Saturday innovation & practical STEM skills workshops for Y10s

HIGHGATE
CHRYSALIS

The Importance of Being Playful

Innovative STEM student science projects
(especially physics and engineering)

Who are we?

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Contents

1. Getting to something new & surprising, messy & uncertain
2. Teamworking, Six Hats and Random Binomials
3. Planning & Building
4. Testing and Collecting Data
5. Analysing Results, using the power of spreadsheets & graphs
6. Improving the project, re-thinking the project, go back to 1 or 2 or 4?
7. Telling the World All About It !

Example projects and how they worked out

Tips & Tricks on getting to a practical project

1. Innovation and Invention: Brainstorming & the Science of Surprises

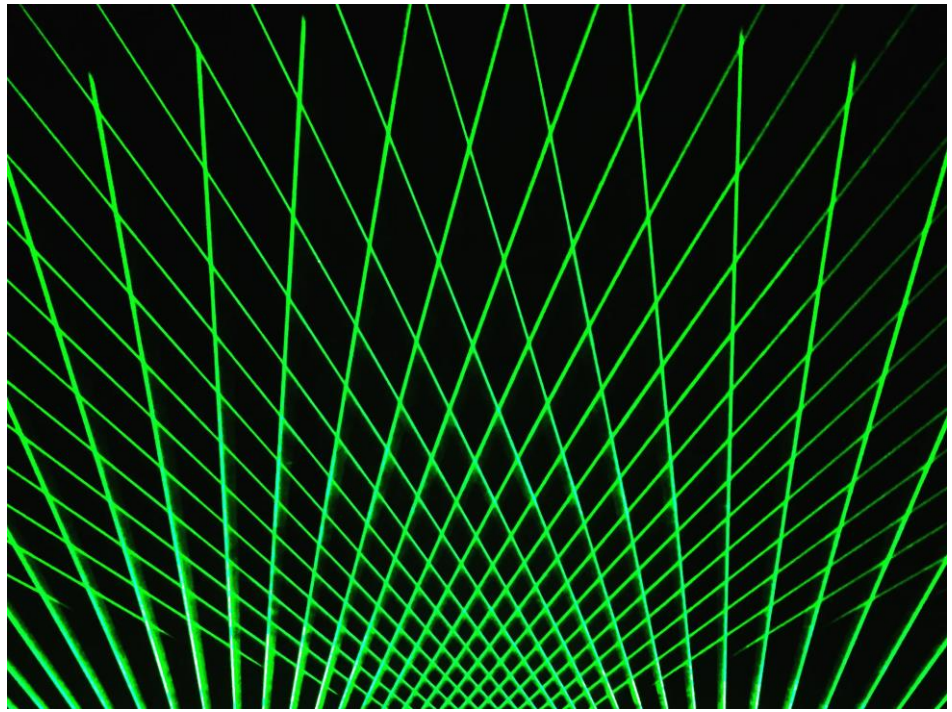
Finding problems

Finding solutions to solve problems

Finding problems to use solutions

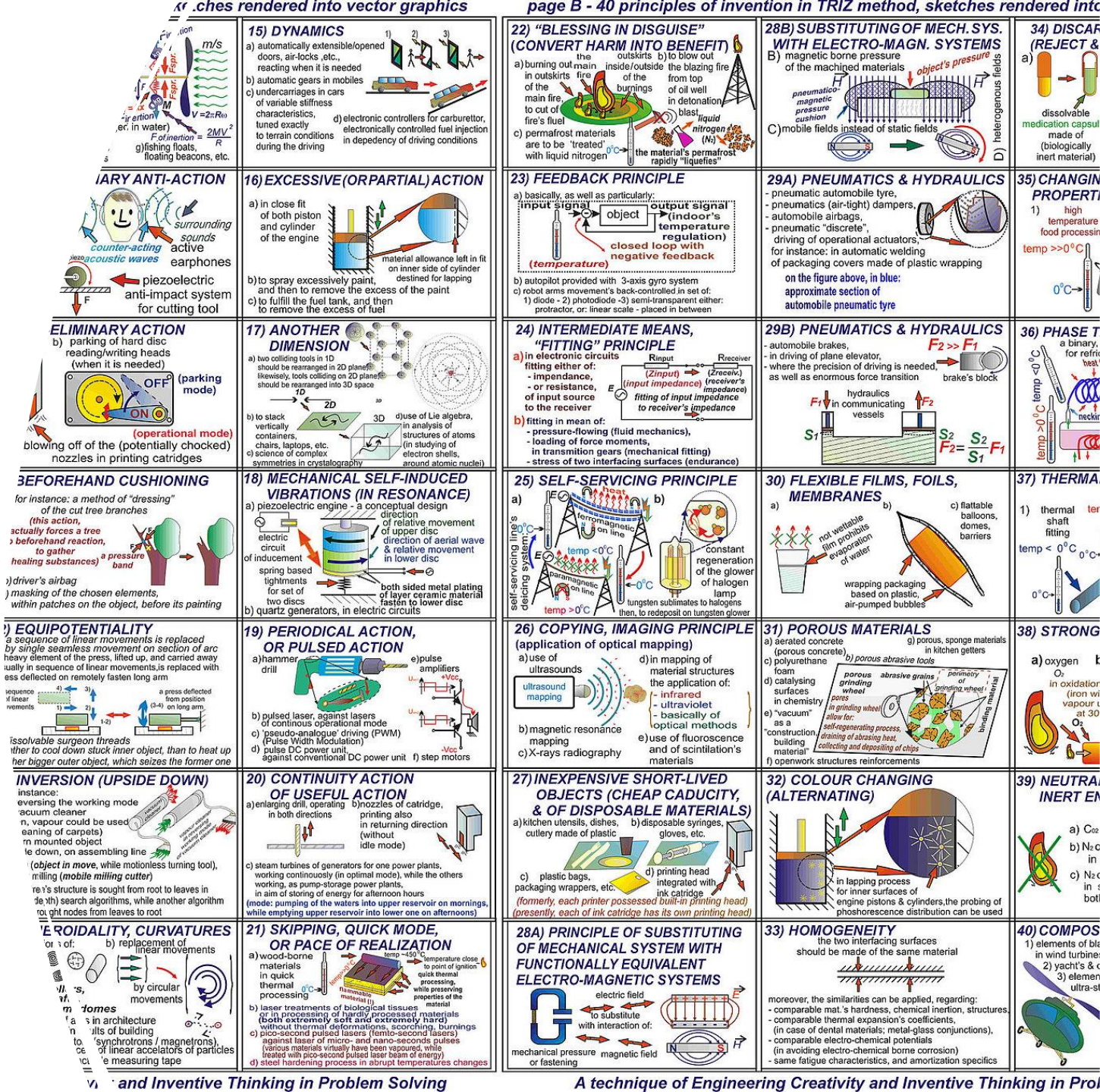
Messiness, Uncertainty & Playfulness

Mistakes are OK!



Innovation and Guide Words

- HAZOP
- TRIZ
- List-Storming



Happy Hunting Grounds for New Ideas

- Sensors
- Interdisciplinary science projects
  - Biomimetics, medical engineering, transport, materials science

Serendipity:
play, random chance & invention

- Random Binomials
- The importance of homonyms

Random Binomial Trigger Words

down return	screen force	stick sun
shape address	gas increase	dozen sheet
force total	sleep liquid	wind slow
refuse time	test steam	vision handle
slow steam	truck mountain	drink bit
plane liquid	sun video	distance roll
wave skin	skin normal	total vision
time plane	crowd boat	return corner
wind strike	vacuum sheet	coach beat
nuclear reader	speed vacuum	replace spot
driver screen	turn time	farm variety
pattern hole	key mountain	strength slow

PROCESS

Blue Hat - Process

Thinking about thinking.
What thinking is needed?
Organizing the thinking.
Planning for action.

CREATIVITY

Green Hat - Creativity

Ideas, alternatives, possibilities.
Solutions to black hat problems.

FACTS

White Hat - Facts

Information and data.
Neutral and objective.
What do I know?
What do I need to find out?
How will I get the information I need?

BENEFITS

Yellow Hat - Benefits

Positives, plus points.
Why an idea is useful.
Logical reasons are given.

FEELINGS

Red Hat - Feelings

Intuition, hunches, gut instinct.
My feelings right now.
Feelings can change.
No reasons are given.

CAUTIONS

Black Hat - Cautions

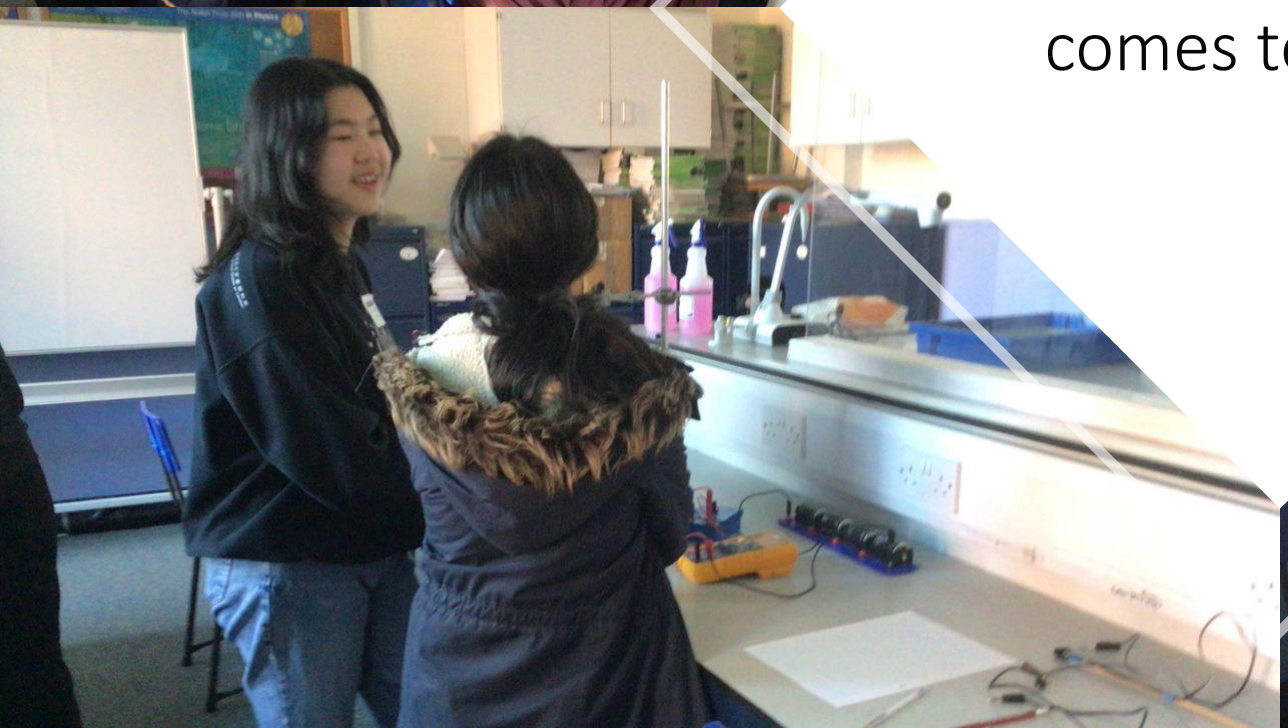
Difficulties, weaknesses, dangers.
Spotting the risks.
Logical reasons are given.

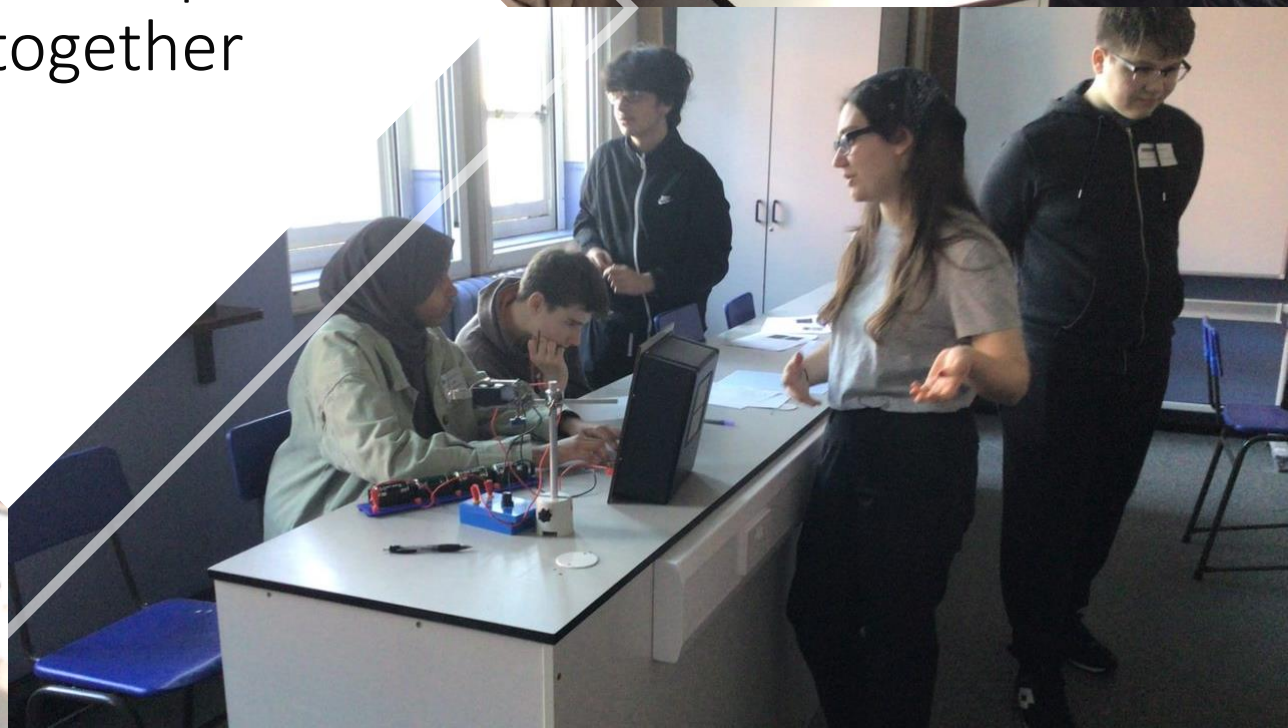
Teamwork – using the ‘Hive Mind’

- Six Hats works better with a team – but its OK for one person too
- Using Specialist Roles in the team
  - If a team member is obviously keen & able doing computers or electronics – then give them computers or electronics to do
  - If two things need doing and can be done in parallel – then do them in parallel
  - Do you need a leader? Maybe
  - Coordinator? Instead of leader, someone who organises – a co-ordinator
- Support team – teachers, technicians, highly able sixth formers, external expert from university or industry?
- Hive Mind: just getting everyone thinking and telling what they think – but avoiding the negative side of Hive Mind – Groupthink*
- Hive Mind and Crosswords
  - Don’t believe it? Try doing a cryptic crossword
  - Now do it with someone else – or maybe a couple of other people

*It may help if everyone notes down what they think at the beginning of a discussion

I love it when a plan comes together





4. Testing & Collecting Data: What do you test?

- ***The Obvious***: the intended function or purpose – how well it solves its intended problem
- Friction affects a lot of things & temperature affects almost everything
- Think about imperfections in the design
- Material properties – properties of fluids, properties of solids
- Dynamics – movement, gravity
- Electrical properties
- Change of scale effects
- Test something that you (think you) can analyse !

5. What on earth is going on?
ANALYSIS of RESULTS

- Draw diagrams: visual understanding and communication
  - Use big sheets of paper – or maybe a whiteboard – you can photograph it
- Select symbols, label diagrams
- Try to analyse, at least at first, in the simplest way possible
  - Pick as few variables as you dare
  - Can you neglect friction, assume an angle is small?
  - Can you use a one-dimensional analysis
  - Is there a symmetry in the project which make it simpler to analyse?
- Check out **scaling**
- Check out length-mass-time dimensional analysis
- *REDUCTIO AD ABSURDUM*
- Put some numbers in, do they check out with your testing?

Curriculum links

Working scientifically

Through the content across all three disciplines, students should be taught so that they develop understanding and first-hand experience of:

1. The development of scientific thinking

- the ways in which scientific methods and theories develop over time
- using a variety of concepts and models to develop scientific explanations and understanding
- appreciating the power and limitations of science and considering ethical issues which may arise
- explaining everyday and technological applications of science; evaluating associated personal, social, economic and environmental implications; and making decisions based on the evaluation of evidence and arguments
- evaluating risks both in practical science and the wider societal context, including perception of risk
- recognising the importance of peer review of results and of communication of results to a range of audiences.

2. Experimental skills and strategies

- using scientific theories and explanations to develop hypotheses
- planning experiments to make observations, test hypotheses or explore phenomena
- applying a knowledge of a range of techniques, apparatus, and materials to select those appropriate both for fieldwork and for experiments
- carrying out experiments appropriately, having due regard to the correct manipulation of apparatus, the accuracy of measurements and health and safety considerations
- recognising when to apply a knowledge of sampling techniques to ensure any samples collected are representative
- making and recording observations and measurements using a range of apparatus and methods
- evaluating methods and suggesting possible improvements and further investigations.

3. Analysis and evaluation

- applying the cycle of collecting, presenting and analysing data, including:
  - presenting observations and other data using appropriate methods
  - translating data from one form to another
  - carrying out and representing mathematical and statistical analysis
  - representing distributions of results and making estimations of uncertainty
  - interpreting observations and other data, including identifying patterns and trends, making inferences and drawing conclusions
  - presenting reasoned explanations, including relating data to hypotheses
  - being objective, evaluating data in terms of accuracy, precision, repeatability and reproducibility and identifying potential sources of random and systematic error
- communicating the scientific rationale for investigations, including the methods used, the findings and reasoned conclusions, using paper-based and electronic reports and presentations.

4. Vocabulary, units, symbols and nomenclature

- developing their use of scientific vocabulary and nomenclature
- recognising the importance of scientific quantities and understanding how they are determined
- using SI units and IUPAC chemical nomenclature unless inappropriate
- using prefixes and powers of ten for orders of magnitude (e.g. tera, giga, mega, kilo, centi, milli, micro and nano)
- interconverting units
- using an appropriate number of significant figures in calculations.

Science programmes of study: key stage 4 National curriculum in England Department for Education 2014

Problems in need of solutions

Off-Shore Wind Turbines

What needs to be monitored?

Off-Shore Wind Turbines

Possible problems

HOW FAST IS OUR TURBINE SPINNING?

IS OUR TURBINE SWAYING?

IS OUR TURBINE SINKING?

Health and Medicine

- What sensors could be used in a hospital to monitor a patient's vital signs?
- What sensors could be used to keep track of a person's health in their daily life?

Health and Medicine

TEMPERATURE

BLOOD PRESSURE

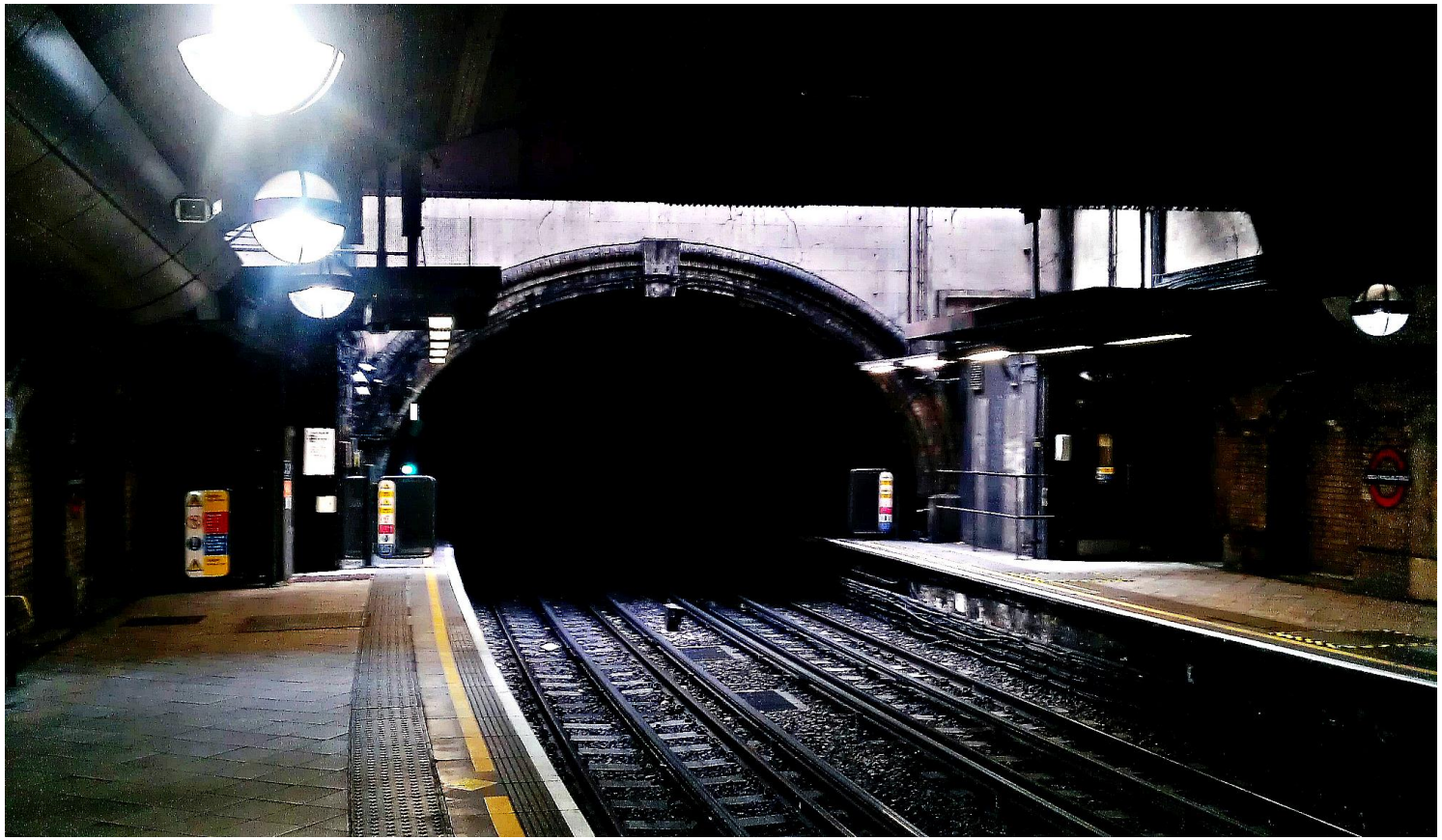
PULSE RATE

BLOOD OXYGEN LEVEL

RESPIRATION RATE / VOLUME

The London Underground

What needs to be monitored



The London Underground

- How many people have passed this point?
- Is the air safe to breathe?
- What is the maximum volume of noise on this journey?
- Is our tunnel flooding?

Home Sensors

What sensors would be useful to have around your home?

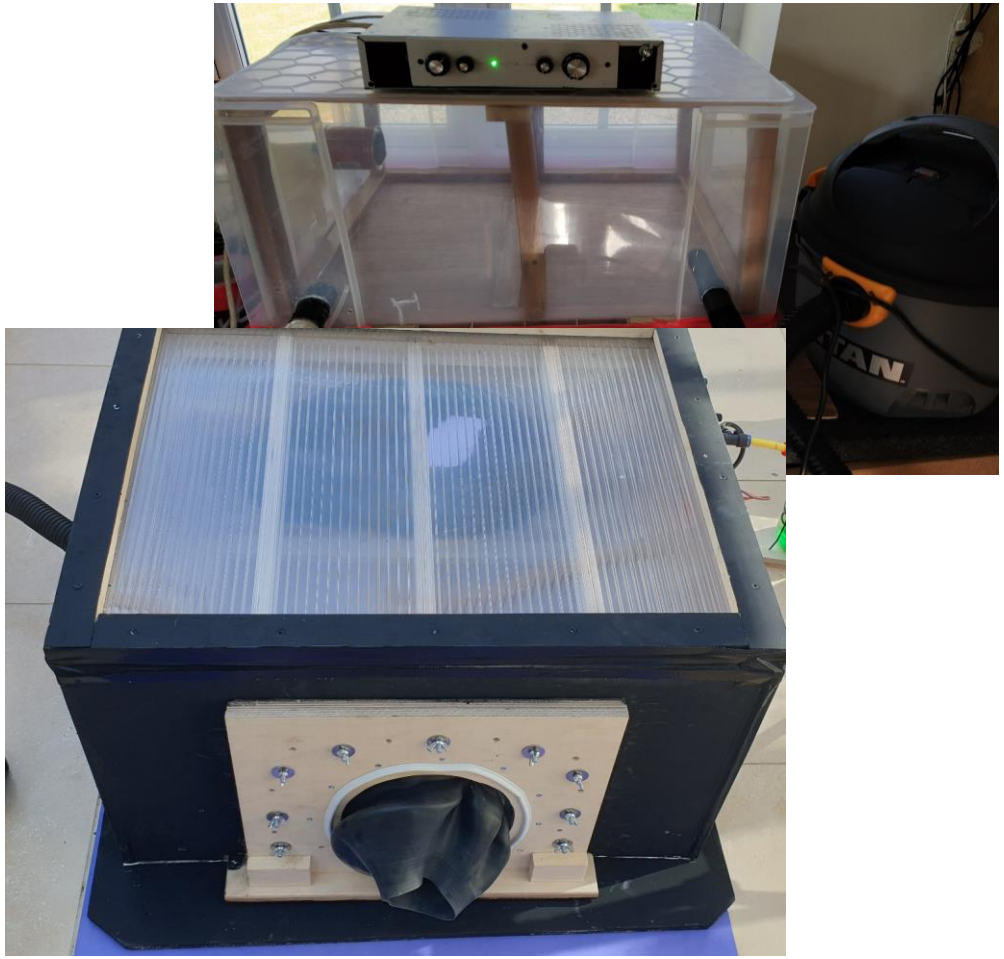
Home Sensors

WHICH DOORS ARE OPEN/CLOSED?

IS ANYTHING/ANYONE MOVING IN A ROOM?

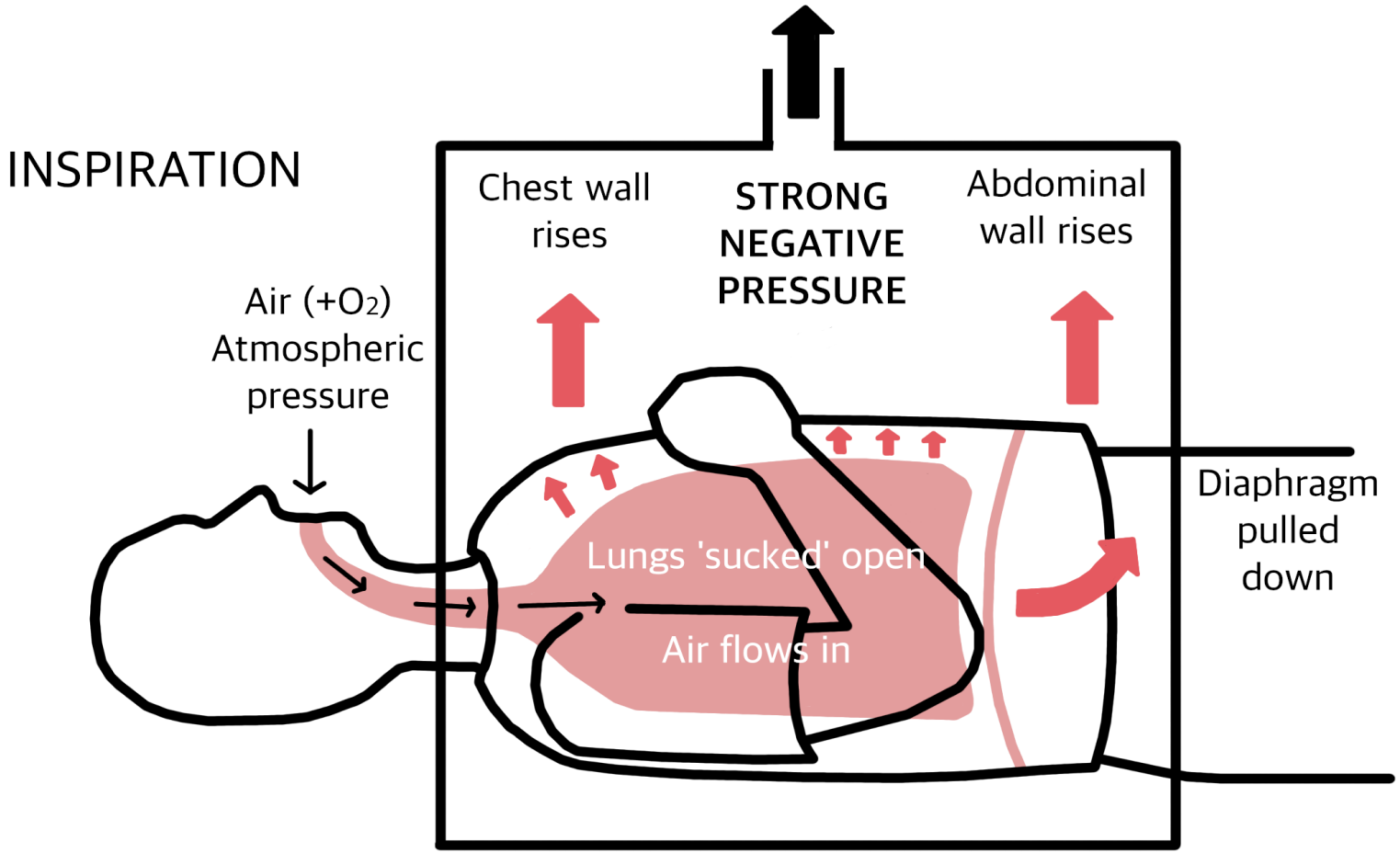
WHICH LIGHTS ARE ON/OFF?

Exovent™: What are we talking about ?

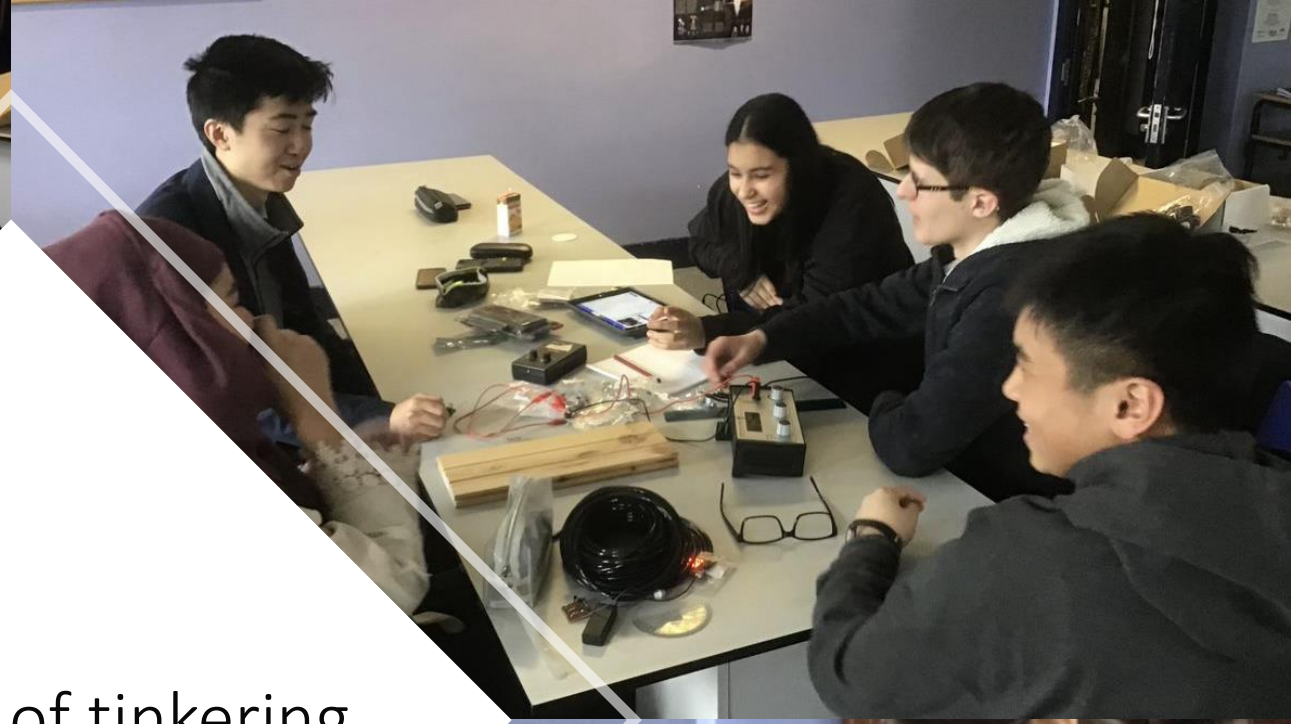


- A registered charity for machines which help breathing

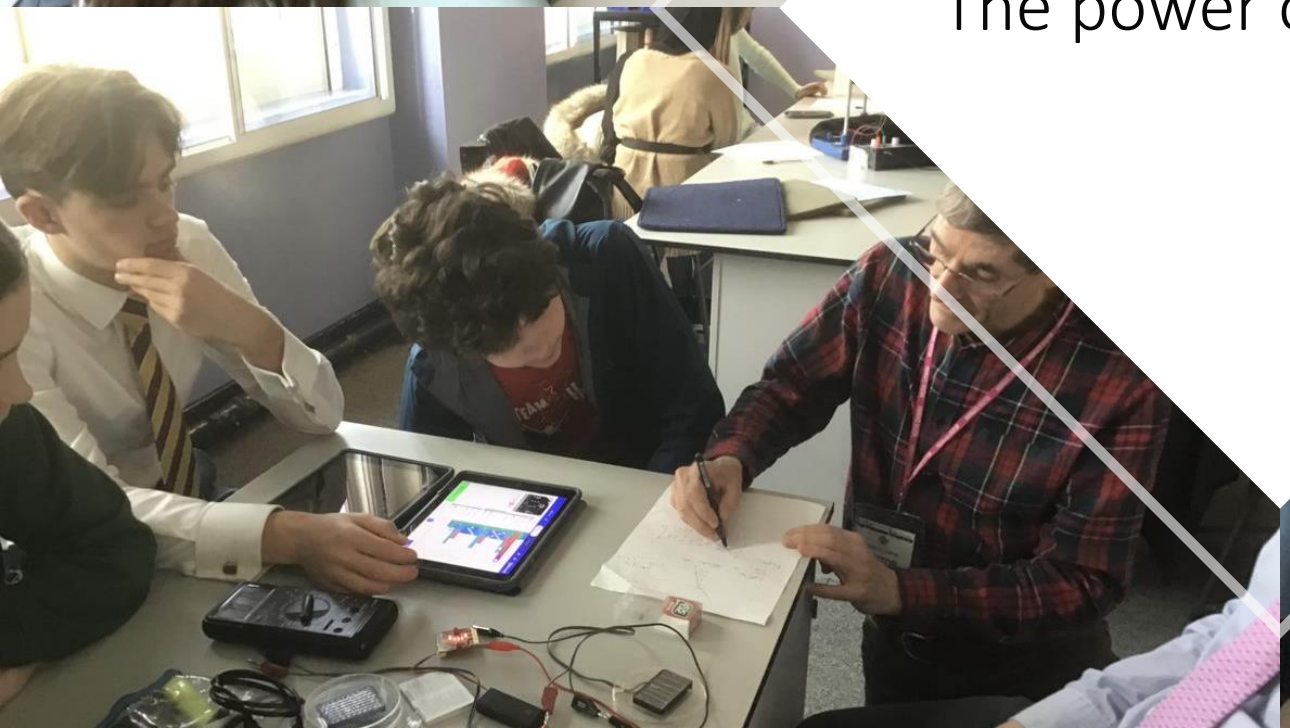
NPV NEGATIVE PRESSURE VENTILATION



NPV 'sucks' air into lungs by creating negative pressure around abdomen and chest

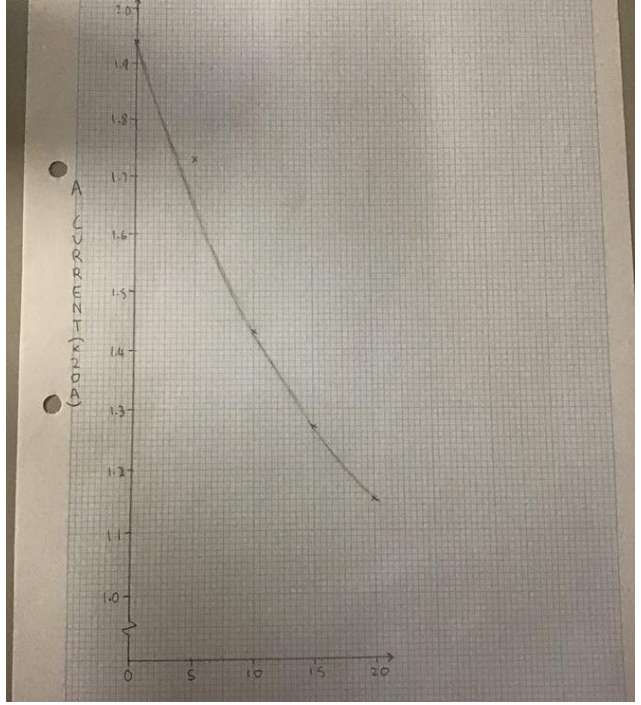


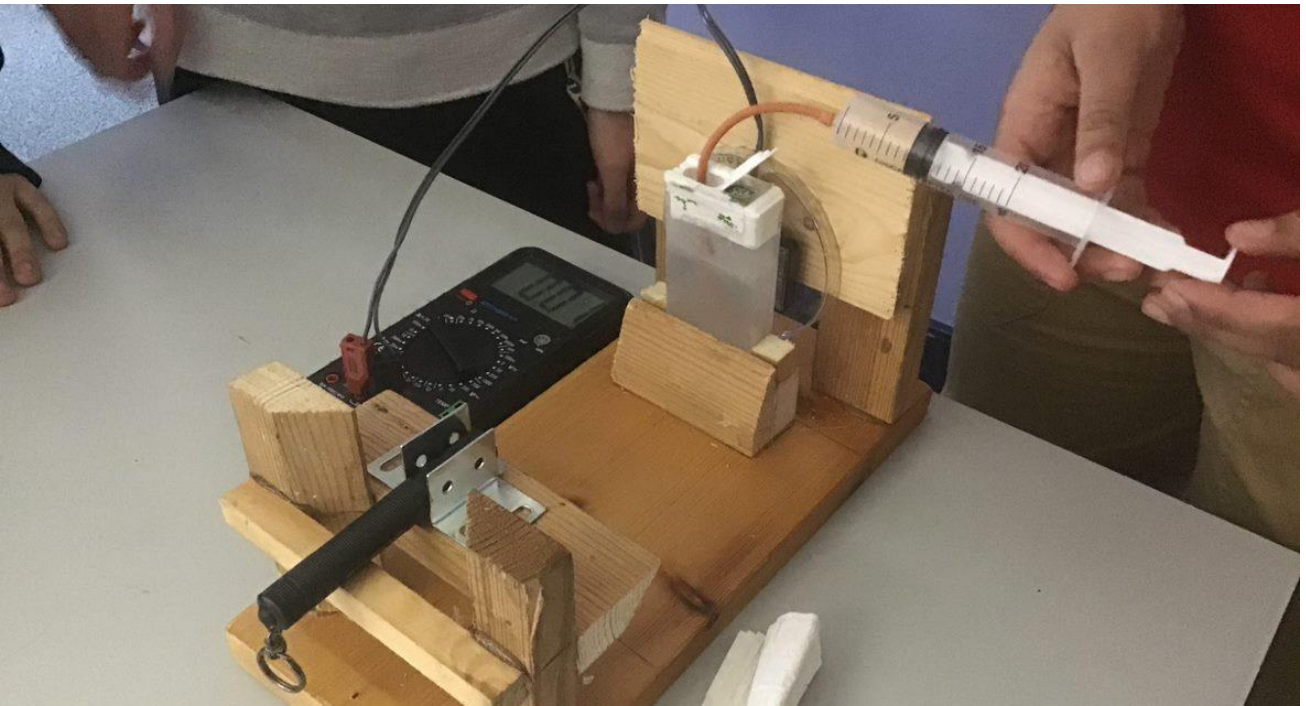
The power of tinkering



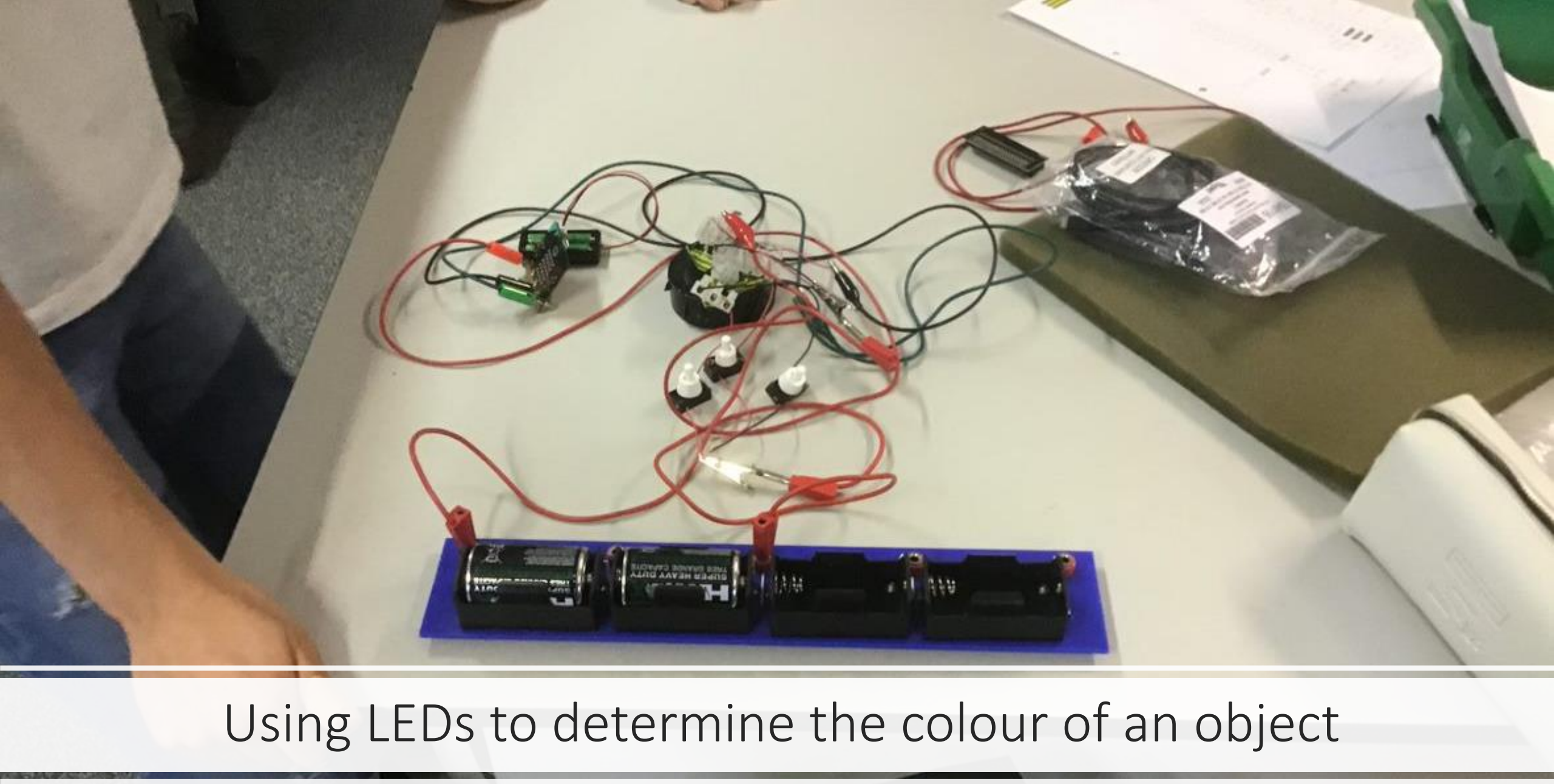
Project examples

- Using LEDs to determine the colour of an object
  - Proposed use: automated fruit selection
- Using ultrasound reflection to determine the dampness of cloth
  - Proposed use: a sensor to reduce waste energy use by tumble dryers
- Monitoring CO2 using light and lime water
  - Proposed use: a simple CO2 sensor
- Measuring respiration rate using light and fabric
  - Proposed use: a sensor to determine if a patient is in need of immediate medical attention.





- Monitoring CO_2 using light and limewater



Using LEDs to determine the colour of an object

7. Telling the World about it: presenting your innovation and results

- Abstract: in a few words, what is the idea, how well did it work?
- Introduction
- Lots of diagrams and photos
- Results of analysis: simple formulae, understandable symbols
- Results of tests: numbers, graphs
- Summarise what you achieved
- **WHAT NEXT what you might do next**

Telling the World about it (cont)

- You don’t need stop telling the world about it !
- You can talk about it to your friends – spread the word about the great things that doing a project does for you
- You can apply new things you learn at school to the project – see how they fit
- You can talk about it when you apply for university

AND… even more importantly…

- You can use it in **UCAS**

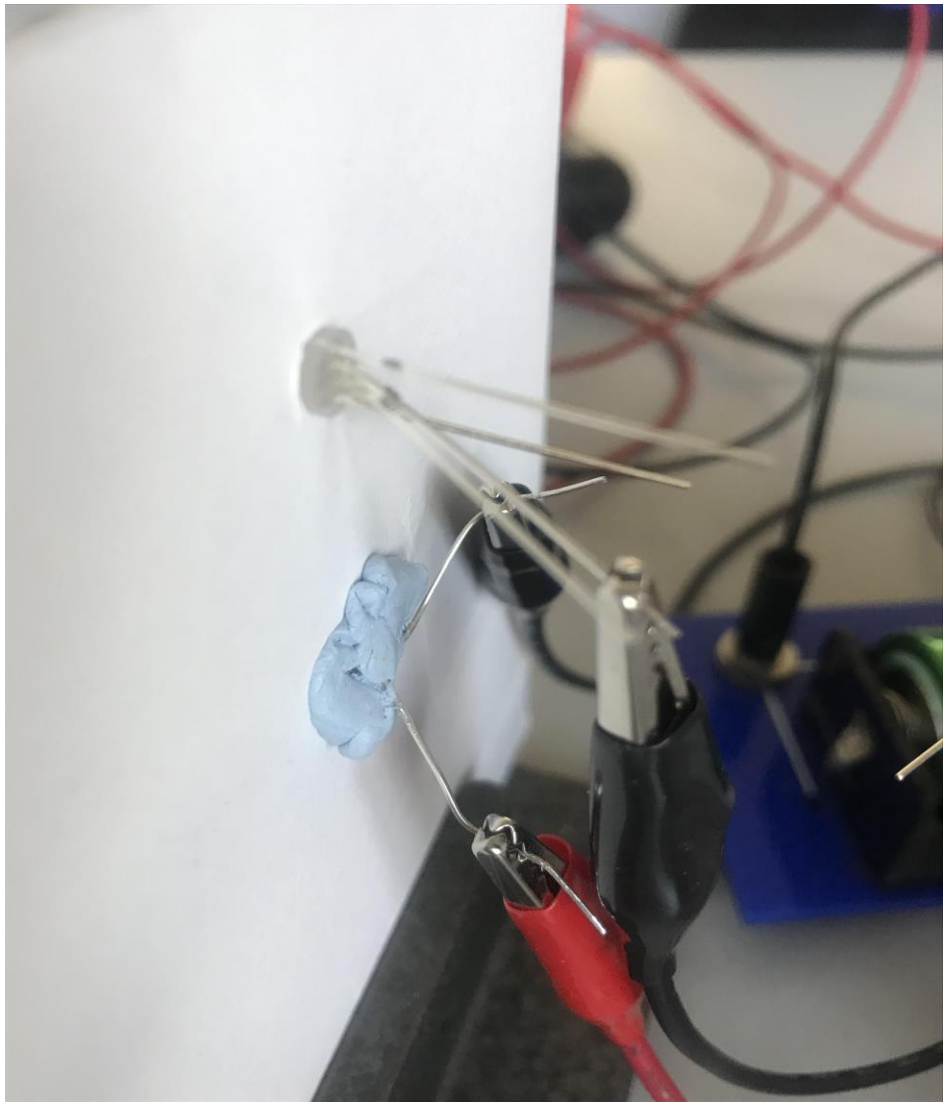
AND… even MORE importantly…

- **Job interviews** – a story about how you worked in a team, brainstormed something new, applied your knowledge, made it work – and interesting science – it’s a great story that might just get you a job in the future

Phototransistor & LED

•We set up the phototransistor and Led and poked them through black card, which we attached to the clamp

•We attached the phototransistor to the multimeter so we could see the voltage

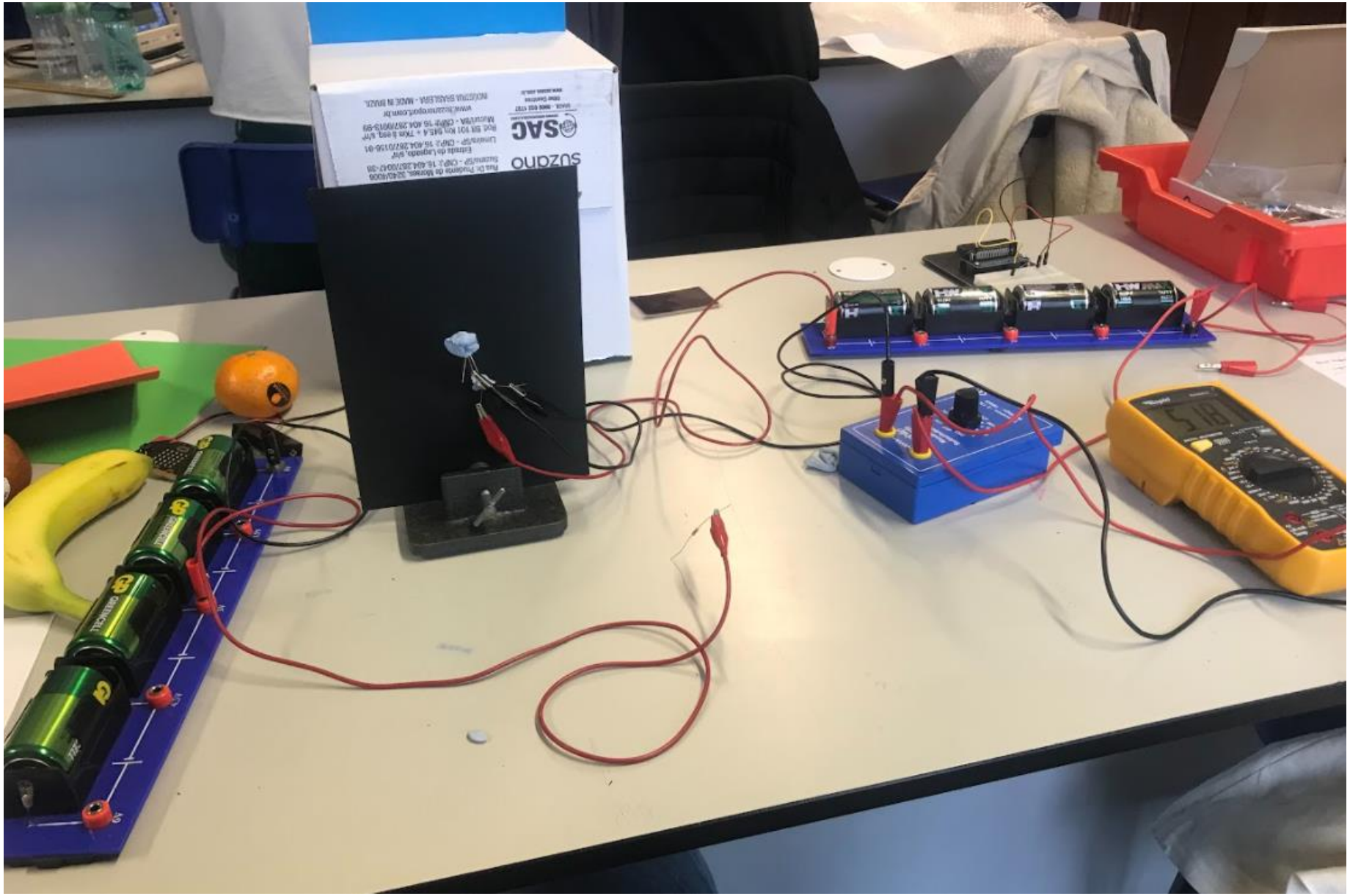


-We placed an apple 5cm away from the led and phototransistor

- We put a box over the apple, phototransistor and led to reduce the amount of background brightness

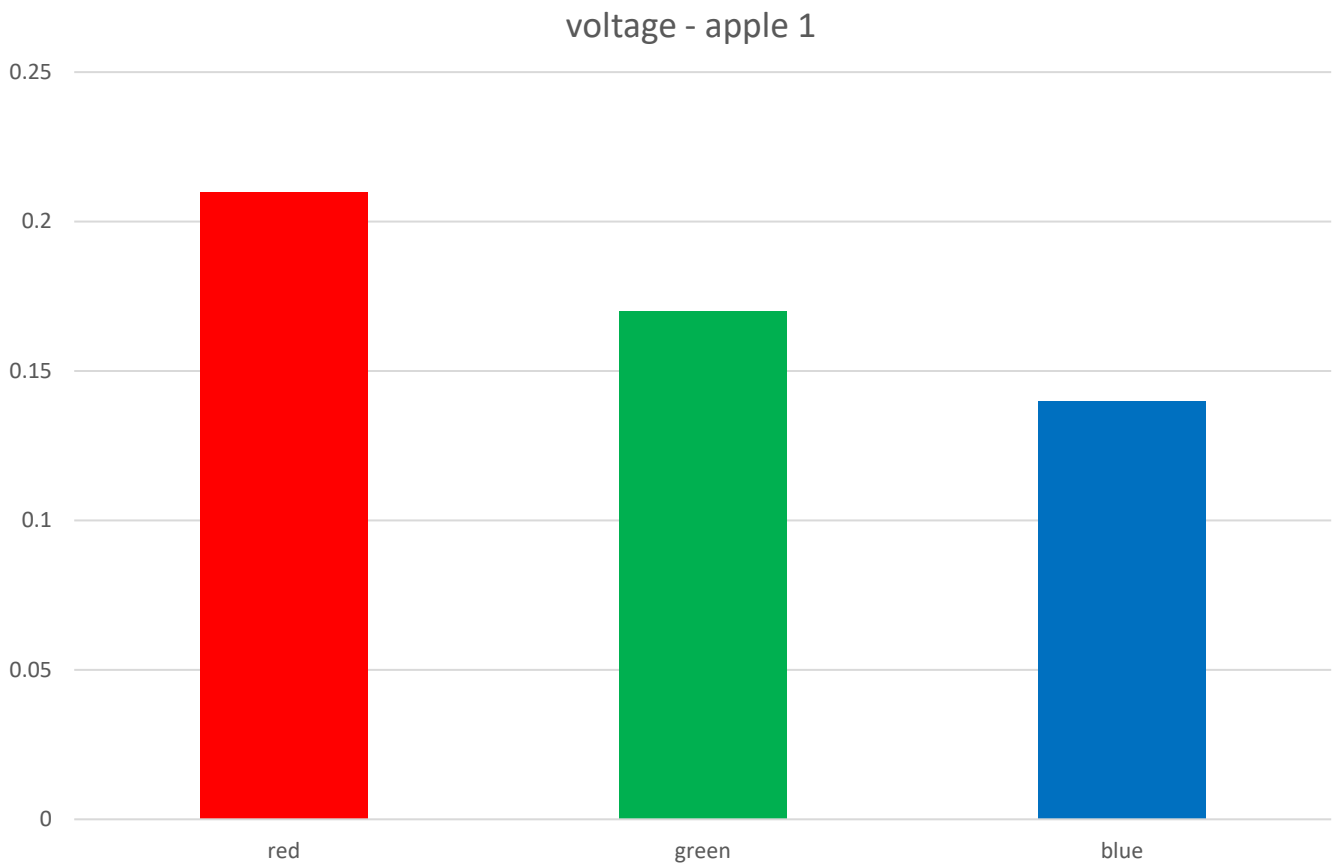
- We measured the voltage when each colour light was shone at the apple

How it came all together

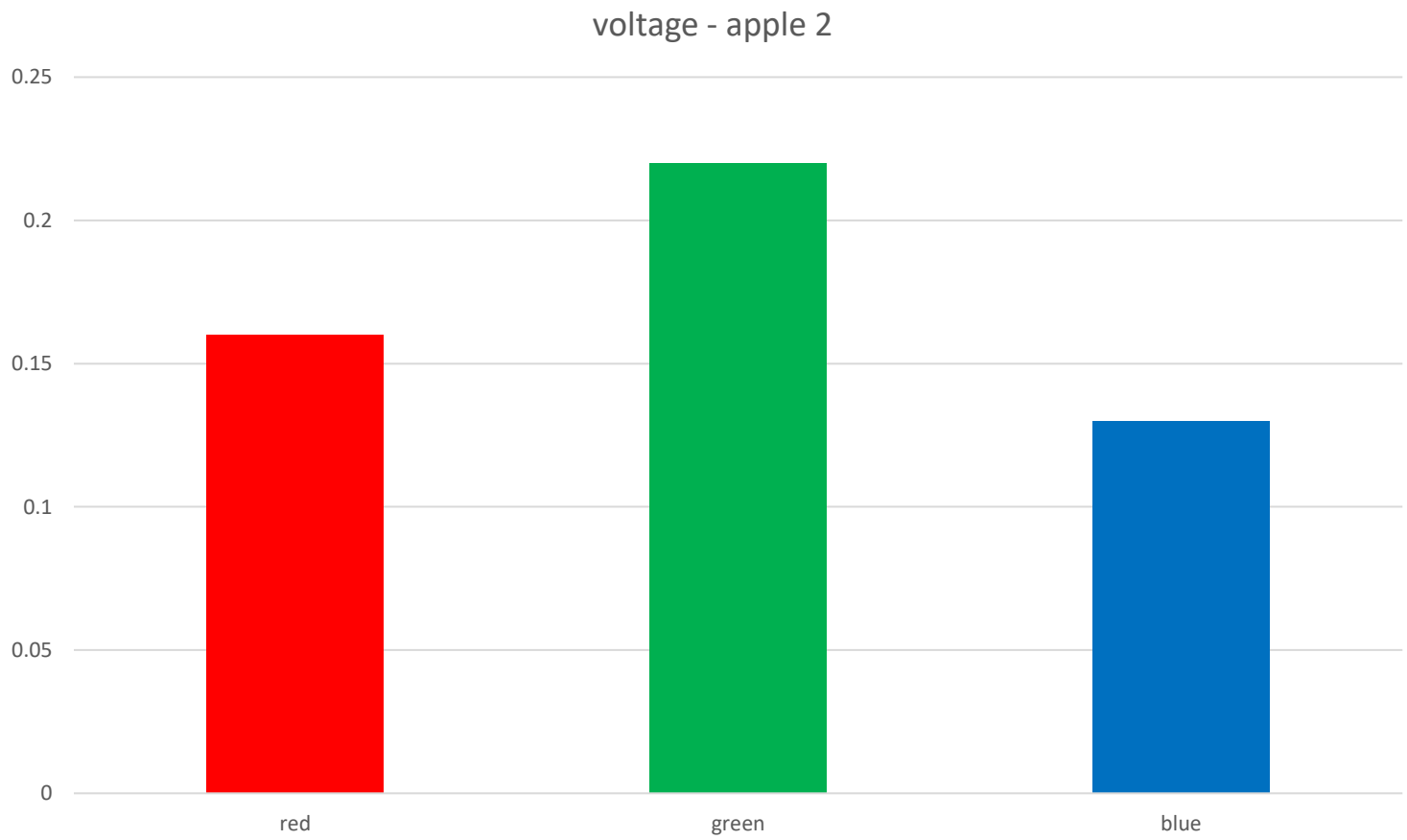


Our data

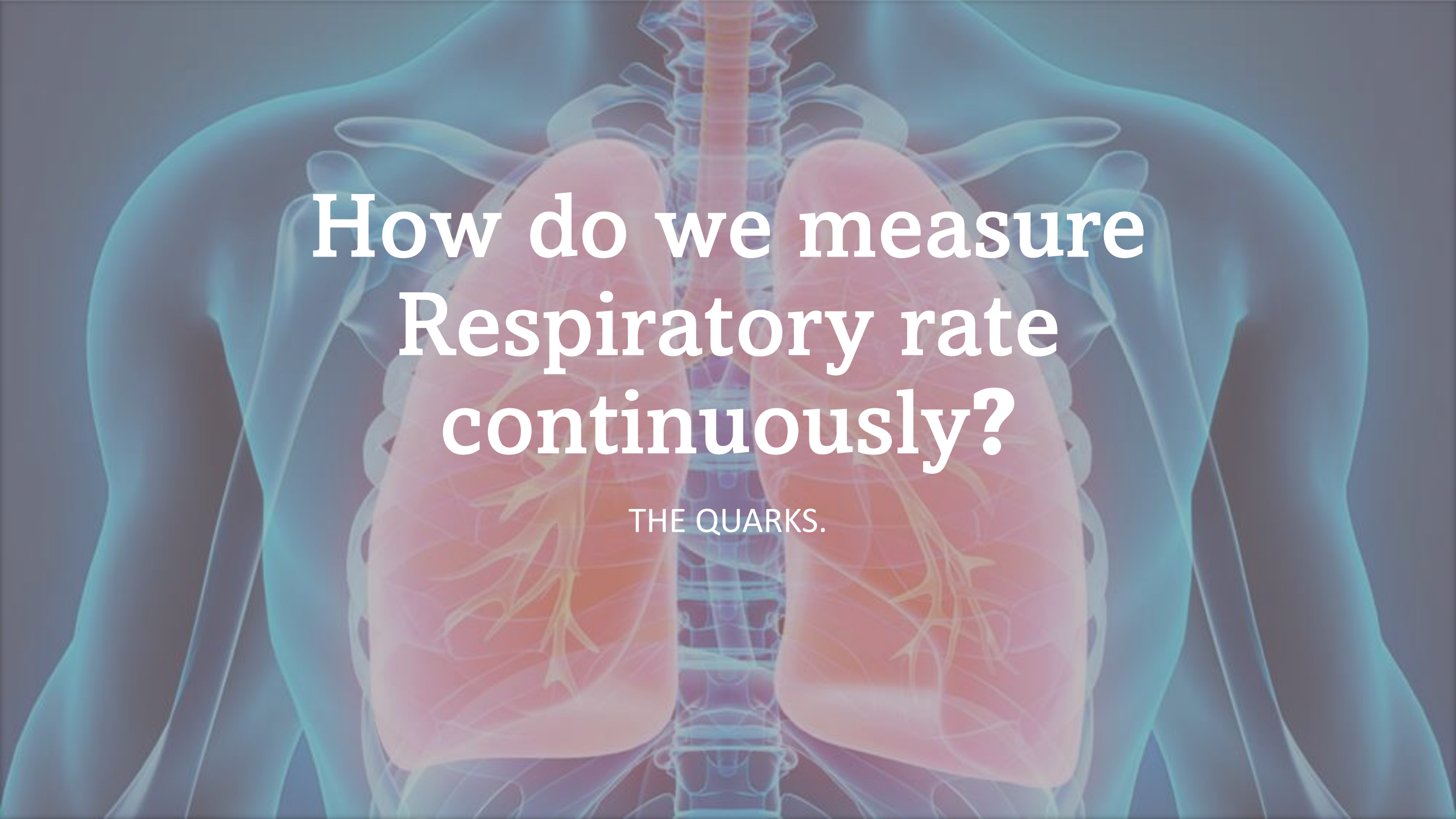
Ripe apple:



Unripe apple:



Learning by failing, and failing better.



How do we measure Respiratory rate continuously?

THE QUARKS.

Initial ideas

As a team, we initially had many ideas of what wanted to do our project on. We chose to measure stress levels as we found it interesting and an aspect that would be relatively useful to measure.

When thinking about a purpose of measuring stress levels we came to the conclusion that it would cater to the many problems some people may have daily such as:

- Uncontrollable sweating – where we could use a moisture sensor
- Measuring Heart rhythm- by measuring the variation in heartbeat
- Increased/decreased body temperature- random spikes in temperature
- hyperventilation

Some problems we had when designing

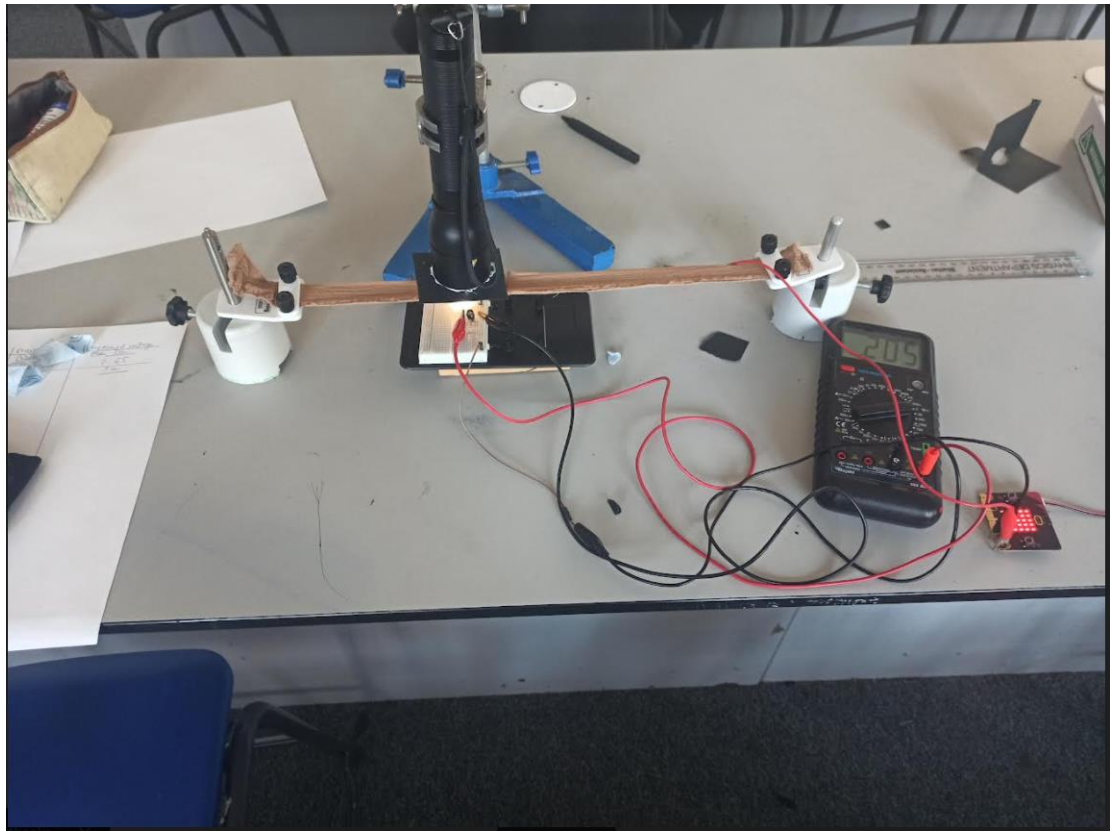
- However, our problems did not end here. With the many symptoms accompanied with stress levels, we found it nearly impossible to measure all of them and come to the conclusion to how stressed someone was.
- We disregarded the idea and decided to choose a new topic; measuring the pressure exerted by a foot using a sensor. The pressure exerted would be an indication to the best possible shoe sole for the person. This would be useful for patients suffering from arthritis and many other related conditions that might cause discomfort and potentially require a more comfortable shoe sole.

Furthermore…

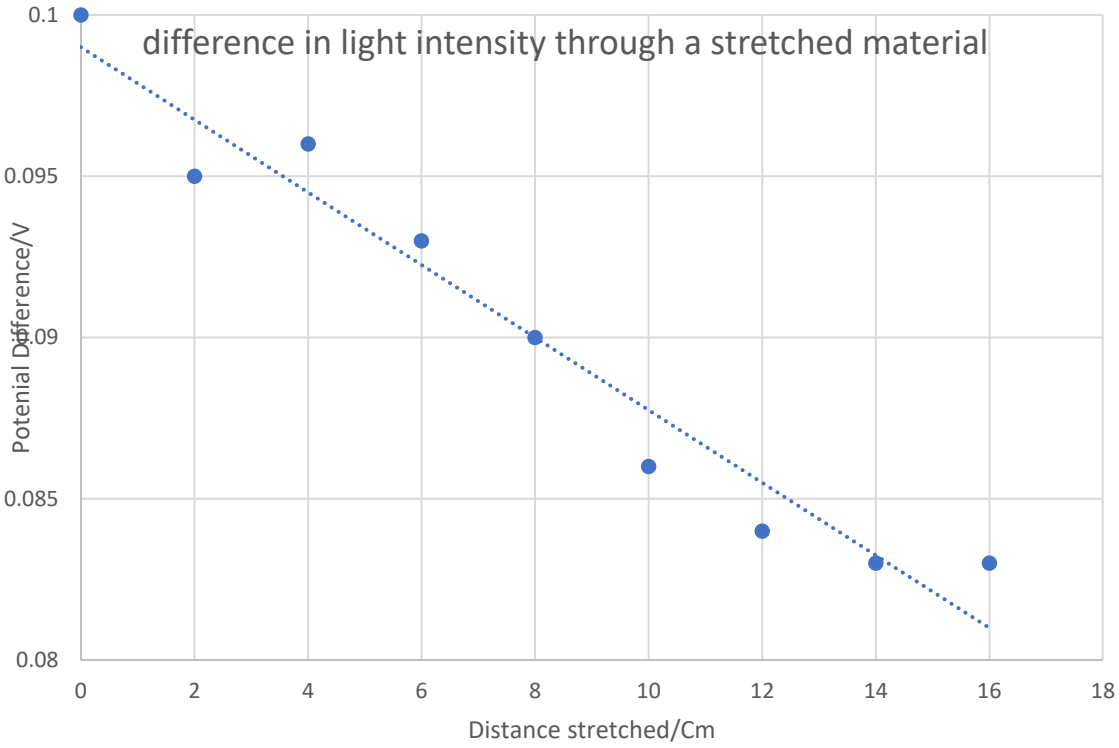
- Once again we found this idea particularly difficult to execute. Whilst the other groups were beginning to do trial and error with their new projects, we found ourselves at the beginning still thinking about the solution to our problems.
- We had many innovative ideas but what we failed to realise was that the solutions to our problems was simplicity. It’s brilliant that we thought of so many ideas but we just had to channel our thoughts and direct into one project (breathing). Although we had further problems with this topic such as deciding on how to measure breathing rates in an unique way- we finally chose a method.

Our method

- We used a phototransistor to measure the intensity of the light through an elasticated material
- As the fibre of the material stretched the light passing through would differ- and we would get a different signal from the multi meter, this meant we had a reliable way of detecting the when the patient breaths in and breaths out



Our data



Our data shows a negative correlation with the difference in light intensity through a stretched material. The further it stretched in distance, the voltage decreased and therefore the light passing through was less. This means a larger difference in voltage therefore showing they are inhaling and exhaling

Physiological parameter	Score 3	2	1	0	1	2	3
Respiration rate (per minute)	≤8		9–11	12–20		21–24	≥25
SpO_2 Scale 1(%)	≤91	92–93	94–95	≥96			
SpO_2 Scale 2(%)	≤83	84–85	86–87	88–92 ≥93 on air	93–94 on oxygen	95–96 on oxygen	≥97 on oxygen
Air or oxygen?		Oxygen		Air			
Systolic blood pressure (mmHg)	≤90	91–100	101–110	111–219			≥220
Pulse (per minute)	≤40		41–50	51–90	91–110	111–130	≥131
Consciousness				Alert			CVPU
Temperature (°C)	≤35.0		35.1–36.0	36.1–38.0	38.1–39.0	≥39.1	

Some problem we had a long the way

- We encounters a lot of problems, for example:

- Systematic problems
- What if the patient was excessively moving
- Comfort
- Our microbit doesn’t work
- We were not able to test on lots of material

How to get started?

- Industrial partnership
- Partnership schools

- Start small and then iterate!
- An expert is someone who has made all the mistakes in a particular domain
- Have fun!

Hub and Spoke Partnerships

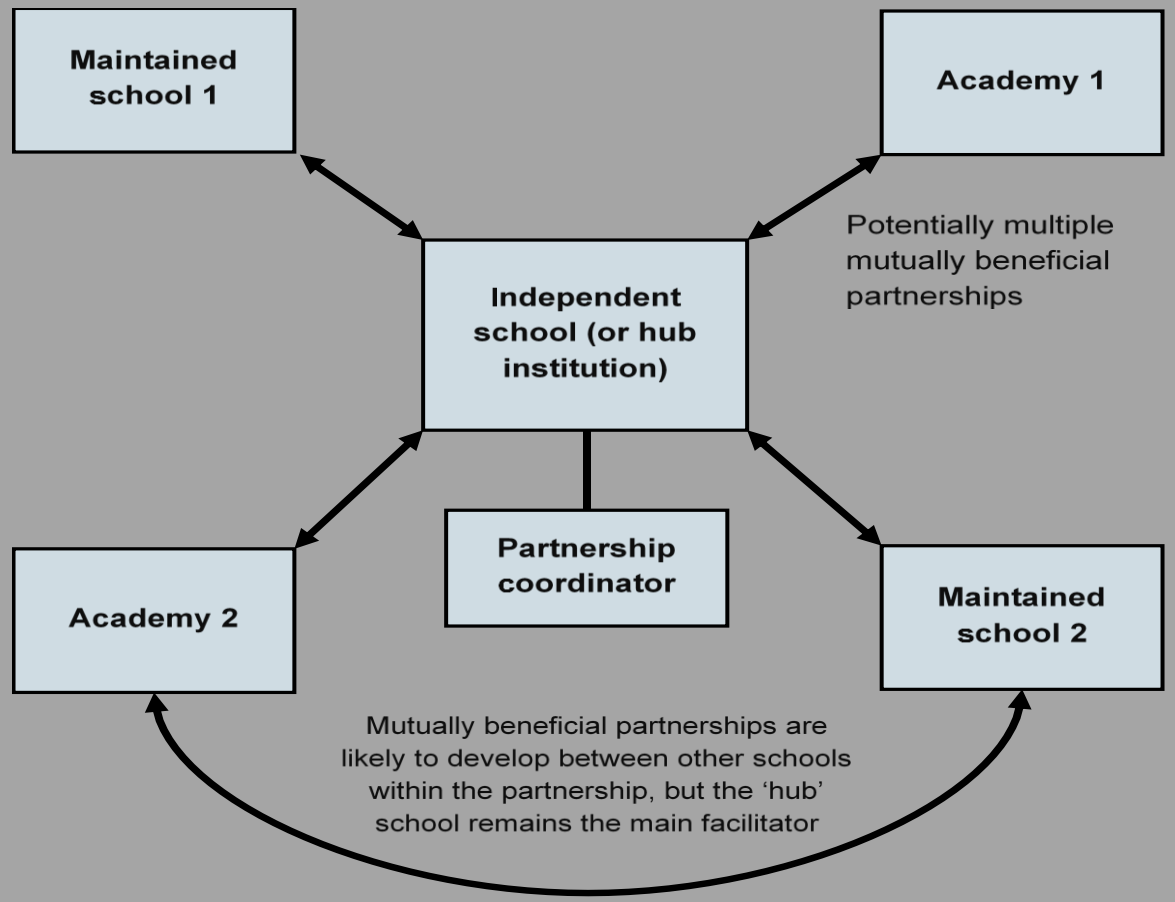


Diagram from https://www.gov.uk/government/publications/setting-up-school-partnerships - accessed on 08-06-2022

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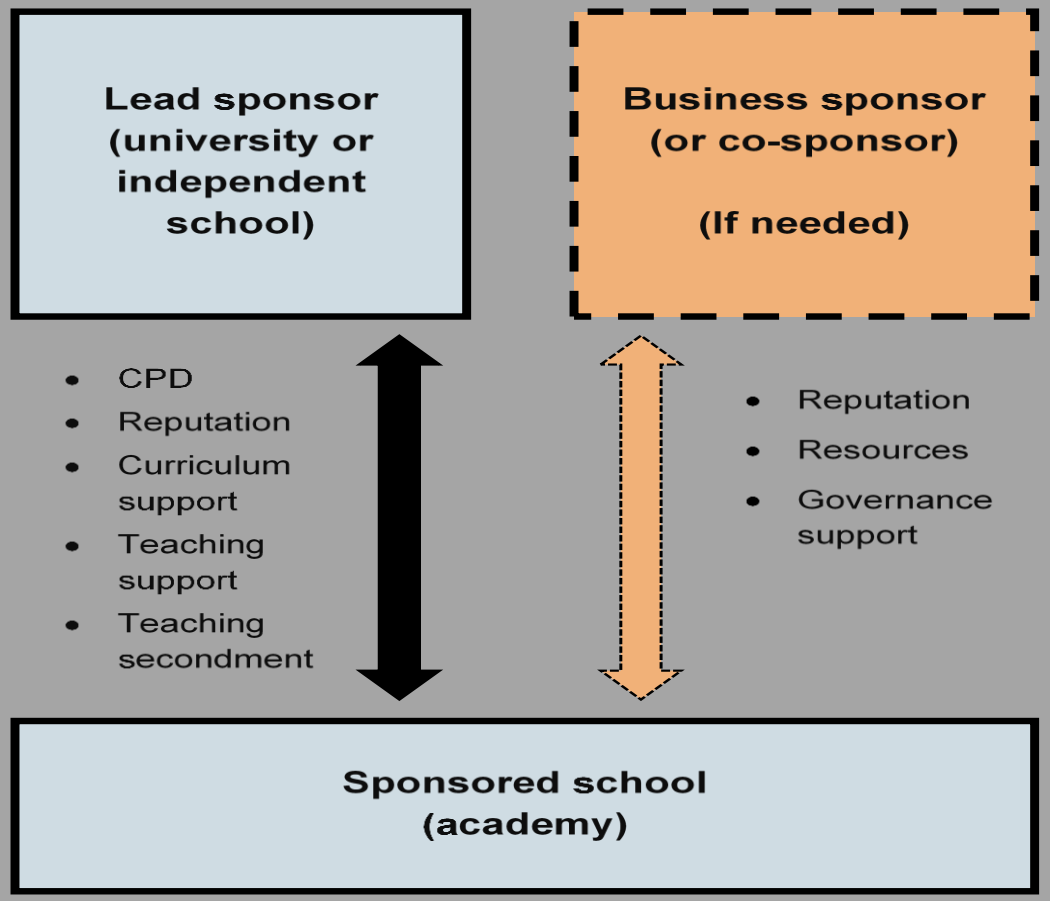
Partnership Models – Academy Sponsorship



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Highgate Chrysalis Partnerships

51
Partner State Schools

32
Secondary Schools and Sixth Forms

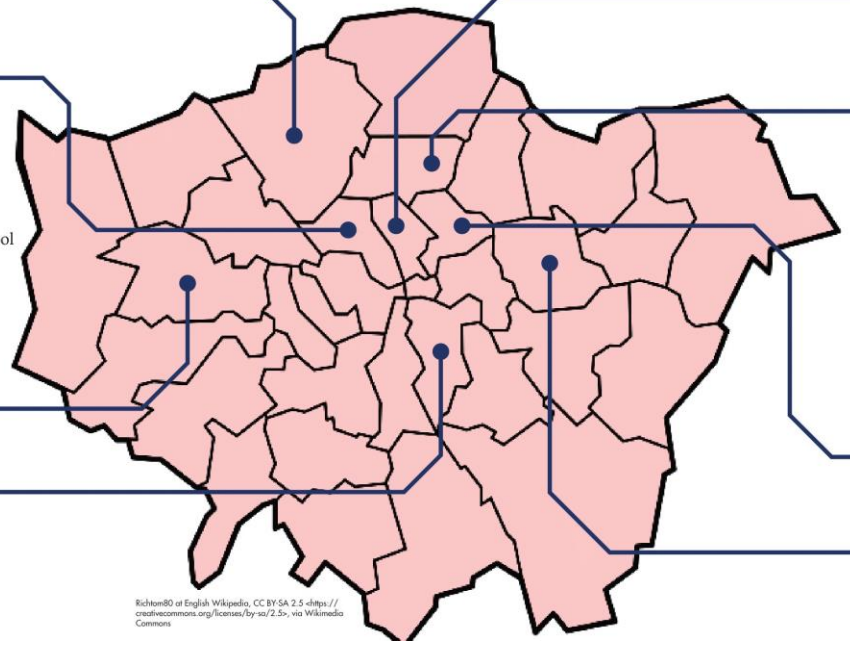
14
Primary Schools

3
Virtual Schools

2
Special Educational Needs Schools

22.5%*
Of pupils in our partner schools are eligible for Free School Meals, compared to the London average of 16.8% (Data form 2019)

OUR PARTNER SCHOOLS



Barnet
The Henrietta Barnett School
The Holmewood School London

Camden
Acland Burghley School
Brookfield Primary School
Camden School for Girls
Camden Virtual School
Hampstead School
Haverstock School
La Sainte Union Catholic Secondary School
Maria Fidelis Catholic School
Parliament Hill School
Regent High School
St. Joseph's Catholic Primary School
UCL Academy
William Ellis School

Ealing
Drayton Manor High School

Lambeth
King's College Mathematics School

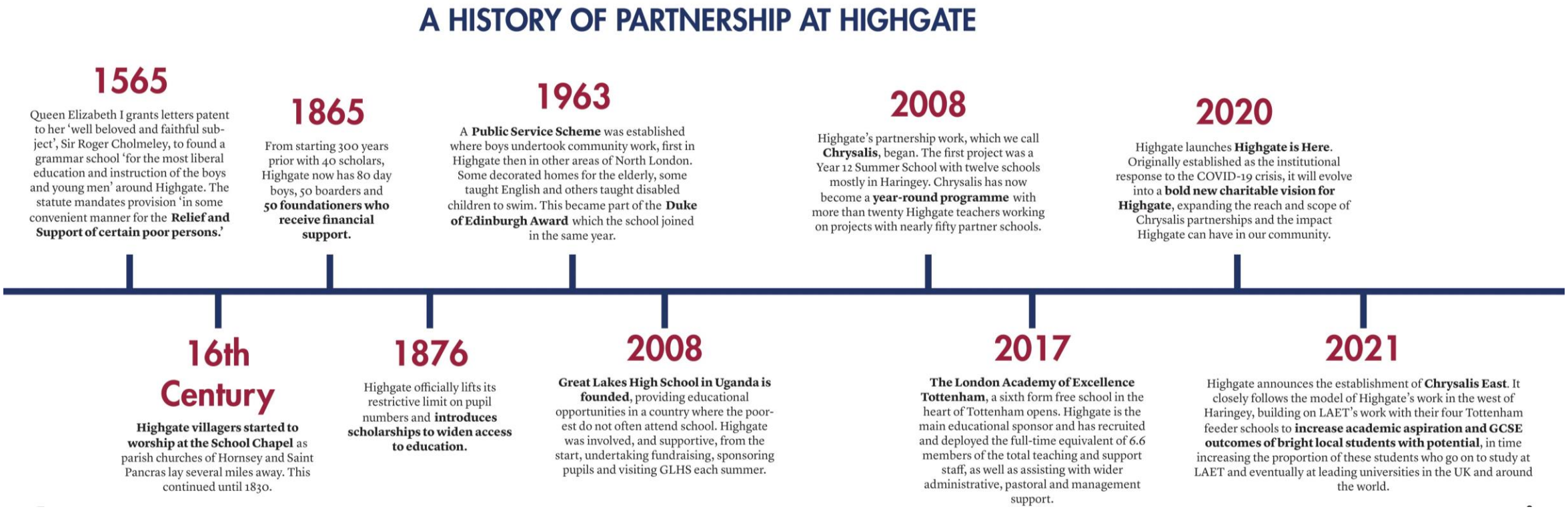
Islington
Grafton Primary School
Islington Virtual School
St Aloysius RC College
St Mary Magdalene Academy
Whitehall Park School

Haringey
Alexandra Park School
Crowland School
Duke's Aldridge Academy
Fortismere School
Gladesmore Community School
Greig City Academy
Haringey Sixth Form College
Haringey Virtual School
Heartlands High School
Highgate Primary School
Highgate Wood School
Holy Trinity CE Primary
Hornsey School for Girls
London Academy of Excellence Tottenham
Park View School
Seven Sisters Primary School
St Thomas More Catholic School
St. Ann's CE Primary School
St. Mary's CE Primary School
St. Michael's CE Primary School (N22)
St. Michael's CE Primary School (N6)
St. Paul's and All Hallows CE School
Tiverton Primary School
TreeHouse School
Woodside High School

Hackney
Stoke Newington School

Newham
Kingsford Community School
London Academy of Excellence Stratford
St Angela's Ursuline School

Highgate Chrysalis Partnerships



Highgate School's Ethos

Learning and Scholarship

•Cultivate individual curiosity and intellectual rigour in our pupils to enable their interests to take flight

•Believe in the enjoyment of learning for its own sake, and as a way of living

•Nurture confidence, creativity and risk taking in our pupils as they study, in preparation for higher education, the world of work and happy, curious lives

A Reflective Community

•Encourage our pupils to look outwards, to play an active part in their community – both within the School and further afield

•Strive for continual learning and improvement, particularly with regards to equality, inclusion, diversity and sustainability

•Facilitate our pupils to use their minds and voices to make a difference to the world around them

Exemplar For the Healthy Life

•Promote kindness, empathy and friendship

•Nurture self-reflection and celebrate individuality, encouraging our pupils to find and develop their unique skills

•Encourage pupils to develop personal qualities such as self-motivation, collaboration and leadership

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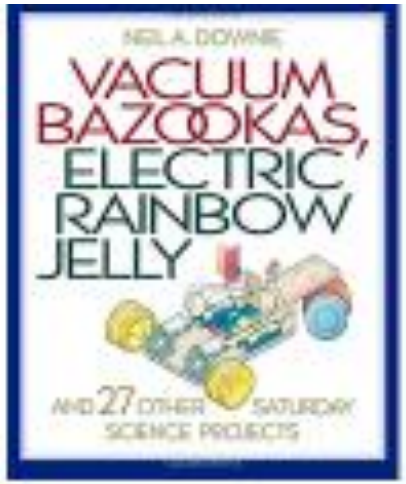
www.exovent.org

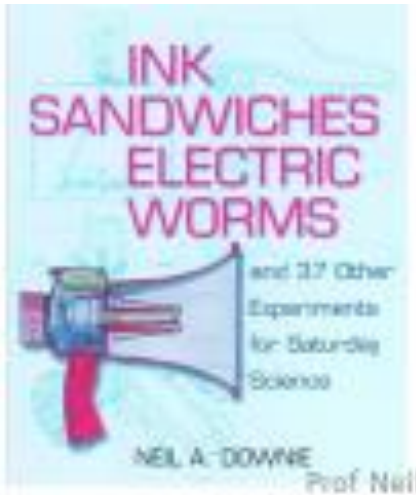
Saturday Science

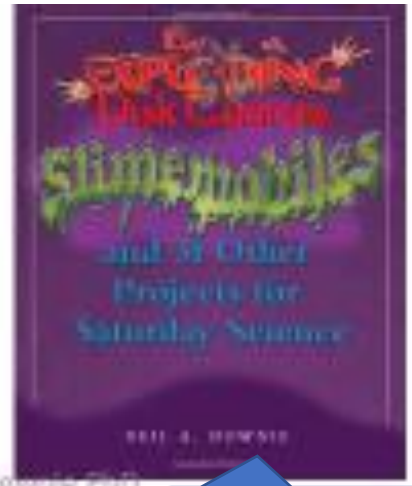
www.saturdayscience.org

More Creative Physics ? Saturday Science

- Website **saturdayscience.org**
- 4 books from Princeton University Press







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