Physics Education Research Club

Carole Kenrick

IOP & St Anselm's School
@HelpfulScience

Welcome! Starter:

- Introduce yourself!
- Why did you choose to attend this conference, and this session in particular?
- Why do you think physics teachers should (or shouldn't?!) engage with education research?

IOP Institute of Physics

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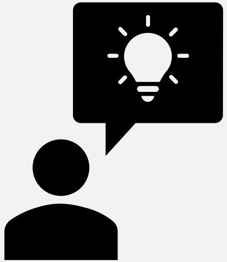
Introduction

- What are some barriers to physics teachers engaging with education research?
- What do you think would make it easier for physics teachers to engage with education research?



Session plan

- Welcome, introductions
- Why set up PER club?
- How does PER club work?
- What has the impact been so far?
- What's next?

Physics Education Research Club

Closed Group

Why set up PER club?

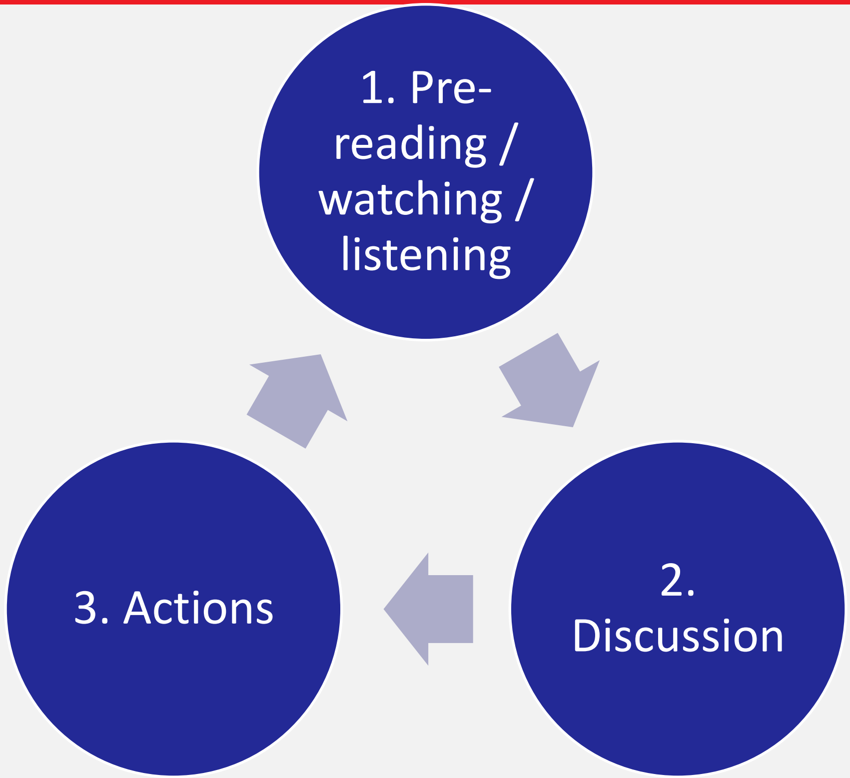
Research as something to…

- Address the 'pebble in our shoe'
- Challenge our assumptions
- Think with!

✓ Remove barriers to engaging with research

✓ Build community ☺

How does PER club work?



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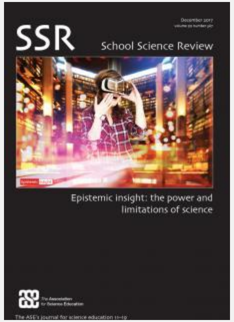
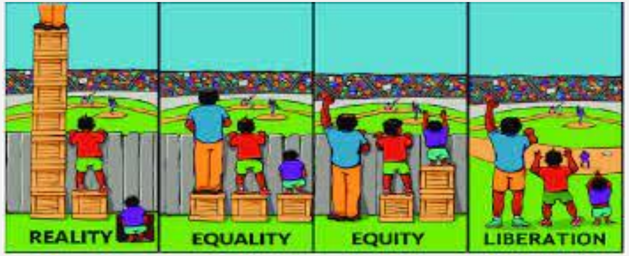
Types of research useful to physics teachers

- ‘General’ education research e.g. metacognition
- Science education research e.g. effective practical work
- Physics education research e.g. misconceptions about circuits
- Maths education research e.g. rearranging equations
- Psychology & cognitive science research e.g. motivation
- Sociology research e.g. equity
- SEND research e.g. supporting students with autism
- …

Practitioner research, theoretical, RCT, meta-analysis

Education Endowment Foundation





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Pre-reading & listening: EEF blog + podcast

1. Scaffolding
2. Explicit instruction
3. Cognitive & metacognitive strategies
4. Flexible grouping
5. Use technology

EEF Blog: Five evidence-based strategies to support high-quality teaching for pupils with SEND

Zoom room (10-15 mins):

- Key take aways from the reading
- Anything surprising / unexpected?
- Which of these do you know about / use already?
- Which are new to you / would you like to find out more about?
- Any implications for your classroom / school?

"High-quality teaching for pupils with SEND is good teaching for all."

Jamboard

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1. Discuss key reading (10 mins):

- What were your main take-aways?
- Were any of the ideas new to you?
- Did you disagree with any of the ideas?
- Can you think of any examples from your practice / any other ... te the

Be more explicit in the use of x and + when working with students

Loved the bar models (in the further reading)

Liked the section on multi-step calculations (p46) amazing how often this goes wrong

Need to find time to work with the maths department

Can do this graphically with motion trackers (can even use phones for this)

Getting students to run when looking at speed. Fastest went furthest, and slowest went least distance. Making speed more visual to the students.

Main take-aways, new ideas

Writing out math operations fully

Promoting the importance of the equals sign and highlighting that what you do to one side you must do to the other

Disagree / challenge

Challenge: all the ideas/approaches are teacher-led. What about institutional feedback/change?

Own examples

This can be linked to literacy with variable definitions

With speed I get them to use a metronome when thinking about the distance for every second.

Emphasising on units in equations. I did it already but for speed, but started focusing on it a bit more this week.

The box plot idea for equations was great. I tried it today.

Really liked the modelling in the two circle examples

Presenting equations differently eg m= f/a but wonder whether it would help or hinder low attainers when they see it differently elsewhere

Found the bar model useful for KS3 but wouldn't use past that.

I am not sure I would write mxa = F:axa

Also agreed - confusing

Agreed!

Thought experiments to get students to identify factors that affect a quantity before introducing the equation

I constantly write y = mx + c at the top of the board and work with students to rearrange formulae in order to know what to plot

2. Next steps (5 mins):

- What would you like to try out / tweak about your own practice as a result of this reading / discussion?
- Which other topics would you like future sessions to focus on?

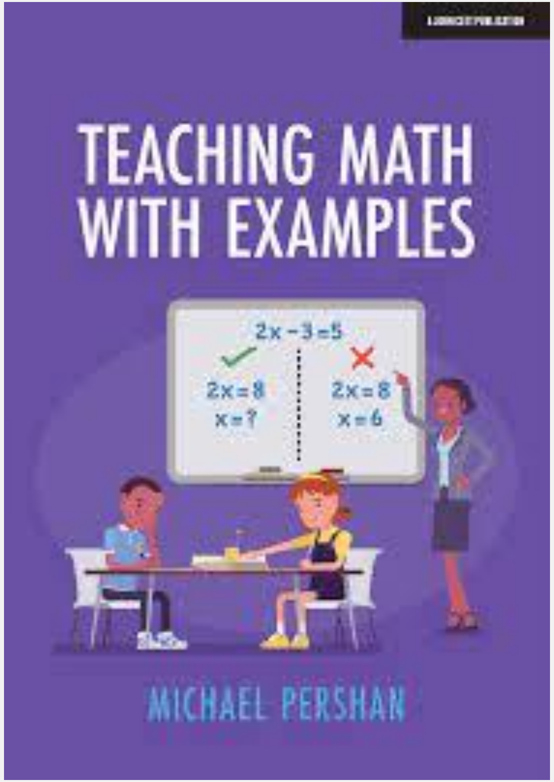
Hinge point

Cognitive Science

Impact

1. Maths: worked examples
2. Literacy: worked examples
3. Equity: culturally responsive teaching

1. Maths: worked examples



Podcast: Michael Pershan and Craig Barton

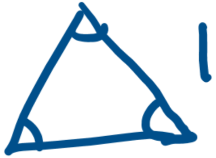
“students learn when they think actively and deeply about a worked example”
Ritter Johnson

A Routine:

1. Analyse
2. Explain
3. Apply

Allows generalisation

The angles in a triangle are in the ratio 3 : 4 : 5
What is the size of the largest angle?



180°

$3+4+5=12$

$$\frac{180^\circ}{12} = 15^\circ$$

$3 \times 15^\circ = 45^\circ$

$4 \times 15^\circ = 60^\circ$

$5 \times 15^\circ = 75^\circ \rightarrow \boxed{75^\circ}$

180°

Quietly in pairs

Take turns explaining each step until you both understand it all then answer these:

1. Where did the 180 and 12 come from to do 180 ÷ 12?

2. If using a box model, how many boxes would you draw and how much would you put in each box?

3. How many degrees do the 3 angles add up to?

Your turn

a) The angles in a triangle are in the ratio 1 : 3 : 6. What is the size of the *largest* angle?

b) The angles in a quadrilateral are in the ratio 3 : 2 : 2 : 5. What is the size of the *smallest* angle?

c) Come up with your own similar question(s).

✓ Multi-step calculations

…fee machine. The coffee machine uses

The coffee machine heats water from 20 °C to 90 °C. $\Delta\theta = 90 - 20 = 70°C$

The power output of the coffee machine is 2.53 kW. $P = 2.53\text{ kW} = 2530\text{ W}$

The specific heat capacity of water is 4200 J/kg °C. $c = 4200\text{ J/kg°C}$

Calculate the mass of water that the coffee machine can heat in 14 seconds. $t = 14\text{ s}$

(F) $\Delta E = m \times c \times \Delta\theta$ ① Need to find ΔE!

② Can now use ΔE here! $\Delta E = P \times t$

$= 2530 \times 14$

$= 35420\text{ J}$

$35420\text{ J} = m \times 4200 \times 70$

$\frac{35420}{(4200 \times 70)} = m$

Mass = 0.120 kg

(5)

Sense-check: that's 120g, which seems sensible!

… the copper block from the information

✓ Conservation of energy calculations

Andrew skis down a hill.

a) Andrew starts from the top of the hill and his speed increases as he goes downhill.

He controls his speed and direction by using his skis.

He brings himself to a stop at the bottom of the hill.

Describe the energy changes that happen between starting and stopping. [3 marks]

- Gravitational potential energy transferred to kinetic energy
- Energy transfer to thermal store because of air resistance/friction
- chemical energy in Andrew transferred to thermal
- when he stops, energy dissipated/transferred to surroundings

b) The height of the hill is 100 m, and Andrew's mass is 70 kg. If the gravitational field strength is 10 N/kg, what is Andrew's gravitational potential energy at the top of the hill? [2 marks]

(I) h = 100 m m = 70 kg g = 10 N/kg

(F) GPE = m x g x h

(S) = 70 x 10 x 100

(S) = 70 000 J

(U)

c) If we assume that no energy is lost to the environment, how much is Andrew's kinetic energy at the bottom of the hill? [1 mark]

energy is conserved

GPE at top = KE at bottom

so 70 000 J

d) Calculate Andrew's speed at the bottom of the hill. [3 marks]

(I) KE = 70 000 J m = 70 kg

(F) KE = ½ x mass x velocity²

(S) 70 000 J = ½ x 70 x v²

2 x 70 000 = 70 x v² (x2)

$\frac{2 \times 70\,000}{70} = v^2$ (÷70)

$\sqrt{\frac{2 \times 70\,000}{70}}$ (√)

e) For what reason would Andrew's speed be less than calculated in part d)? [1 mark]

Air resistance/friction means some energy dissipated/transferred to the surroundings/thermal store

✓ Uncertainties

7 A student records the following data during an experiment to determine the internal resistance of a battery.

e.m.f. = (4.5 ± 0.2) V
terminal p.d. = (3.0 ± 0.1) V
current = (2.0 ± 0.1) A

What is the percentage uncertainty in the value for the internal resistance of the battery?

A 5.0 %

B 6.1 %

C 13 %

D 25 %

Your answer D

[1]

$\mathcal{E} = V + Ir$

$r = \frac{\mathcal{E} - V}{I}$

(1) Add absolute uncert of $\mathcal{E}$ and V
(2) Turn this into % uncert,
(3) add this to % uncert of I

(1) $0.2 + 0.1 = 0.3$

(2) % uncert of $(\mathcal{E} - V) = \frac{0.3}{(\mathcal{E} - V)} = \frac{0.3}{(4.5 - 3.0)} = 0.2 \times 100 = 20\%$

% uncert of $I = \frac{0.1}{2} \times 100 = 5\%$

(3) $20\% + 5\% = 25\%$

Checked yup!

at this point know already that answer must be D

Complete the Steps, Solve the System

1.	2.	3.	4.
$-6x + y = -50$	$-10y = x$	$3x + 4y = 50$	$y = 2x$
$y = -4x$	$-5x - 7y = 43$	$-2x = y$	$-3x + 8y = 26$
-6x + (-4x) = -50	-5(-10y) -7y = 43	3x + 4(-2x) = 50	
-6x - 4x = -50	50y - 7y = 43		
-10x = -50			
x = 5			
y = __			

Key take away:

The goal is not to get the right answer…

The goal is to **understand how to get the right answer**!

1. Maths: worked examples

A Routine:

1. Analyse
2. Explain
3. ***Operationalise***
4. Apply

2. Literacy: worked examples

Could the same ideas help students with extended writing?

A Routine:

1. Analyse
2. Explain
3. Apply

Method A

1. Put the ice cubes in the funnel and cover it with one of the materials
2. Put the funnel in a beaker and leave it for ten minutes
3. Measure how much water is in the beaker

- Would you know exactly what to do if you were given this method?
- What information is missing?

Method B

1. Place each funnel in a beaker
2. Place 2 ice cubes in each funnel
3. Cover each funnel with a different material, using a rubber band to keep the material in position
4. Start the timer and wait for 1 hour
5. Pour the water from the first beaker into a cylinder, measure the volume and record it
6. Repeat with the other beakers

- How is this method an improvement on the previous one?
- How could it be improved further?

Method C

1. Place a funnel in a 250ml beaker - the funnel should be large enough to hold two ice cubes
2. Place 2 ice cubes in the funnel - make sure the ice cubes are as similar in volume as possible
3. Cover the funnel with bubble wrap, as shown in the diagram, using a rubber band to keep the bubble wrap in position
4. Repeat steps 1-3 three times, using a different material each time (white paper, black paper and aluminium foil) - use as many layers of the material as necessary to make it as thick as the bubble wrap
5. Repeat steps 1-2, leaving the ice cubes uncovered - this is the control sample
6. Start the timer and wait for 1 hour
7. Pour the water from the first beaker into a cylinder with 1ml graduations, measure the volume and record it - make sure that you measure it side on
8. Repeat with the other beakers

Which parts of this method are suggesting ways to make your results:

- Accurate?
- Precise?

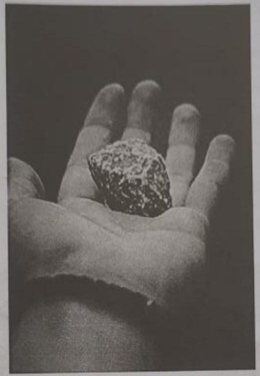
Success criteria for writing a method

- ❑ **Numbered** steps
- ❑ **Verb** at the start of every step
- ❑ **Specific** about every piece of equipment - include the **range** and **resolution** (maximum and smallest measurement it can make)
- ❑ **Accurate**: include hints that will help make your results more accurate - e.g. how you will keep your control variables the same every time
- ❑ **Precise**: include hints that will help make your results more precise - e.g. equipment with the smallest possible graduations (1ml more precise than 10ml)
- ❑ **Integrity**: be honest about what you did, and why you did it
- ❑ **Redrafting**: every time you redraft, ask yourself: “would someone who missed the lesson be able to do exactly what I did if I gave them this method?”

Q5.

The figure below shows a rock found by a student on a beach.

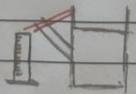
To help identify the type of rock, the student took measurements to determine its density.



(a) Describe a method the student could use to determine the density of the rock.

1. Fill Eureka can up with water to the spout
2. ~~[illegible]~~ find mass of rock with measuring scale.
3. Put mesuring cylinder under spout of Eureka can.
4. Carefully ~~[illegible]~~ drop the rock in Eureka can.
5. Measure how much water came out of spout and into measuring cylinder
6. divide mass of rock by volume of water

Mass ÷ Volume = Density



(6)

Q5.

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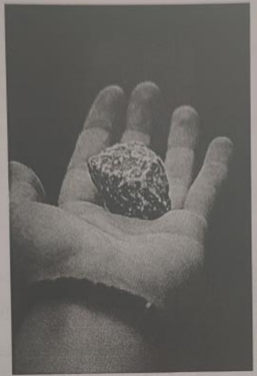


(a) Describe a method the student could use to determine the density of the rock.

The student should get a displacement can and fill the can up with water up until its spout. Placing a beaker under its spout also. Tie thin string to the rock and then submerge it into the displacement can. The water that spills out of the displacement can will be the volume. Then get scales to find its mass. To find its density use the equation:

$$density = \frac{mass}{volume}$$

(6)

Exemplar 1 — 4 marks

Describe the evolution of the Universe up to the formation of the first nuclei.

At first Universe is very dense, hot and it's a singularity. There is high concentration of ~~ph~~ gamma photon energy. ~~As the expand, the universe~~ [...] is unified at that stage, as Universe expan[...] starts to cool down. Quark is than forme[...] ~~the~~ lepton. These quark and lepton are than c[...] due to gravitation force forming the first pro[...] These proton and neutron than combined due [...] gravitational force to form the first nuclei ([...]

Exemplar 2 — 2 marks

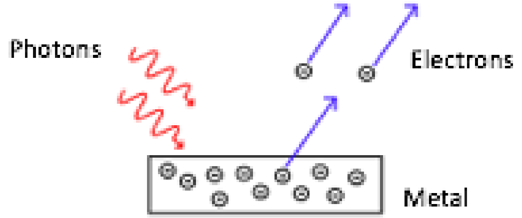
In the beginning there was a singularity. The universe was of infinite density and very hot giving creating high energy gamma photons. These photons had such high energy through a process ^involving the higgs boson turned into matter. Gamma photons became quarks. Quarks spontaneously appeared and dissapeared back into energy. When quarks interacted with eachother they began to form hadrons and barons. Some of these unstable but some remained and formed protons and neutrons. Leptons also formed this way by energy to mass. [4]

protons, neutrons and electrons all existed and through collisions created nuclei.

Describe and explain the photoelectric effect

Planning my writing: The Photoelectric Effect

Draw the process & annotate:



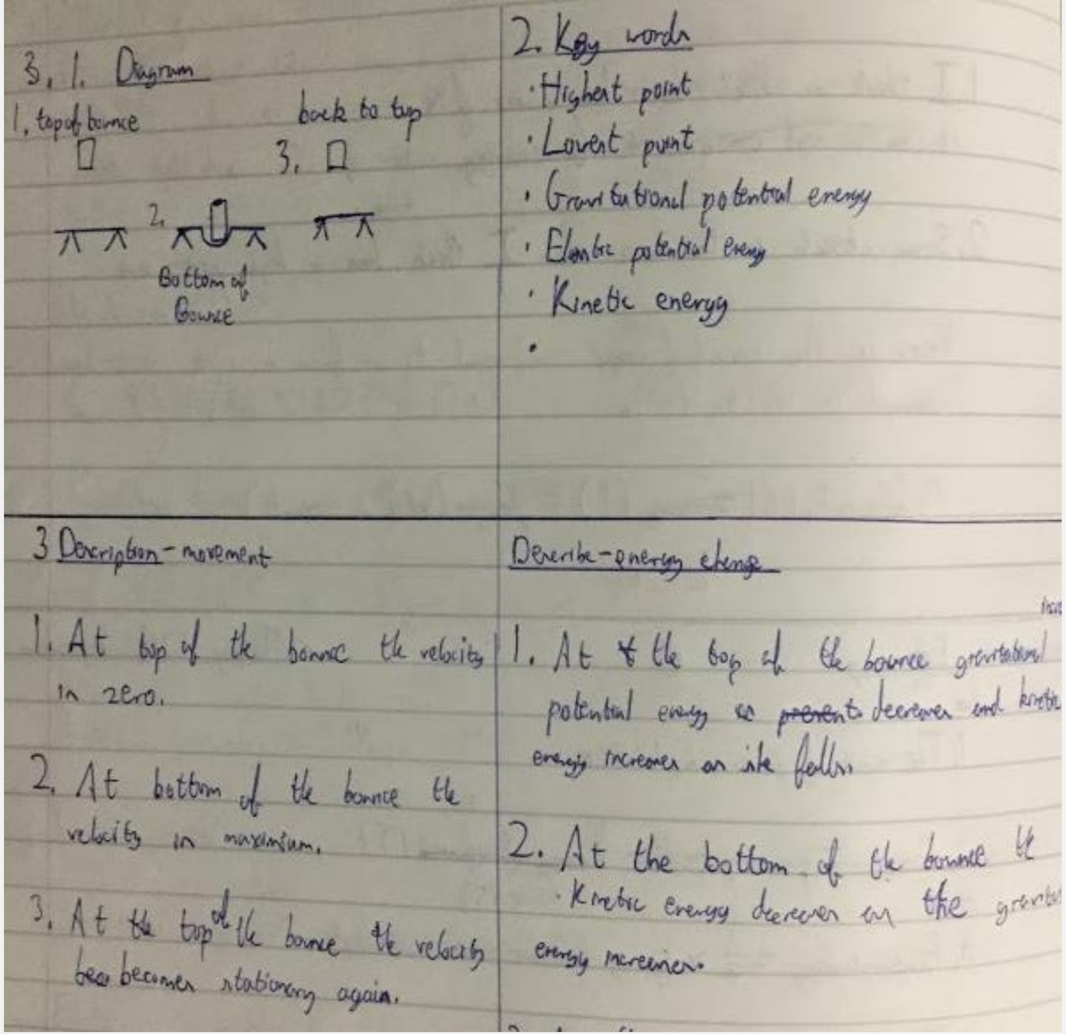
Write the key words and relationships:

- Threshold frequency
- $E = hf$
- $W = hf_0$
- Electrons
  Metal
- Emitted
- Photon
- Kinetic energy
- Intensity

llet point description of process:

Bullet point explanation of each step:

Describe the energy changes as the trampolinist moves from the top of one bounce to the top of the next bounce



As the ball is dropped, energy is transferred from the gravitational potential store to the kinetic store. When the ball hits the ground, energy is transferred from the kinetic store to the elastic potential store.

2. Literacy: worked examples

Could the same ideas help students with extended writing?

A Routine:

1. Analyse
2. Explain
3. ***Operationalise***
4. Apply

3. Equity: culturally responsive teaching

- Importance of classroom culture
- What does a 'good physicist' look like?

A Model of Culturally Relevant Pedagogy in Physics

Angela Johnson

Department of Educational Studies, St. Mary's College of Maryland, St. Mary's City, MD 20686 USA

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Abstract. There has been a surge of interest in the United States recently in culturally relevant/responsive/sensitive teaching in physics and similar disciplines. Two brief examples: In his call for papers addressing race for *The Physics Teacher*, Gary White lists "culturally responsive teaching" as the first topic, and one of the two aims of a $4.9 million grant received by the American Association of Colleges and Universities is to "empower STEM faculty to adopt culturally sensitive pedagogies." So the question is: What is culturally relevant physics teaching? How would we even know it if we saw it? I argue that a framework for culturally relevant pedagogy developed by Gloria Ladson-Billings is a useful model for university physics faculty.

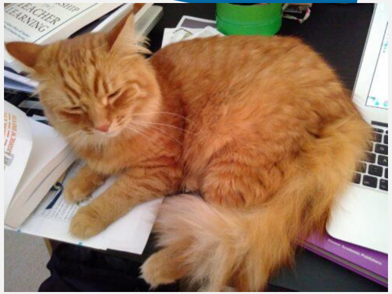
About me



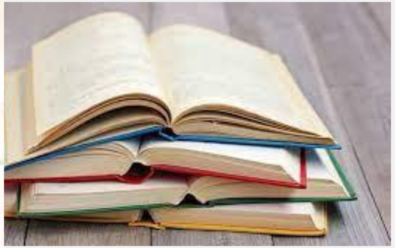






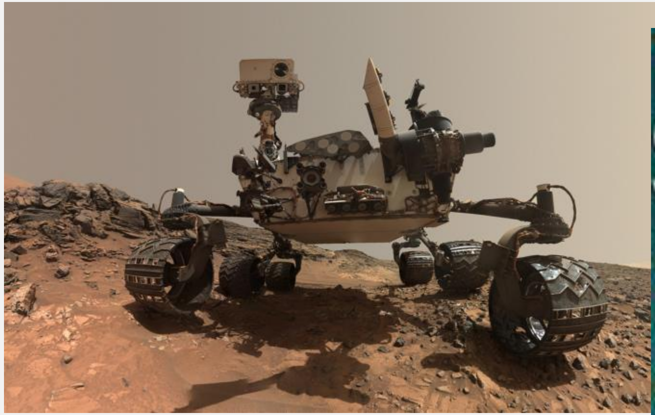







Our physics values

Curiosity



Precision

Integrity

About you – introductory letter

On the sheet of paper, write a letter introducing yourself

- What are your interests, hobbies and passions?
- Which subjects are you studying at A level?
- Which jobs are you interested in doing in the future?
- What are you thinking of doing after your A levels?
- What are you looking forward to about physics this year?
- What are you worried about when it comes to physics this year?
- Is there anything your other teachers do / have done that really help you with your learning?
- Anything else you would like Ms Kenrick to know about you?

14th September 2022

Dear Ms Kenrick,
I am …

Yours sincerely,

….

Homework

Part 1 (40 mins)
Go the Institute of Physics career paths website:

https://www.iop.org/careers-physics/your-future-with-physics/career-paths

Identify a physicist featured on this website whose job looks interesting to you, and read their profile. Write a fact file summarising what you've found out, including:

- What is their name?
- What is their job?
- Where do they work?
- What do you think looks interesting about their job?

Assistant Headteacher

Assistant Principal

Automated Test Engineer

Background Artist

Central Banker

Chief Executive Officer

Consultant Medical Physicist

Education, Outreach and Diversity Officer

Geospatial Modelling Lead

Manufacturing Realisation Section Leader

Market Risk Project Manager

Policy Researcher

Postdoctoral Researcher

Scrum Master

Senior Programme Manager for Photonics

Space System Engineer

End of half term reflection

Write a letter about your progress in science this half term.

How have you shown our science values (curiosity, integrity and precision)?

Is there any way you can improve next half term?

What you have particularly enjoyed?

What are you most looking forward to in our future science lessons?

Dear Ms Kenrick,

This half term I have shown curiosity, for example when I…

Next half term I will try to show more… for example, I will...

I have particularly enjoyed…

I am looking forward to…

Yours sincerely,

Dear Miss Kenrick,

I have shown curiosity by thinking about every single questions you ask me. I have shown precision by making sure that I use a ruler ~~to use~~ so my lines are perfect. I have shown integrity by putting my hand up when I need help. What I want to learn next is ~~that~~ How people can walk on water/forces/friction and magnetic forces.

TV laptops phones robots

Miss,

Thank you so much for being understanding and patient.

You are one of the few teachers I have ever told about my pronouns and my gender. You are also one of the few that has been accepting of my easily distracted, hyper mind.

To that thank you. :)

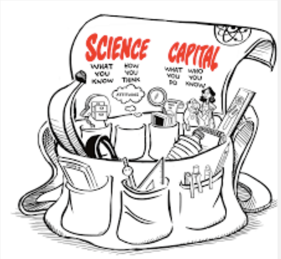
[redacted]

(they/them)

Impact: community

- A chance to pause, evaluate and reflect with other practitioners
- New connections (local & online)
- My lessons, my coaching, department, ECT, other networks.


ASPIRES
Young people's science and career aspirations, age 10–14
Closing Doors
Exploring gender and subject choice in schools
Improving Gender Balance
Why not physics?
Opening Doors
A guide to good practice in countering gender stereotyping in schools
It's Different for Girls
The influence of schools
Girls in the Physics Classroom
A Teachers' Guide for Action
Girls in the Physics Classroom
DRAFT: NOT FOR CITATION WITHOUT THE PERMISSION OF THE AUTHORS


SCIENCE CAPITAL
WHAT YOU KNOW
HOW YOU THINK
WHAT YOU DO
WHO YOU KNOW

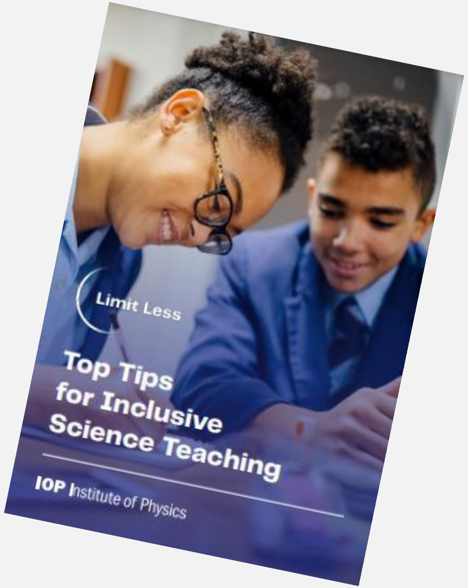
per central


Limit Less
Top Tips for Inclusive Science Teaching
IOP Institute of Physics

Build numeracy and literacy for science

Create an inclusive classroom culture

Make the learning relevant



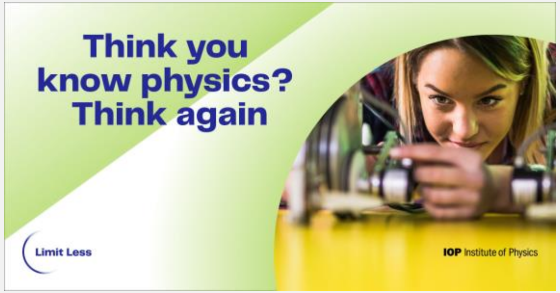
What's next?

- PER Club 2.0 – sign up on talk physics!
- Evaluation of PER Club pilot
- Sharing learning
- Inclusive teaching booklet
- Over to you…!

Discussion

- What can you ‘magpie’ from this session?
- Do any of the ideas shared apply to your setting?
- Would you be interested in participating in PER club?
- Would you be interesting in co-facilitating PER club?
- Would you be interesting in leading your own PER club?
- What are your actions from this session?

Limit Less campaign



The Limit Less influencing campaign was launched by the IOP in October 2020

Aim: Increasing the amount of young people taking physics post-16

The campaign is focused on five underrepresented and underserved groups in particular:

- Black Caribbean young people
- Disabled young people
- Girls
- LGBT+ young people
- Young people from a lower socioeconomic background

- For more information visit: www.iop.org/LimitLess
- Sign up to our manifesto for change: www.campaign.iop.org/manifesto

IOP Institute of Physics of Physics