Situating sustainable development within chemistry education through systems thinking oriented outreach activities in primary and secondary schools

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EuroVariety 2021

Elements of Sustainable Chemistry (ESC)
eschemistry.org

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Acknowledgement of Country

I join you in this conference today from the lands of the Wurundjeri people of the Kulin nations, and I wish to acknowledge them as Traditional Owners.

I would also like to pay my respects to their Elders, past present and emerging, and Aboriginal Elders of other communities and other countries around the world who may be here today.

Systems Thinking in Chemistry Education

Recognise the **material basis of society** as a core element in sustainability challenges

Shape the **practice of chemistry** by sustainability science

Re-orient chemistry education to address the sustainability of earth and societal systems

Educate about the **molecular basis of sustainability** using **systems thinking**

Mahaffy, P. G., Matlin, S. A., Whalen, J.M. & Holme, T. A. (2019). Integrating the Molecular Basis of Sustainability into General Chemistry trough Systems Thinking. *Journal of Chemical Education.* Doi: 10.1021/acs.jchemed.9b00390

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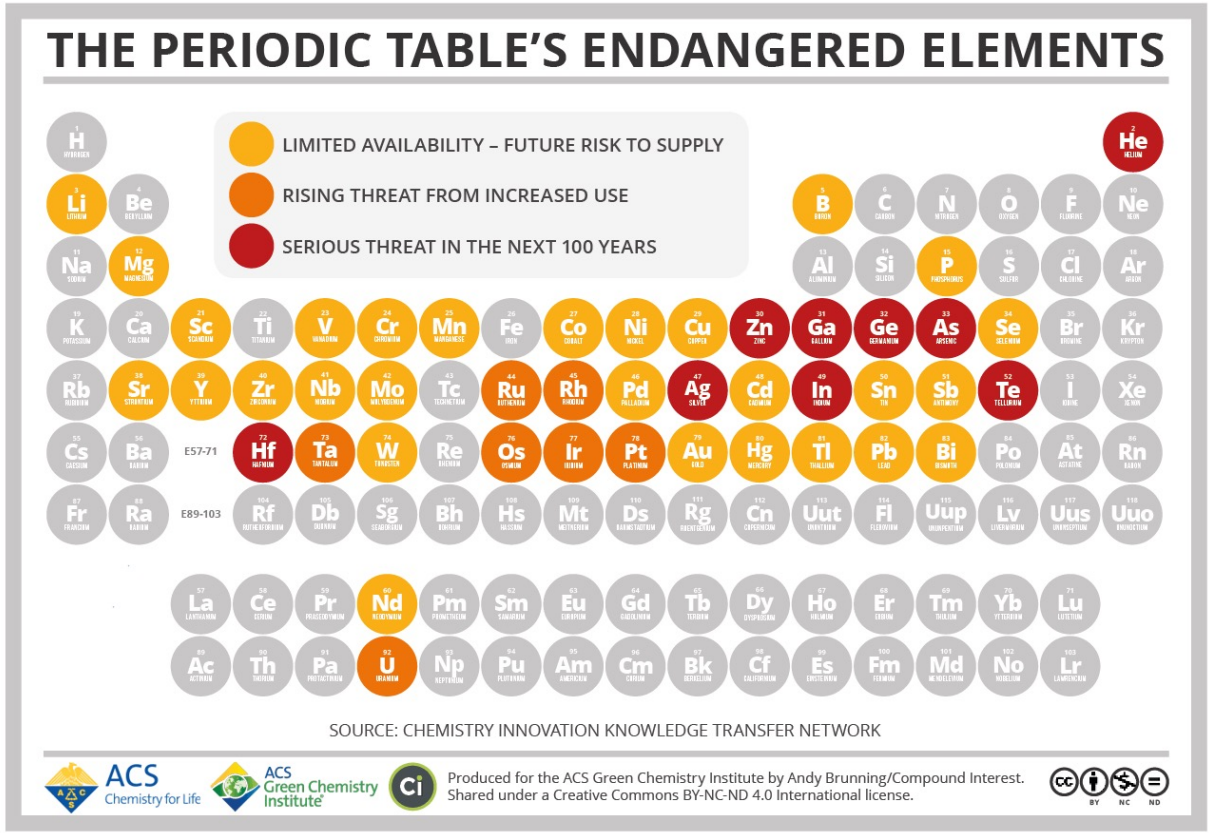
Endangered Elements

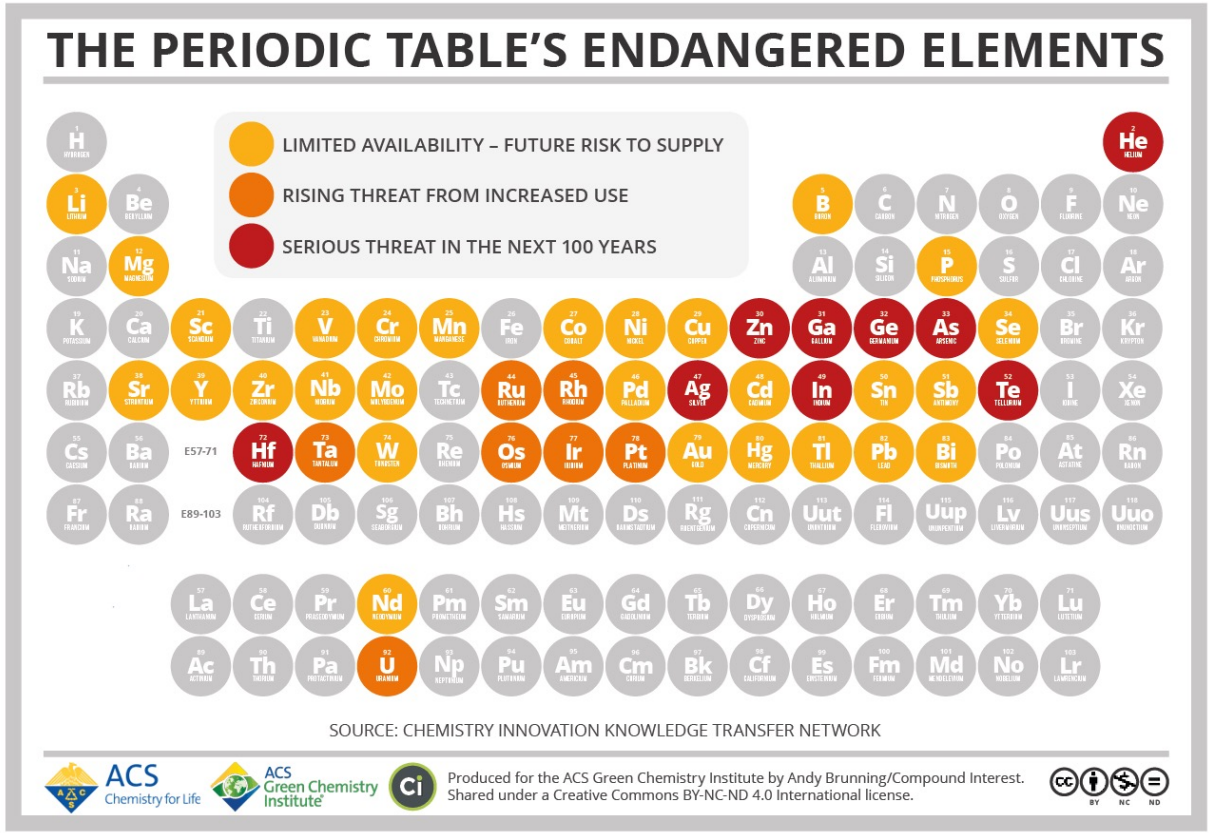


Material basis of society

- **Why** are they considered 'endangered'?
- **Where** and **What** are they sourced from?
- **What** are they used for?
- **So what** can we do about it?

Credit: ACS Green Chemistry Institute / Andy Brunning CC BY-NC-ND 4.0

Endangered Elements



Credit: ACS Green Chemistry Institute / Andy Brunning CC BY-NC-ND 4.0

Material basis of society

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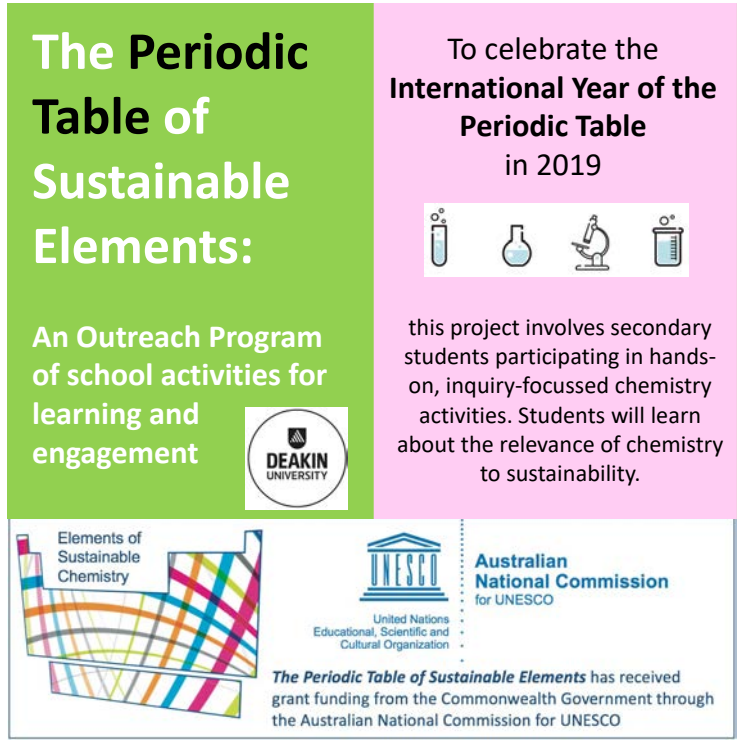
Periodic Table of Sustainable Elements

- Chemistry-based school outreach program
- Upper Primary / Lower Secondary students (10-14 year-olds)
- Middle-Senior Secondary students as student leaders
- Undergraduate and postgraduate students as **university mentors**
- Modelled on National Indigenous Science Education Program (NISEP)
- Designed with chemistry and chemistry education researchers to incorporate **contemporary science practice**
- Using practical activities to demonstrate the **relevance** of chemistry to sustainability



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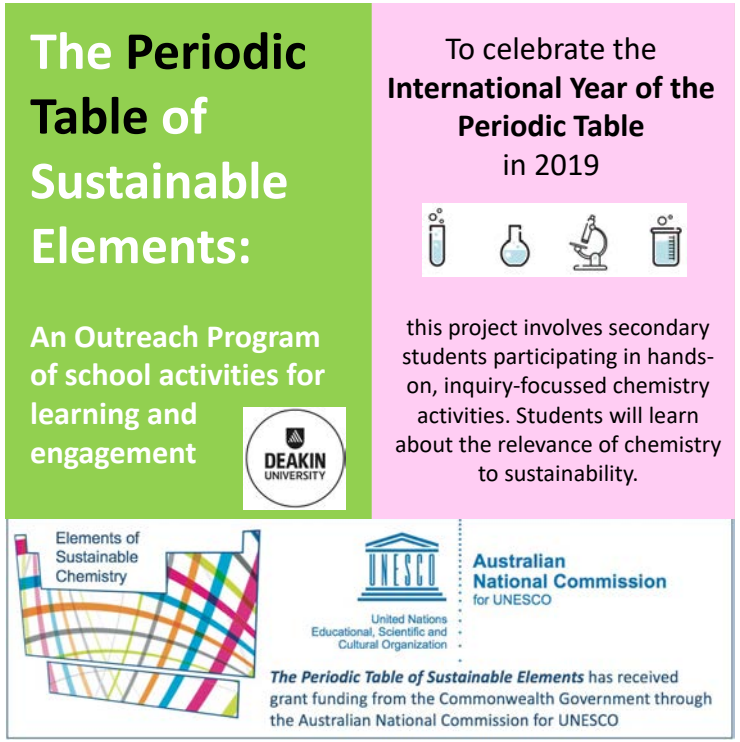
Periodic Table of Sustainable Elements

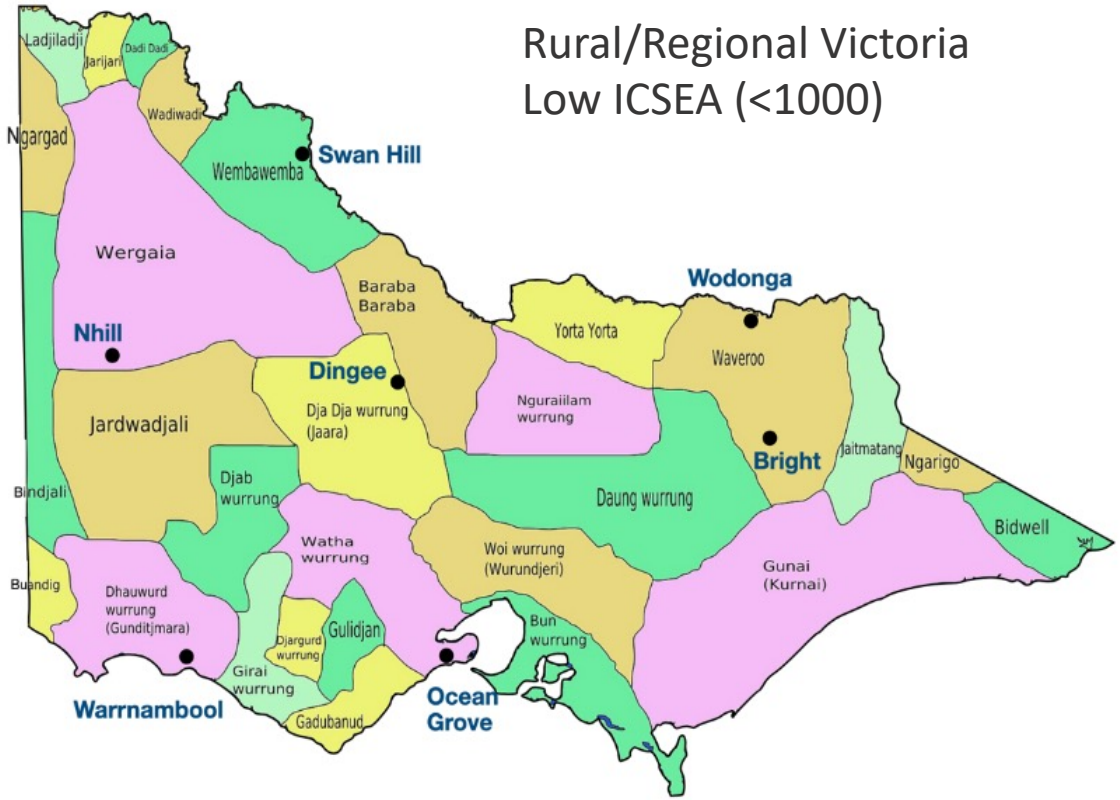
Key Objectives

- Students, teachers and schools **engage positively** with systems thinking-oriented, sustainability-focussed, hands-on chemical science experiments.
- Students become **leaders of chemistry outreach** within their own schools, potentially increasing their participation and engagement with STEM.
- University students **developing their own leadership skills** and those planning teaching careers, are offered **valuable opportunities to interact with students**



Periodic Table of Sustainable Elements

Seven Schools (Nov 2019 – Mar 2020)



Rural/Regional Victoria
Low ICSEA (<1000)

School	No. Students	No. St Leaders
School 1	~180 (Year 8)	18 (Year 8)
School 2	~80 (Year 4 - 8, 12)	8 (Year 8)
School 3	~150 (Year 8)	12 (Year 9)
School 4	~80 (Year 4 – 8)	12 (Year 9)
School 5	~230 (Year 8)	9 (Year 11)
School 6	~130 (Year 8)	14 (Year 9)
School 7	~75 (Year 8)	11 (Year 11)
Total	**~925**	**84**

Victorian Local Nations map showing school locations Credit: Tirin CC BY-SA 3.0

Pre-program development / training

Training day for university student volunteers (1 day)

- Trialled all activities, packed up all materials for school visits
- Interactive discussion around program themes (sustainability, use of elements)
- Students also made useful suggestions to improve the experiments!

17 students – postgraduate (3), undergraduate (12), pre-service teachers (2)
Expression of interest through university subject news items

Program outline (1 day)

Student Leader Session (90-120 minutes)

- Test all activities, discuss how to provide support to younger student participants
- Informal Q&A chat Deakin student volunteers to discuss with them their own STEM journey

Program outline (1 day)

Student Sessions (90-100 minutes)

- ~10-15 minute ‘Intro’ session – Demonstrations
- Four 15-20 min practical activity sessions with groups of 8-12 students per station
- ~10-15 min ‘Outro’ session – Demonstrations and connecting dots on relevance of chemistry to **sustainable development challenges**

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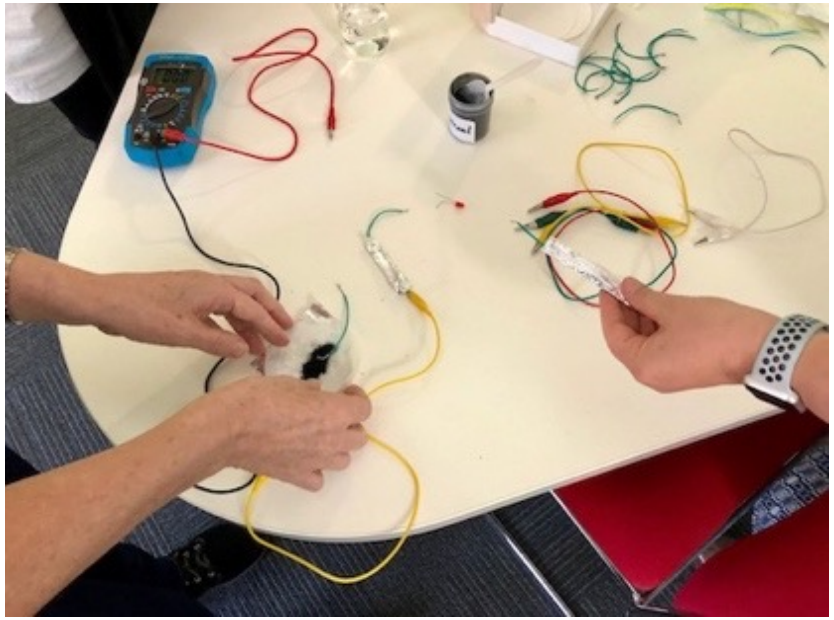
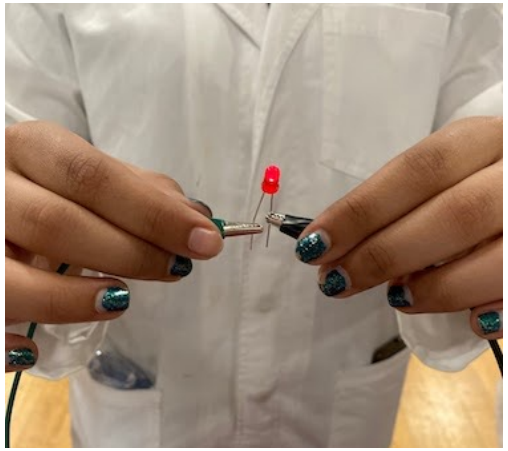
Outreach activities

Practical activities highlighting elements

All resources avail on website – eschemistry.org

- Aluminium-Air battery
- Copper crystals growing on aluminium sheet in agar gel



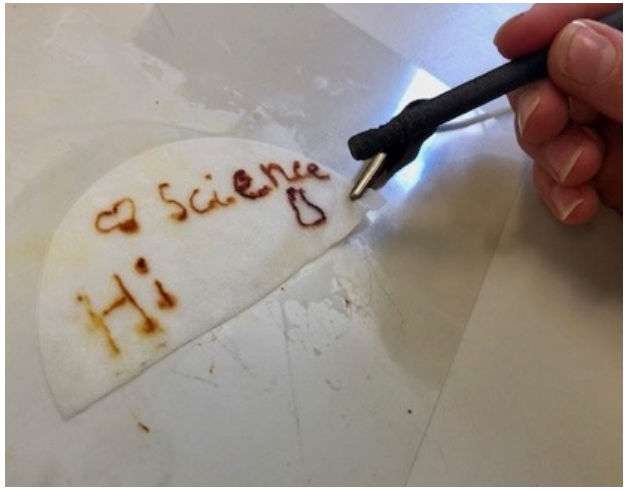


Aluminium-Air battery prac: Thanks to Diana Kennen (Rockdale K-12) and Matt McDowell (School of Materials Science and Engineering, Georgia Institute of Technology)

Outreach activities

Practical activities highlighting elements

- Zinc plating on copper coins
- Iodine
  - Electrolytic writing
  - Disappearing messages and fingerprinting



Outreach activities

Practical activities highlighting elements

- Periodic Table Sets (Prof Stuart Batten, Monash University)
- Handling gallium
- Endangered elements sorting activity

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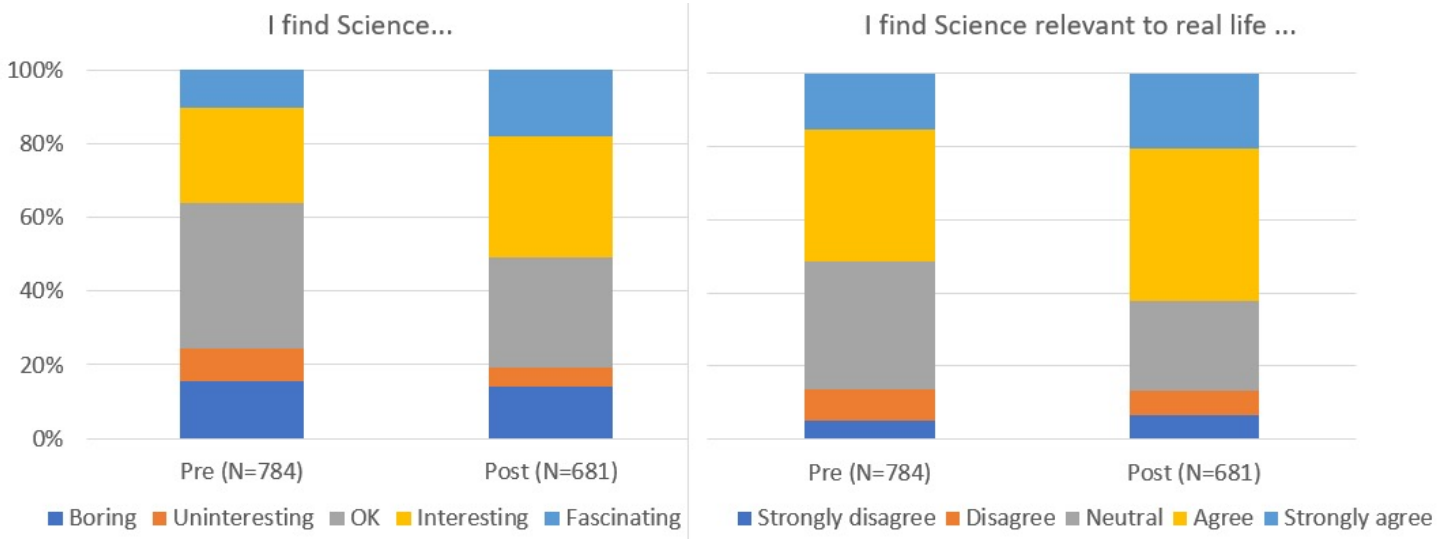
Outreach activities

Practical activities highlighting elements

- Mini-thermite reaction - Energy in/out from aluminium processing
  - 3% of global electrical supply used to extract aluminium
  - **Recycling** aluminium uses only 5% of the energy requirements to make new aluminium

Research Evaluation - Students



5-point Likert	I find science…	I find science relevant…
Pre (N=784)	3.06 (2.98-3.14)[a]	3.48 (3.41-3.55)
Post (N=681)	3.35 (3.26-3.44)	3.63 (3.55-3.71)

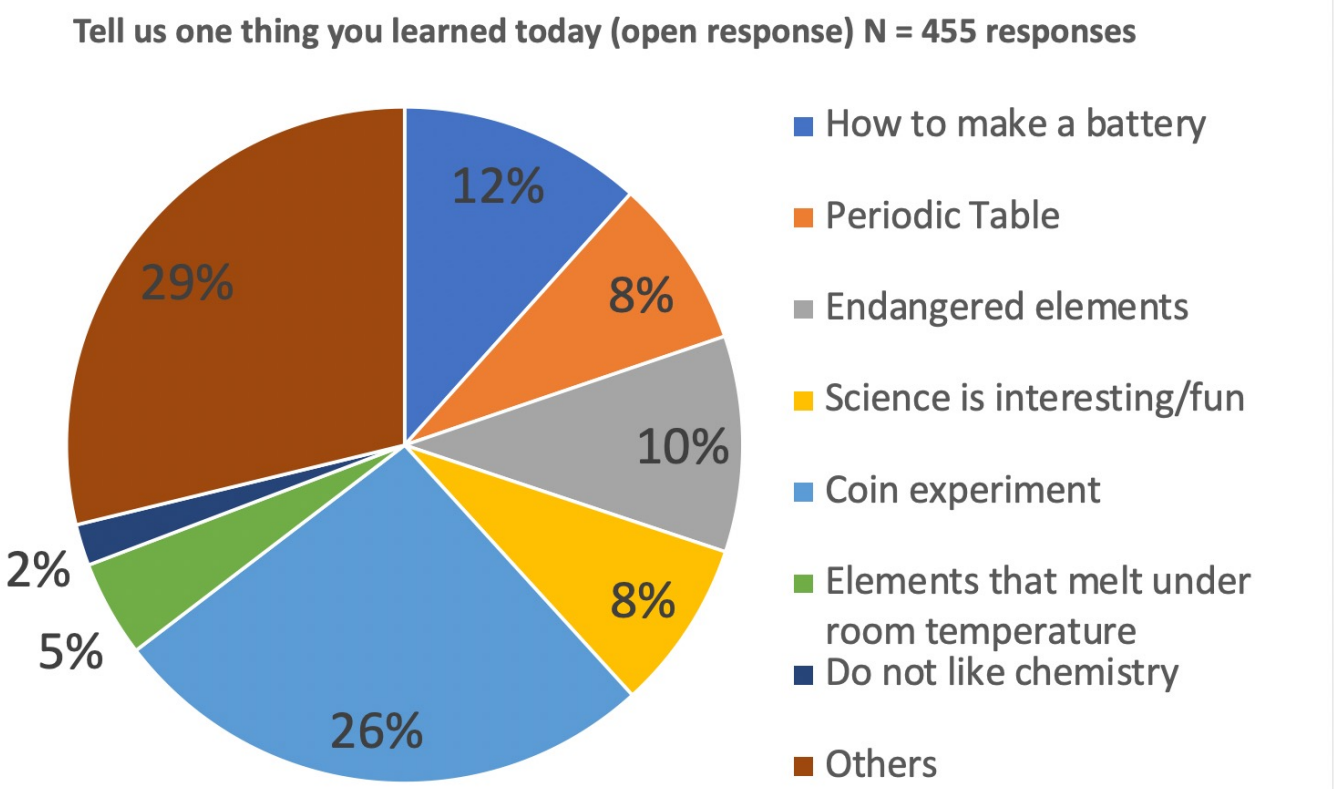
[a] 95% confidence interval

Research Evaluation

Students pre/post

- **Engagement** with science
- **Relevance** of science
- **Relevance** of chemistry to sustainable development
- Identifying **endangered** elements
- Open response

Research Evaluation - Students



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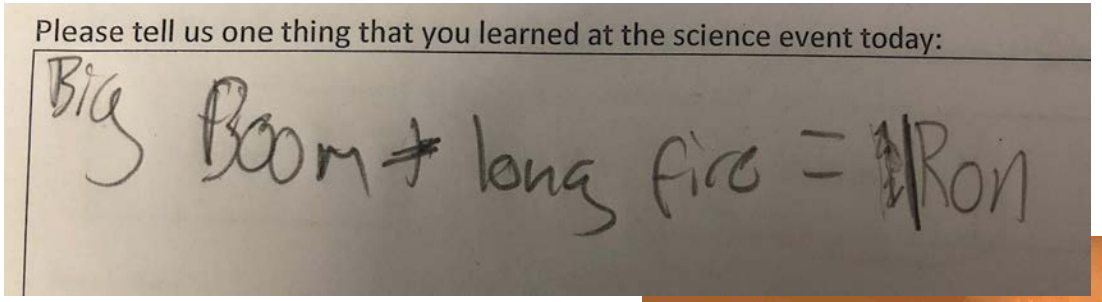

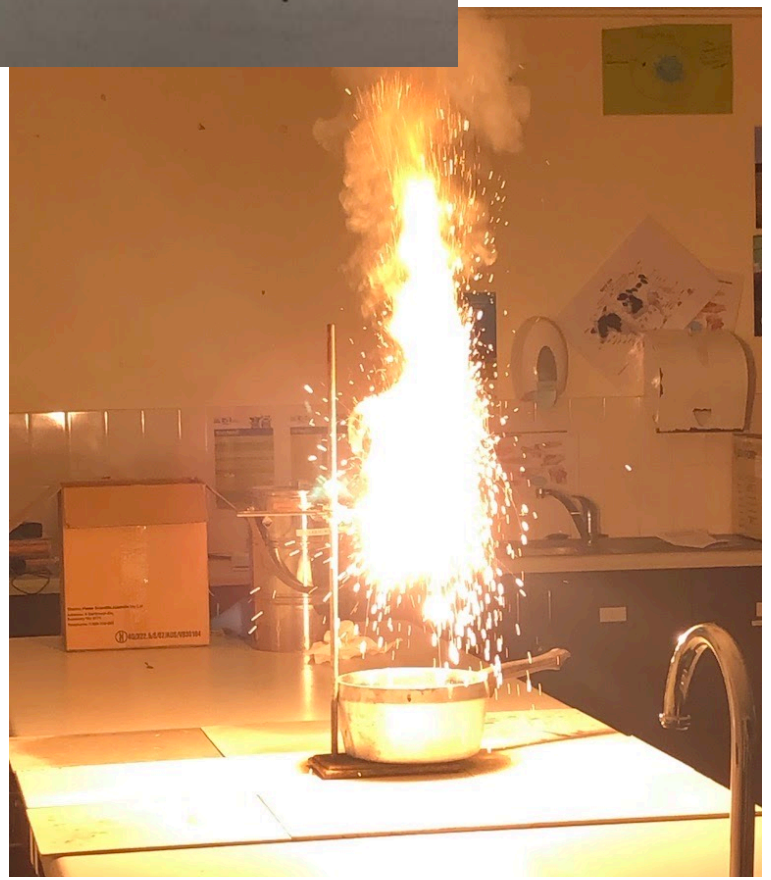

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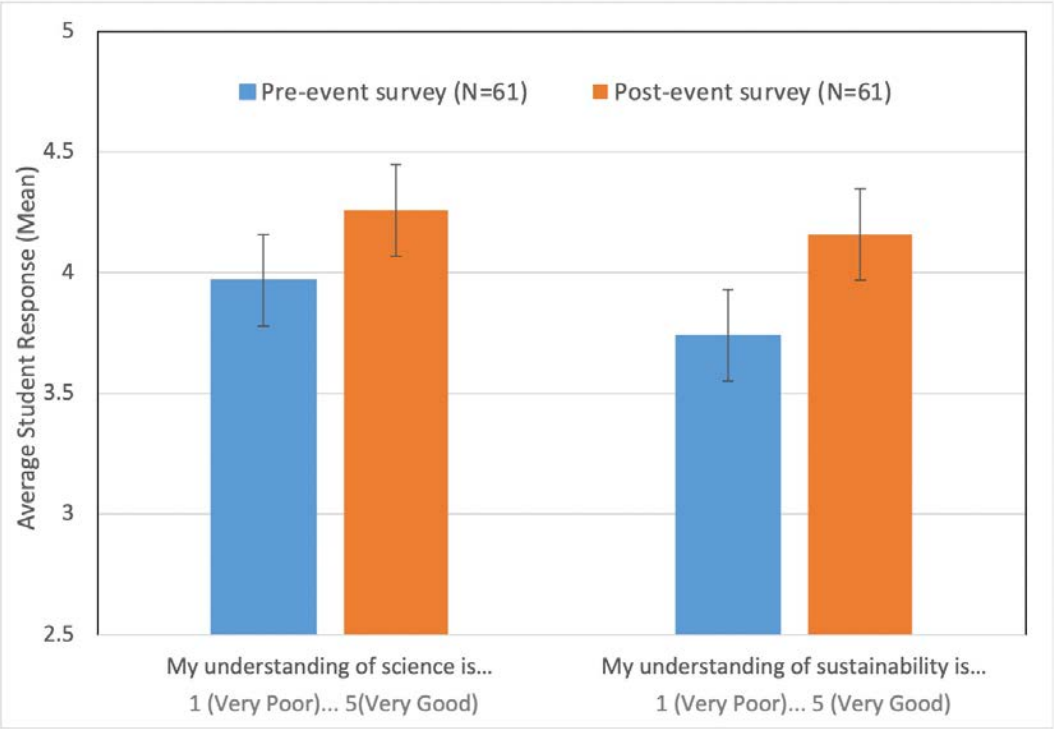
Research Evaluation – Student Leaders



5-point Likert	My understanding of science is…	My understanding of sustainability is…
Pre (N=784)	3.97 (3.78-4.16)[a]	3.74 (3.55-3.93)
Post (N=681)	4.26 (4.07-4.45)	4.16 (3.97-4.35)

[a] 95% confidence interval

Research Evaluation

Students leaders pre/post

- **Inc understanding** of science
- **Inc understanding** of sustainability
- Open response

Due to involvement in program…
Increase in interest in **science** 4.06 (±0.20)[a]
Increase in interest in **sustainability** 3.87 (±0.20)[a]

1 (Disappeared)… 5 (Increased greatly)

Research Evaluation – Student Leaders

"I **gained confidence** to help other people complete experiments."

"More **knowledge on sustainability** and possibility of elements"

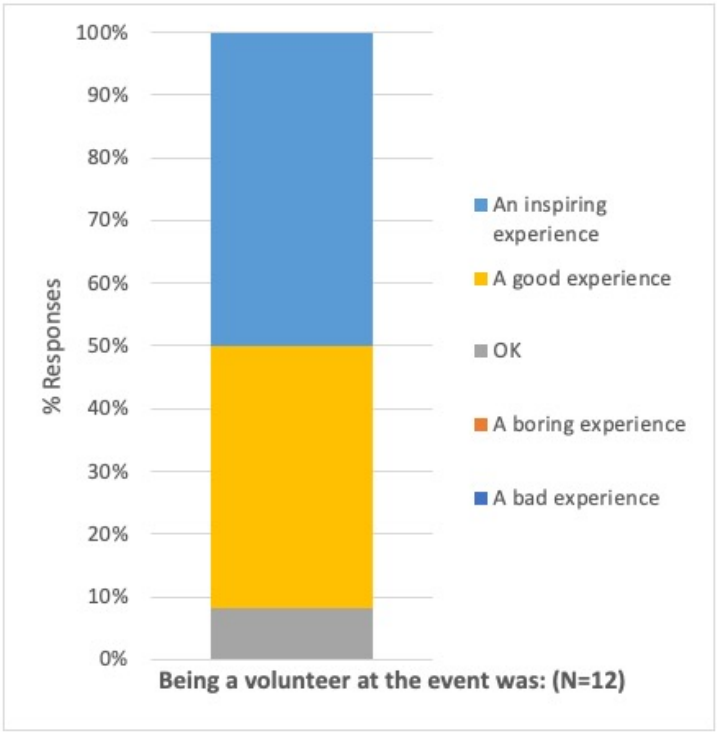
Research Evaluation

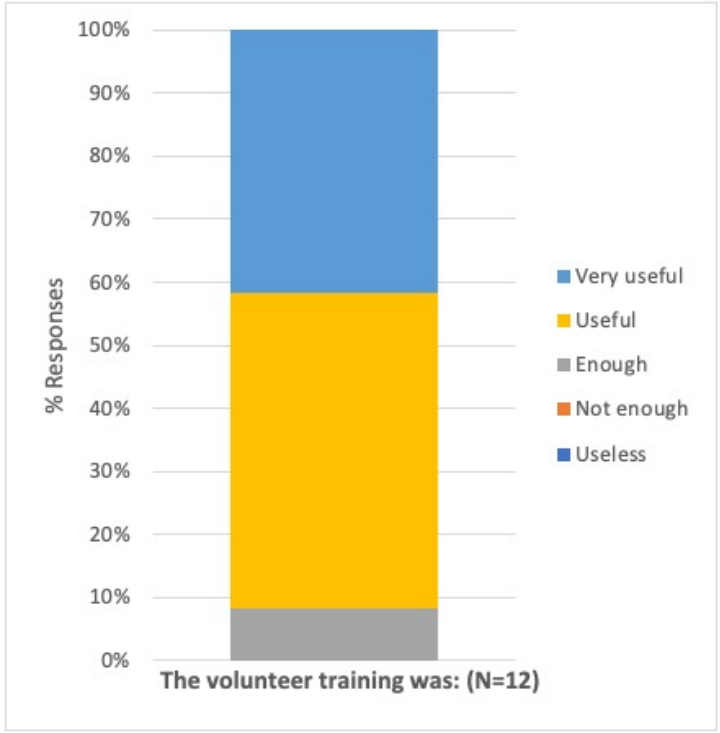
Students leaders pre/post

- **Inc understanding** of science
- **Inc understanding** of sustainability
- Open response

"I've certainly gained more knowledge about sustainability with elements… I also **loved showing it to the younger students**"

Research Evaluation – University students





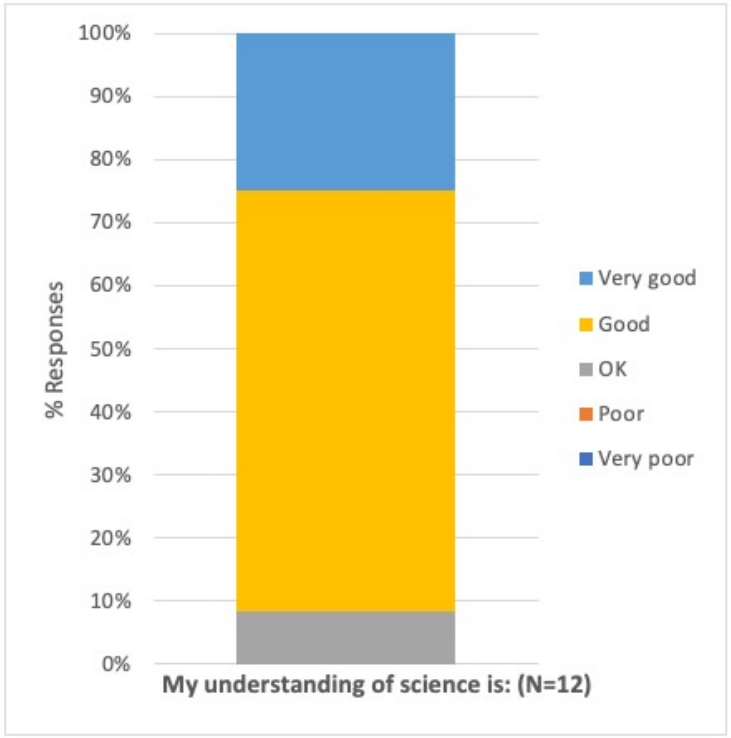
Research Evaluation

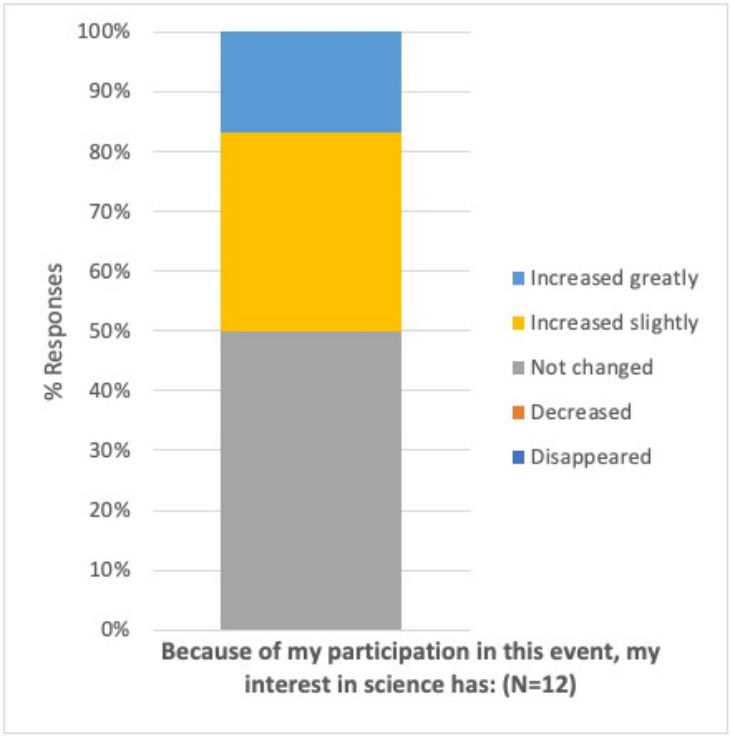
University students post

- **Engagement** with experience
- **Engagement** with training
- **Shift in understanding** of Science
- **Shift in understanding** of Sustainability
- Open response

100% of respondents said, as a result of this outreach experience, would you be interested in volunteering at further Deakin University events

Research Evaluation – University students





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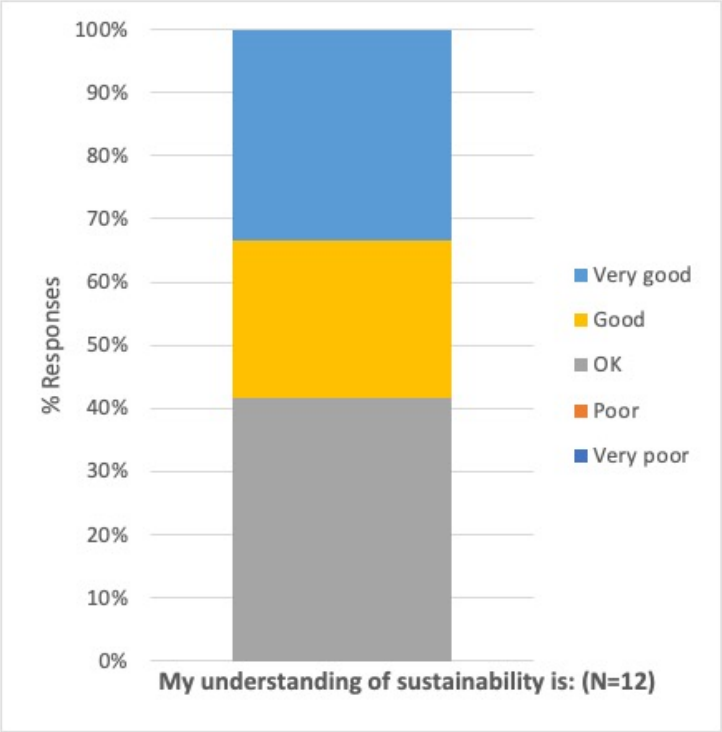
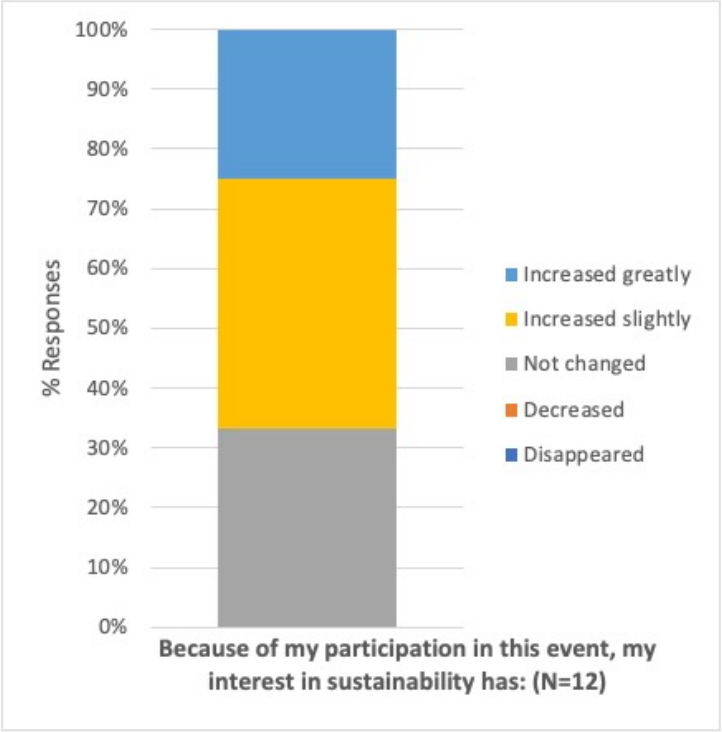
Research Evaluation – University students





Research Evaluation

University students post

- **Engagement** with experience
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- Open response

Research Evaluation – University students

"I have gained a **sense of leadership**… I now have a greater appreciation for teachers and demonstrators trying to explain the principles of chemistry"

"An **inspiration to share my love** of chem, and to do more school-based volunteering. Also I am inspired by the **link between chem and sustainability**"

"I've gained an understanding that year 8's are hell children who want to put anything in their mouth "

Research Evaluation

University students post

- **Engagement** with experience
- **Engagement** with training
- **Shift in understanding** of Science
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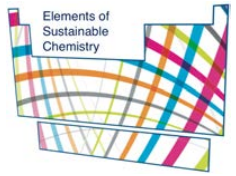
- Open response



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Research Evaluation – Teachers

"I really liked that model… where it actually tried to embed some **student agency** into that as well and **develop their leadership skills**. I thought that was really clever"

"that the **hands-on activities were really unique**, so they weren't something that we could mimic for the kids in the lab"

"they like the opportunity that they can **talk to actual scientists and actual researchers** and ask them questions about going to uni and what they do as well, so I find that's really valuable"

Research Evaluation

Teacher interview (3-4 month follow-up)

- Emergent themes from coding

"…so it just had **all these other layers** in there not just about the chemistry but about also the – the humanities part to it as well. It was just so positive"

Research Evaluation – Teachers

Student outcomes	No. Responses (N=7)
'**Positive**' learning experience	7
Helped **explain concepts** that students are learning in class	6
Noticed **change in students** in months after event	5
Enjoyed speaking to '**actual scientists**'	3
Helped students with **confidence** in class	3
Content may have gone 'over their head' (*Primary*?)	2
Scheduling made **event hectic** for students	2

Research Evaluation

Teacher interview (3-4 month follow-up)

- Emergent themes from coding
  - Utilisation of outreach in rural settings, teacher perspectives, choice of student leaders - ongoing

Future Directions…

Systems thinking / SDGs professional learning for teachers

Project-based learning / STEM Maker projects

Federal Government Community STEM Engagement grant

Enabling a Better Future: STEM Making Within Low SES Regions (Future STEM Gen)

Macquarie University, Deakin University and others

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Deakin Research for Educational Impact (REDI)

Our PTSE 2019 Schools and our Uni volunteers!