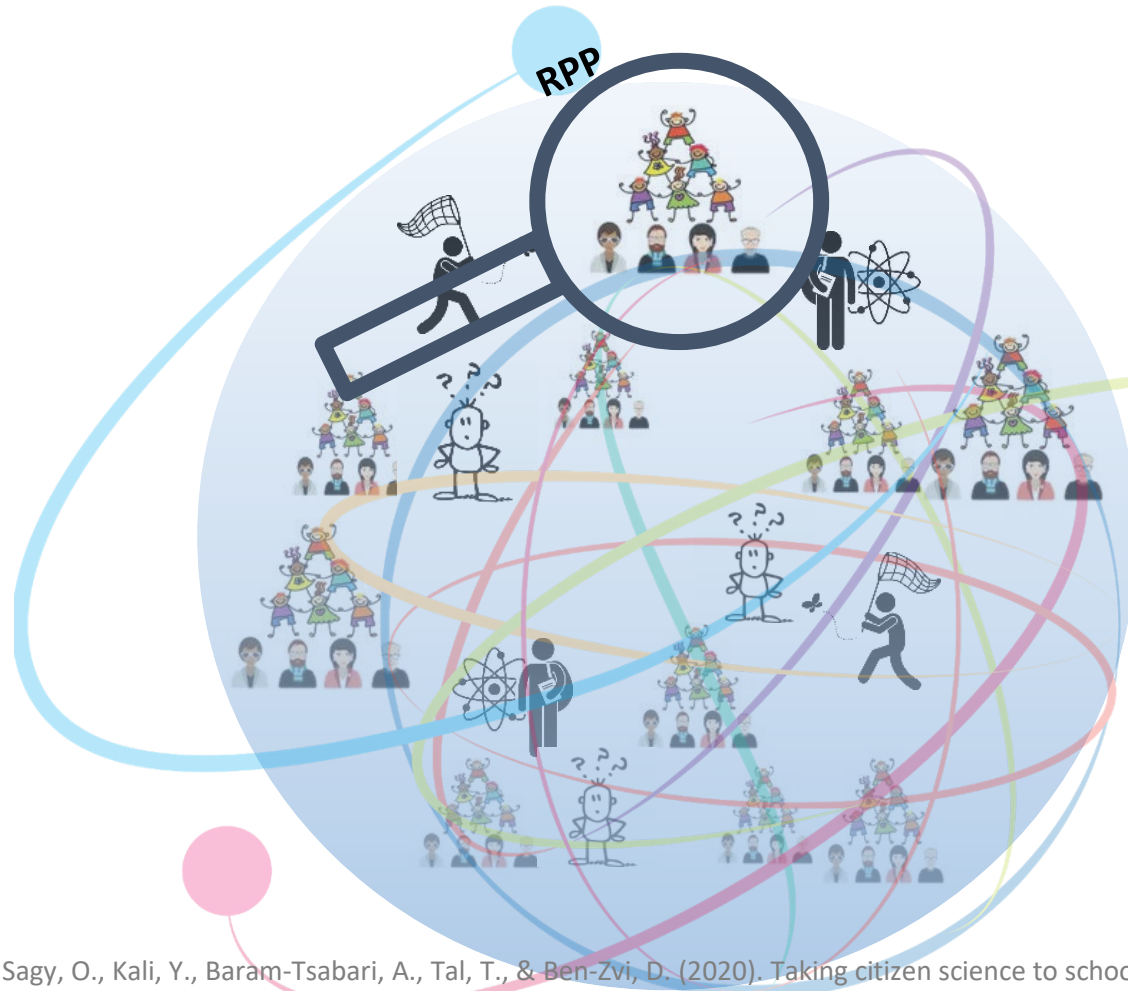


Wild boars at the inquiry fair



The Radon gas: Students' impact on an ongoing scientific research
Contributed by Alin Perry

Network of Research-Practice Partnerships (RPPs)



~ 100 schools

~ 180 teachers

> 5000 students

~ 10 scientist teams



tcss.center/learning-environments (Hebrew only)





SLEEP - A THIRD OF OUR LIFE

A citizen science project invites
you to explore your sleep

Suitable for grades 7-10

← START



Taking Citizen Science to School
המרכז לקידום מדע אזרחי בבית הספר

<https://view.genial.ly/6418766e0a35590018b33aca>

המעבדה
האזרחית
סניפון - מדעסק - קהילה



הטכניון
מכון טכנולוגי
לישראל



אוניברסיטת חיפה
University of Haifa
جامعة حيفا

MAIN MENU



AN OVERVIEW OF THE PROJECT

General information

Contents

Sequence of activities



TAKING THE ACTIVITY TO THE CLASSROOM

Signup form

Download

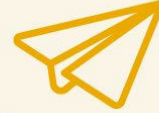
Approval forms



TOOLS FOR PLANNING

Planning tools

Dynamic sequence



INSPIRING

Teachers share

Students products

Insight stories

OUR LIFE

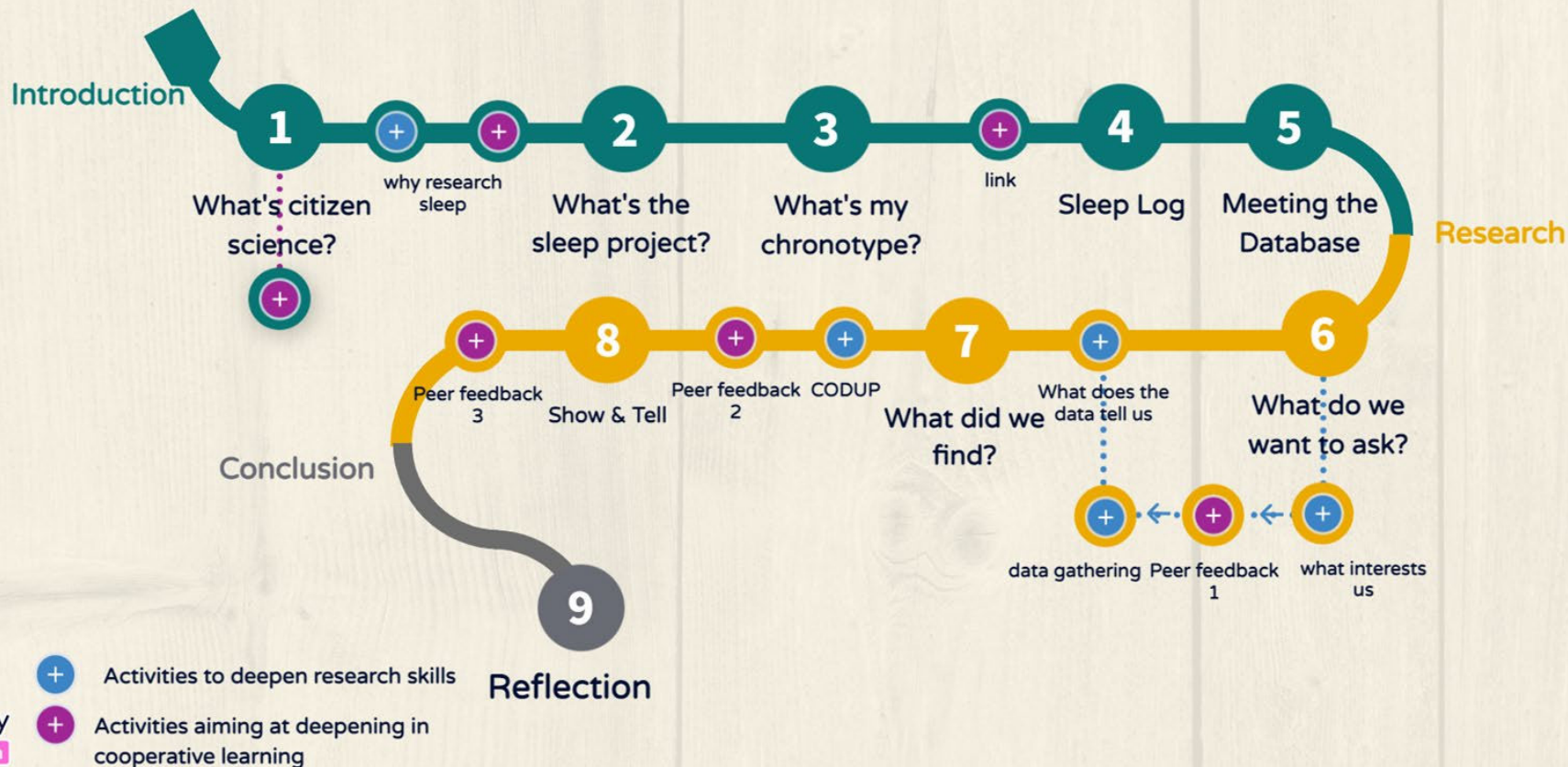
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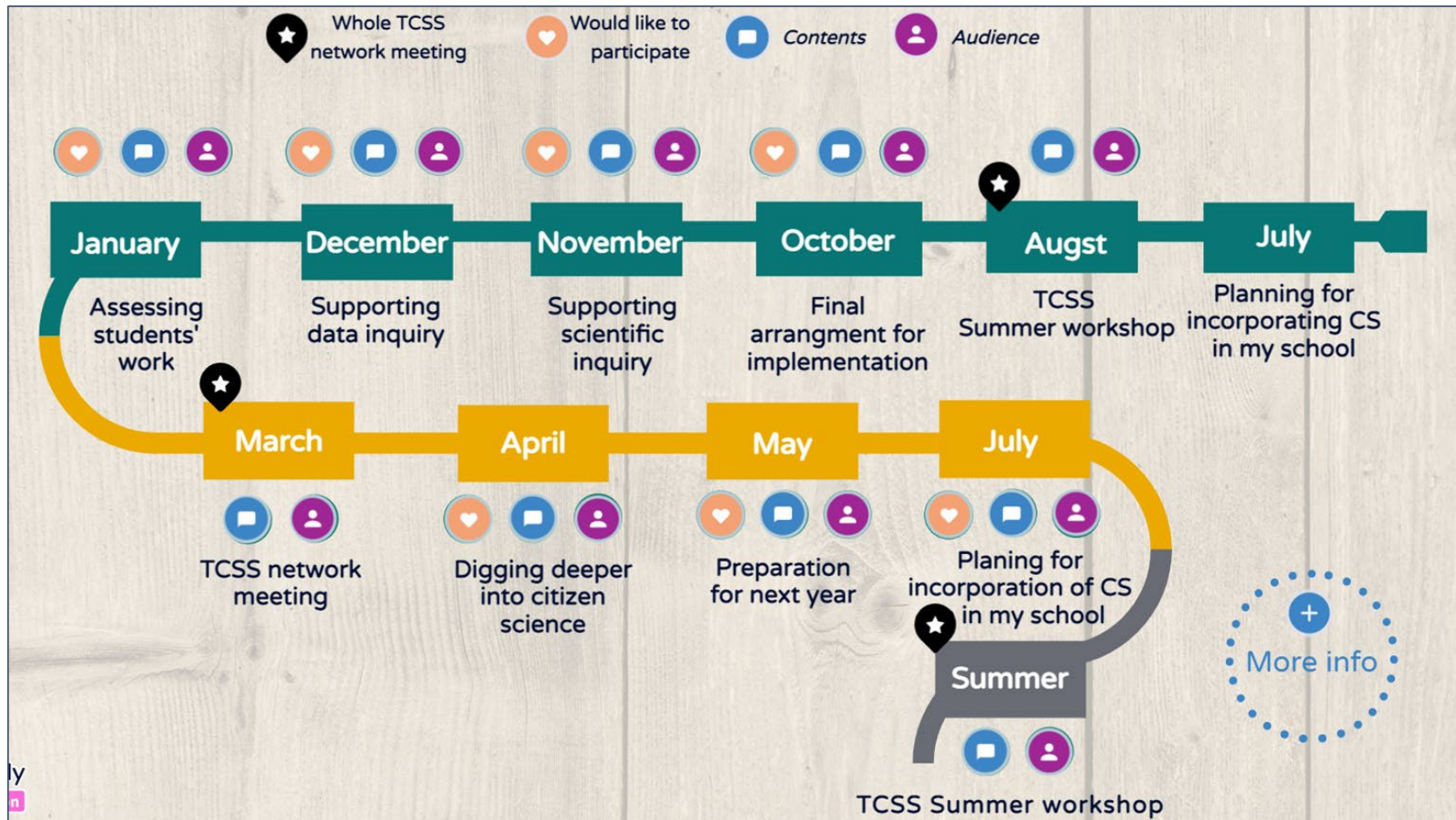


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ACTIVITY SEQUENCE





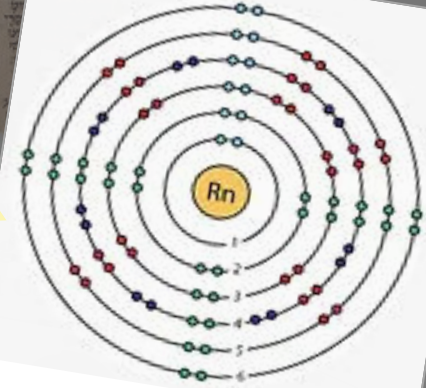
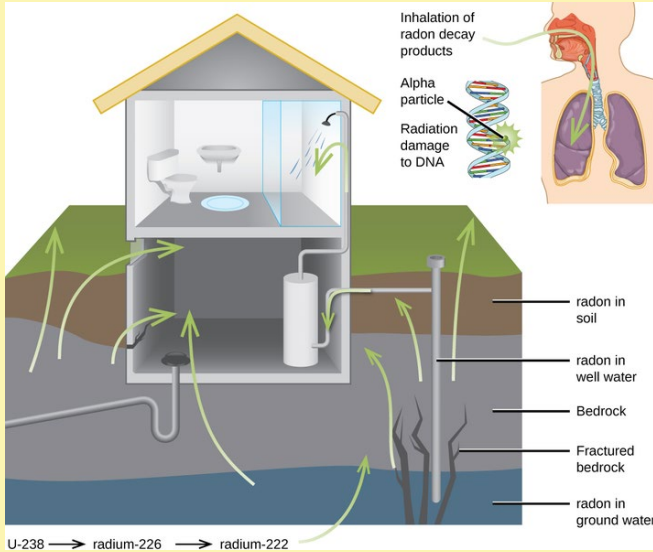
Part II.

Reasoning with Data in School-Based Citizen Science: The Case of Students' Articulations of Uncertainty in the Radon Project



86

Rn
radon



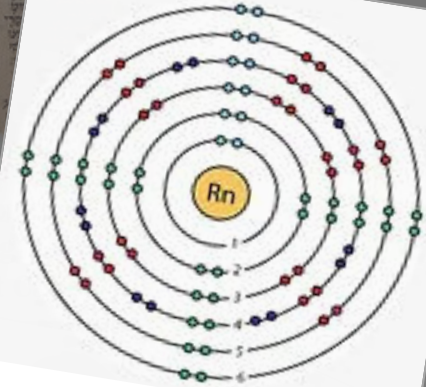
Radon at home?

**Sleep:
One third
of life**

**The Bermuda
Buttercup
Mystery**

The Scientists' Goals

1. Describe the high temporal variation of the Radon
2. Develop and test a new Radon measurement method
3. Map the Radon levels in Israel



**Radon at
home?**

Alternative Radon measurement device



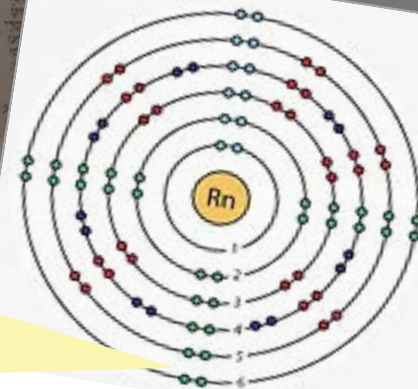
Long range (e.g., months)
measurement device
of the annual average
concentration

Precise but expensive and
requires extended period

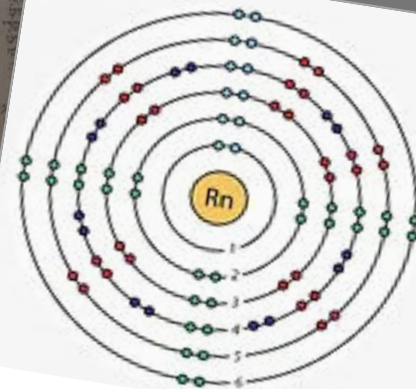
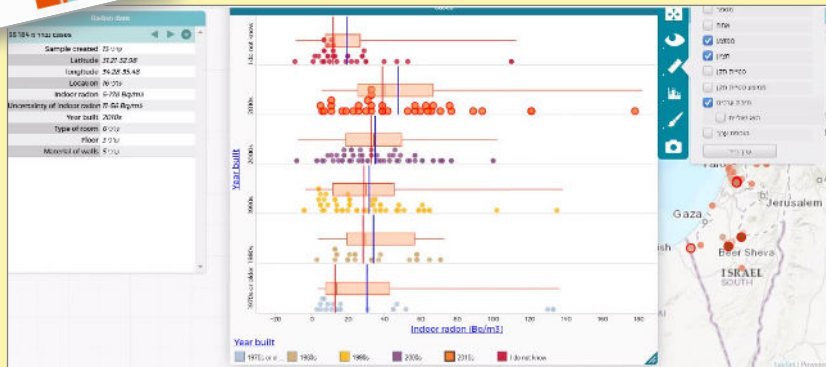
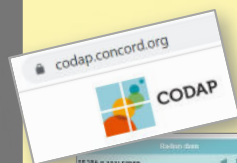
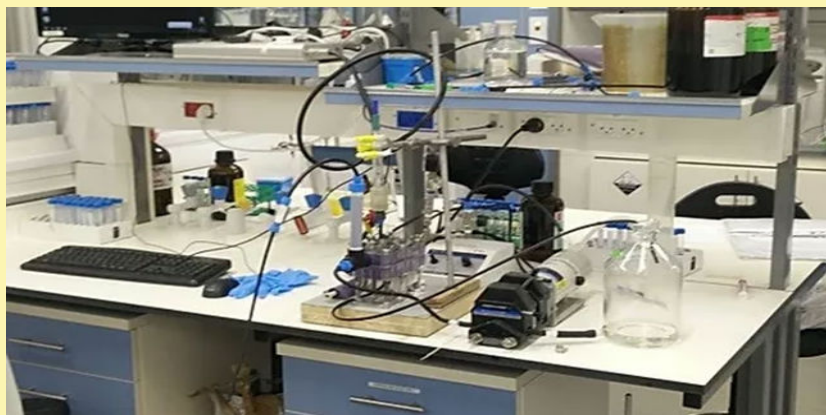


Short-term measurement
device of 3-4 days average
Radon Concentration Level
(RCL)

Low cost and short time
but inaccurate



**Radon at
home?**



Radon at home?

**Sleep:
One third
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Buttercup
Mystery**

The Radon learning sequence of this study

First cycle: Familiarize with the Radon, its two measuring devices, and the scientists' work in their lab.

Second cycle: (a) Characterize the Radon temporal variability over a year based on samples of data collected by the long-term measurement device in the scientists' lab; and (b) evaluate the measurement error of the short-term measurement device using modeling and simulation software.

Third cycle: Investigate big data collected by the short-term device to describe relations between the Radon and other attributes (e.g., room type).

(Aridor et al., 2023; Aridor & Ben-Zvi, 2018; Dvir & Ben-Zvi, 2021; Manor et al., 2014)

The second investigative cycle

EDA

Investigate the long-term measurement device's data, using the **Growing samples heuristics** (24, 48 and 72 cases)



Model

Model the population using the TP2 Sampler and **compare** between random simulated samples of 72



Sampling distribution

Reason with a sampling distribution of 100 simulated random samples (sized 72 and 96)



Evaluate and quantify uncertainty about samples sized 72 and 96 to estimate the inference from the real sample ($n=72$) and to assess the reliability of the short-term measurement device (72 or 96 hours)

Method

Research question: *What statistical uncertainty articulations can young students express in the context of a Radon Citizen Science project?*

A case study of one pair of middle school students' (Liv 13 and Yoni 14) engagement in an extended learning sequence as part of this project.

Seven activities in the learning sequence (a total of 13 hours).

Two researchers accompanied the students' participation.

The analysis: a qualitative approach using an interpretative microgenetic and two-tiered triangulation methods.

Students' uncertainty articulations

Deterministic (no uncertainty)	“Not nothing, not everything, but something”	Relativistic (full uncertainty)
Sample representativeness	representativeness is evaluated alongside sampling variability	Sampling variability

(Makar, Bakker, & Ben-Zvi, 2011; Manor, Ben-Zvi, & Aridor, 2014; Shaughnessy, 2007)

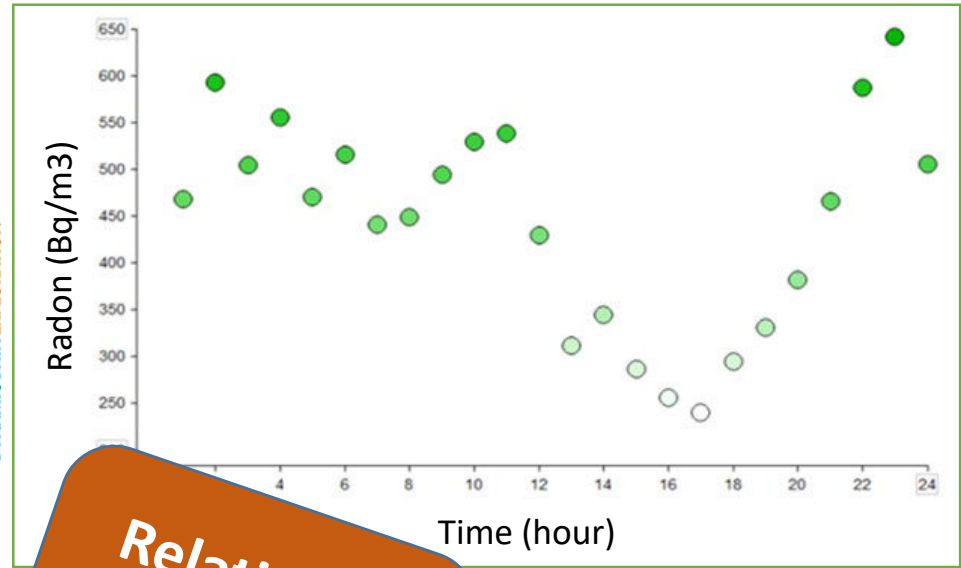
Demonstration

[The Radon data](#)

The Scientists' laboratory
long-term measurement device
(72 cases, every hour, 3 days in a row)



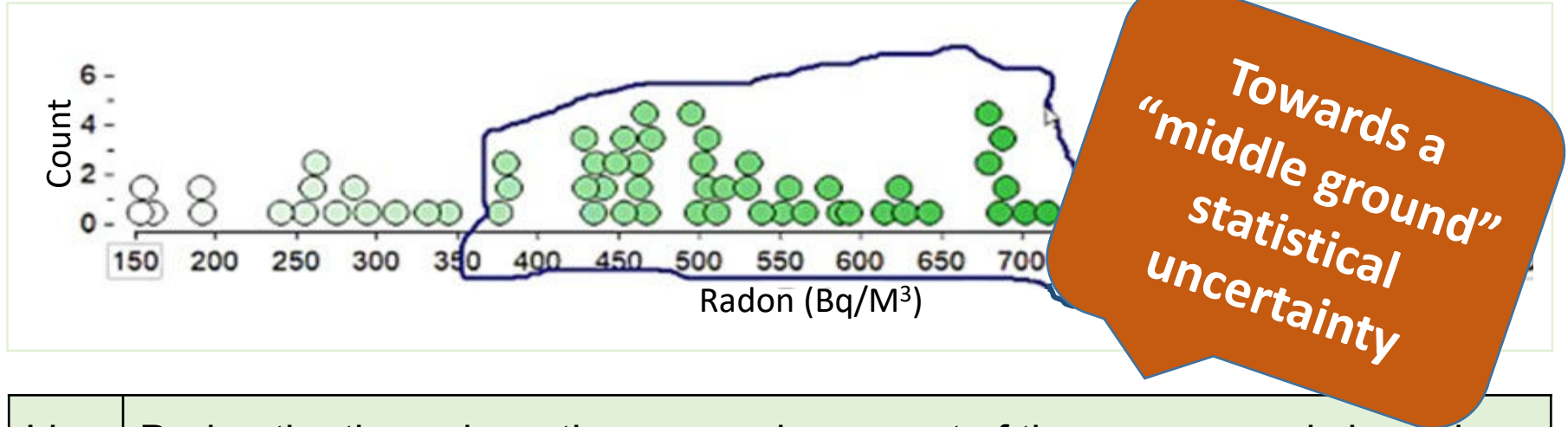
First sample investigation: Radon levels per hour (n=24)



**Relativistic
statistical
uncertainty**

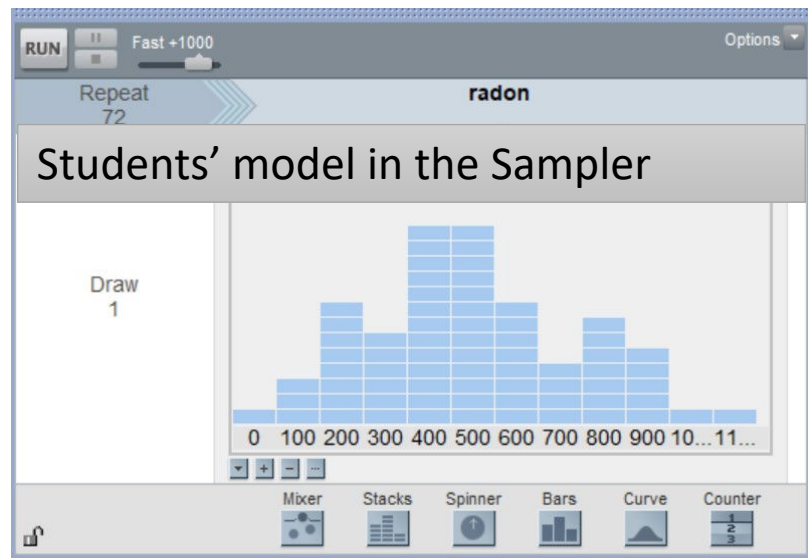
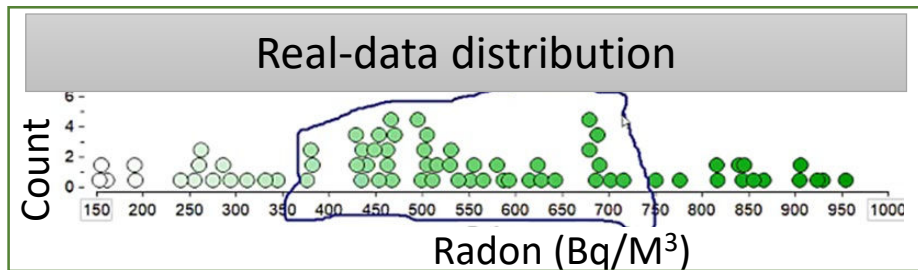
R	What can you say about the Radon
Yoni	That every day its concentration can change. Because you can look at this day: There was a period where it was 240 and the highest was 640. So that is a change of 400 from the lowest to the highest point.

Third sample investigation: Radon levels per hour (n=72)



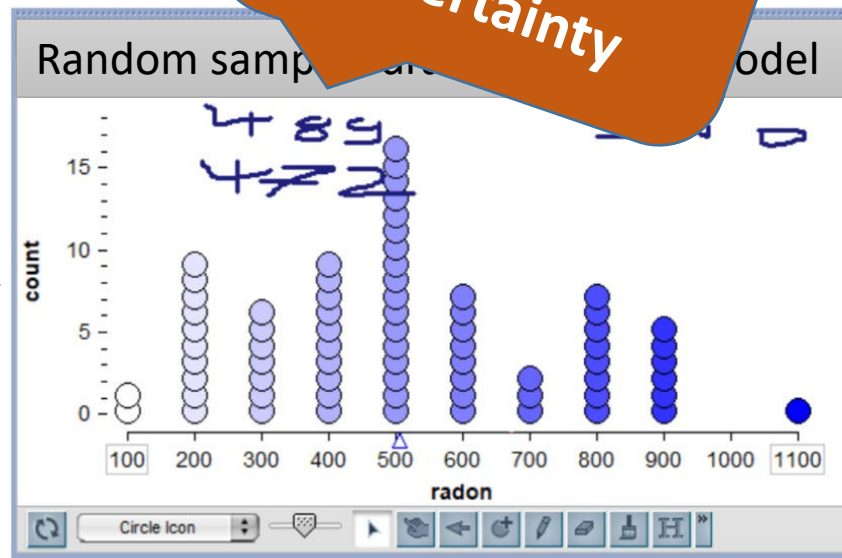
Liv	During the three days, the range where most of the cases are - is here, in the middle [she draws a blue shape around this 'modal clump']... I predict that this will also be the [annual] range. A few more cases may be here [right of the shape], or a few more may be in the lower concentrations.
-----	---

Can we trust samples of 72 cases?



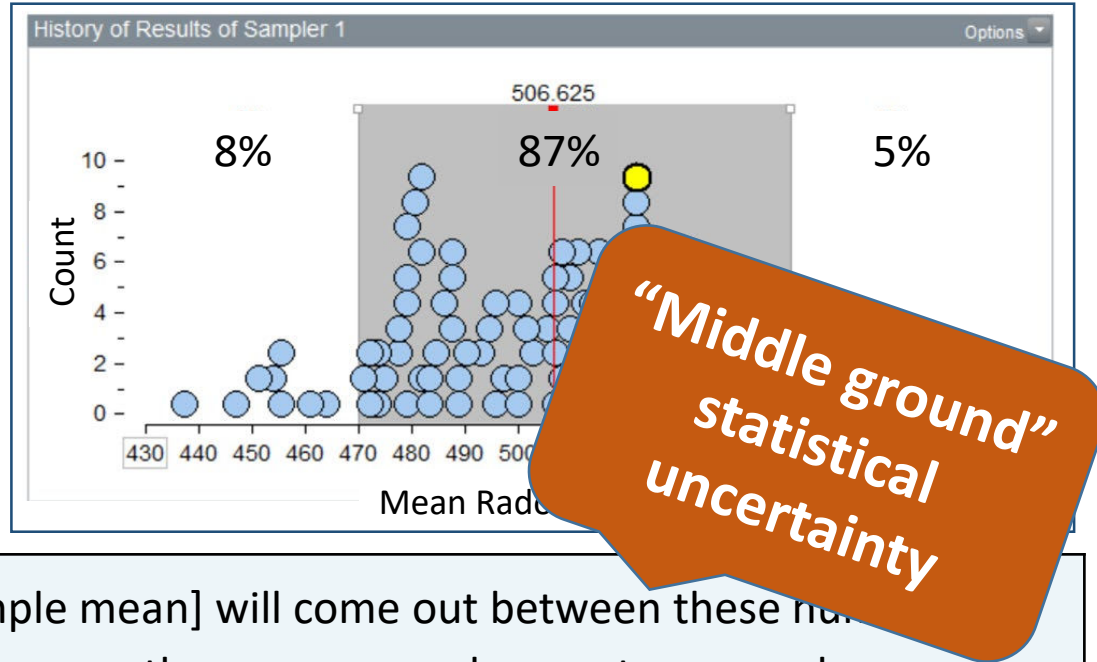
How long
charcoal
about the

Towards a
"middle ground"
statistical
uncertainty



If we drew another sample,
where is it likely to be in the sampling distribution?

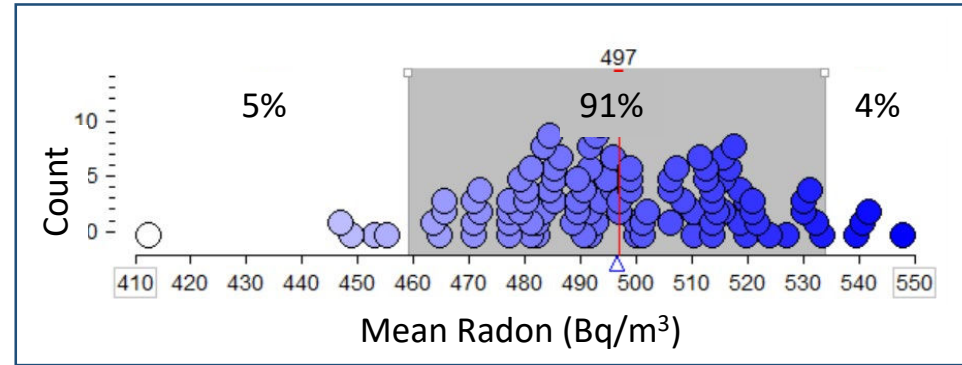
What are the chances to
sample another
representative sample
[that falls in the gray
area]?



Liv	Most likely it [the new sample mean] will come out between these numbers [points at the gray area], because there are more chances to appear here.
Yoni	The error range [the chance to get a non-representative sample] here is quite large [13%], but it [a sample size 72] can be trusted.

Applying uncertainty in the context world

How many days should the charcoal bottle be opened, in order to learn about the annual behavior of the Radon?



Liv	Four days. Because according to what we checked in TinkerPlots, when we drew a 96-hour sample, we could reduce the [...] “error range” [to 9%]... We wanted to know what is the [measurement] error level of the charcoal bottle. When it is opened four days, there are less chances that this result will be wrong.
-----	---

Summary: The students' expressions of uncertainty

Activity	Views
First data investigation (n=24)	Conflict between extreme uncertainty articulations
Third data investigation (n=72)	Reconcile conflicting extreme uncertainty articulations
Comparing simulated samples (n=72)	Recognize and Evaluate uncertainty within a sample and between simulated samples
Sampling distributions (100 samples, n=72, 96)	Quantify uncertainty within a sample and between simulated samples and apply it to the real-sample (open the charcoal bottle for four days)

Discussion: The contributions of the CS unique setting

What does the innovative setting of Citizen Science offer?

- New pedagogical opportunities that allow concurrent engagement with authentic scientific and statistical practices
- The unique data – the scientists' complex data with non-systematic variation, access to large authentic data sets
- The adaptation of the data investigation to the unique nature of the Radon scientific context and the authentic scientists' goals
- Students contribute to the advancement of science, community and society

(Aridor et al. 2023; Schuttler et al., 2019)

Discussion: Expansive framing of the various stakeholders



Began to view learning as important ***beyond the classroom*** contributing to the advancement of science, community, and society

“I felt it was important to invest in the project because scientists will use the data we contributed to help people with disabilities”



Began to view own expertise as important ***beyond school***, as part of partnerships with scientists and educational researchers

“Providing students an opportunity to do something that really contributes to science - that was fantastic in my opinion... much beyond the didactic goals”



Began to view own expertise as important ***beyond the academic world***, as contributing to education, and societal change

“A significant part of my motivation is to drive changes in society in the context of sustainability and nature conservation. Working with children and youth is an important part of that”

Current and future work of our team

- Scale up: Radon at Home and Sleep CS projects
- Big data in the Radon and Sleep CS projects
Gafny, R., & Ben-Zvi, D. (2023). Students' articulations of uncertainty about big data in an integrated modeling approach learning environment. Teaching Statistics, 1-23.
<http://doi.org/10.1111/test.12330>
- DReaM: Integration between statistical, scientific and nature of science
Aridor, K., Dvir, M., Tsybulsky, D., & Ben-Zvi, D. (2023). Living the DReaM: The interrelations between statistical, scientific and nature of science uncertainty articulations through citizen science. Instructional Science.
<https://doi.org/10.1007/s11251-023-09626-8>

Thank you!

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[TCSS](#)