What should everyone KNOW about Toby Payne-Cook #CurriculumEd2019

Toby Payne-Cook  #CurriculumEd2019
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Marlborough House School, Hawkhurst, Kent (Independent Prep)
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Tweets @CREducATE
Who am I? (~ 4 mins)

Why Science? [multifarious perspectives] (~ 7 mins)

When Science? [Top down Vs Bottom up] (~ 7 mins)

What Science? (~ 17 mins)

- [A themed approach to] Scientific Knowledge, Investigation & Thinking (in KS3)

Questions & Discussion (~ 10 mins)

• Paper copies of slides & associated blog post available...
• Electronic copies available – see Twitter & Email on front sheet
!!! WARNING !!!

• I’m probably wrong

• I’m going to present some views which challenge our current bias towards an exam orientated education system

• I am a fantasy philosopher who’d like to teach Art or English, teaching Science, trapped inside an analytical Scientist’s mind...

Who am I?

I am not Graham Coxon (Blur) but he said something really interesting about “unlearning” the guitar once...
My scientific “epiphany” or “Eureka!” moment aged 20-21...

WOPR – the “super computer” featured in 1983 blockbuster film “War games”

A Sciex-API-III triple quadrupole atmospheric pressure ionisation mass spectrometer circa 1993...

The instrument (along with the wonderful Dr Duncan Bryant) that inspired my scientific career.
1) 1995 - 2001: Agrochemical formulation (for treating fungal diseases on wheat)

2) 2001 - 2003: Freeze dried protein medicines (for treating cancer)

3) 2003 - 2005: Controlled release capsule technology (for MED...)

4) 2005 - 2011: The materials science of dry powders for inhalation (Asthma & COPD)
My last formal podium talk...
In a different life...
Why learn Science? (a brief canter)

- Media perspective / Modern Philosophy perspective (Alain de Botton)
- Academia perspective (Bill Wilkinson @DrWilkinsonSci)
- Parent perspectives (Dr Jekyll & Mr Hyde)

- The Utilitarian view of Education
  - Edutainment
  - Economic perspective
  - Industry perspective
  - STEM, STEAM or SHAG?

- The engagement-orientated educationalist’s perspective
- The exam-orientated educationalist’s perspective

- My (current) view...partially influenced by a trip to Spain and Professor Susan Greenfield
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>To inspire awe and wonder at the universe, the world, life &amp; ourselves (KS1/2)</td>
<td><strong>CURRICULUM</strong></td>
<td>Pedagogy Still Matters But We Must Acknowledge That You Cannot polish A Turd...</td>
<td>Knowing where you’re at and what you’ve gotta do to improve helps...</td>
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<tr>
<td>To explain the world...(KS1/2 &amp; HE)</td>
<td></td>
<td></td>
<td>BUT this OMNIPRESENT TAIL Has a nasty habit Of wagging The CURRICULUM DOG</td>
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<tr>
<td><strong>CURRICULUM</strong></td>
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<tr>
<td>To learn how to think methodically, logically, rationally, empirically, critically and creatively (KS4/5) some KS3 foundations</td>
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<tr>
<td>To identify and develop [foundational] scientific capability for the future (KS5/FE/HE)</td>
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<tr>
<td>To invent, to innovate, to improve, to create, to research, to discover, to develop...(HE/Employment)</td>
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<tr>
<td>To develop our scientific literacy (saving personal money, looking after the environment, improving health &amp; diet, debunking fads) KS3</td>
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<tr>
<td>To celebrate and understand the importance of science to our culture, our ethics, our economy &amp; our future <em>KS3</em></td>
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</table>
When to teach Science:

• Top down
  • The Edumagnetic Spectrum

• Bottom up
  (@Solomon_teach)
Top down...

If we are going to stick with the NC & content heavy / understanding lite Govian GCSE specifications then @adamboxer1 probably has all the scientifically purist answers we need...

AQA

GCSE CHEMISTRY
Higher Tier Chemistry 2H
Specimen 2018

Materials
For this paper you must have:
- a ruler
- a calculator
- the periodic table (enclosed).

An over-diluted homeopathic tincture...
A massive misconception generator for the masses...
The “Edumagnetic” Spectrum

Skills orientated

Individual strengths

Attributes dominate

Subjects merged/linked/destroyed

Self-awareness & specialisms developed early

Knowledge orientated

Shared culture

Academics dominate

Subjects preserved

Broad foundational opportunities
Inspired by @solomon_teach fictional Mr Yamazaki...

- Should the S-word be banned in primary school?
- Is there any real purpose in the dilution of Science to make it make sense, to make it accessible?
- Is comparing soft fabric with hard bricks really Science?
- Isn’t meaningful scientific knowledge underpinned by significant capability in English & Maths?

Should more historical / cultural / factual science, scientific language & description be taught via KS2 English comprehension: “ScieNGLISH”

- Should more analytical science and data handling skills be taught via KS2 maths: “MATHSci”
- And should the “engaging” and “curious” elements of primary Science be taught via lessons titled: “Exploring & Investigating”
  - Isn’t that more honest?

Shouldn’t we leave the conceptual stuff alone until there is time to teach it properly, to those who really need – or want – to understand it? (with the exception of SPACE obviously, cos it is brilliant, right)?
Caveat: A solid foundation of basic oracy, literacy & numeracy is required before access to this graph...

Depth of Knowledge

(Breadth of Knowledge)

(Expertise)

Top down

Too much depth too soon

Too shallow for too long

A bottom up approach
What should everyone know about Science?

• Scientific literacy
  • Bananas & Paracetamol (or my Mother is wrong)
  • Sugar & Fat (and a Viagra™ anecdote)
  • Oxidation (and how not to get ripped off!)

My proposal:
• A themed approach to Scientific Knowledge, Investigation & Thinking in KS3
Oxidation (or a brief rant about my mother in law, and her mother-in-law too)

• Fire (combustion reactions) is the oxidation of a fuel........
• Addition of oxygen e.g. Copper + oxygen $\rightarrow$ Copper oxide
• Removal of hydrogen e.g. oxidation of alcohols to form aldehydes
• Loss of electrons (reduction is the gain of electrons)
• Transition metal oxidation states (colour changes)
  • Oxygenated & Deoxygenated blood
  • Pigments in plants
• Autumn leaf colour changes

Vitamin C (Ascorbic Acid) is a sacrificial antioxidant...

Red wine turns to vinegar...
Core Curriculum Content
- Threshold Concepts
- Underpins Further Academic Study
- Scientific Principles
- Logical Reasoning
- Analytical Thinking
- Key Topic Vocabulary & Definitions
- Direct Instruction
- Retrieval Practice
- Long-term Learning
- Teacher Demonstration
- Some Illustrative Practical Work

Investigative Science
- Curiosity
- Observation
- Practical knowledge
- Research projects
- Inquiry-based learning
- STEAM
- Engagement...
<table>
<thead>
<tr>
<th>Term</th>
<th>Autumn 7</th>
<th>Spring 7</th>
<th>Summer 7</th>
<th>Autumn 8</th>
<th>Spring 8</th>
<th>Summer 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theme:</td>
<td>Humans &amp; Machines</td>
<td>Discovery &amp; Ideas</td>
<td>Earth &amp; Sustainability</td>
<td>Industry &amp; Invention</td>
<td>Home &amp; the built environment</td>
<td>Innovation &amp; the future</td>
</tr>
<tr>
<td>Core Science Content</td>
<td>Anthropology</td>
<td>Space (big)</td>
<td>Atmosphere &amp; Pollution</td>
<td>Refined &amp; synthetic materials</td>
<td>Science in the home: kitchen &amp; garden</td>
<td>Biotechnology</td>
</tr>
<tr>
<td>~ 60 %</td>
<td>Anatomy</td>
<td>(tiny)</td>
<td>Energy cycle</td>
<td>materials</td>
<td>chemicals</td>
<td>(including selective breeding)</td>
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<tr>
<td></td>
<td>Physiology</td>
<td>Periodic Table</td>
<td>Climate change</td>
<td>Chemical reactions &amp; processes</td>
<td>The Medicine cabinet (germs etc)</td>
<td>Food security</td>
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<tr>
<td></td>
<td>Reproduction</td>
<td>Cells &amp; DNA</td>
<td>Respiration &amp; Photosynthesis</td>
<td>Energy transfers</td>
<td>Construction</td>
<td>New materials</td>
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<td>Food, Diet &amp; Health</td>
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<td>Farming &amp; plants</td>
<td>Forces</td>
<td>Electricity</td>
<td>Satellites</td>
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<td>Natural resources</td>
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<td>Forensics</td>
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<td>Investigative Science</td>
<td>Energy in crisps</td>
<td>Microscopy</td>
<td>Field trials in garden plots</td>
<td>Science of Sherbet</td>
<td>Yeast fermentation</td>
<td>Practical assessment</td>
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<td>~ 20 %</td>
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<td>Bouncing balls</td>
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<td>Wider context</td>
<td>The Human Brain &amp; how we learn.</td>
<td>How do we know?</td>
<td>Are humans still part of nature, and if not,</td>
<td>If we knew in 1800 what we know now, what</td>
<td>How do our everyday lives depend upon</td>
<td>Is innovation always good? Should we stop</td>
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<tr>
<td>(Curiosity, Culture, Ethics,</td>
<td></td>
<td>How do we find out?</td>
<td>are we responsible for it?</td>
<td>would we have done</td>
<td>Science? Food technology. How has</td>
<td>doing Science? Is it a good thing that your</td>
</tr>
<tr>
<td>Thinking etc)</td>
<td></td>
<td>How do we gather evidence?</td>
<td>Impact of humans on Earth. Sustainability.</td>
<td>differently?</td>
<td>technology improved / harmed our lives?</td>
<td>life expectancy is approaching 100 years?</td>
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<tr>
<td>~ 20%</td>
<td></td>
<td>How small is small?</td>
<td>Reducing consumption.</td>
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<td>How big is big?</td>
<td>Improving efficiency.</td>
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The numbers in the table represent the percentage of each category in the course content.
HUMANS & MACHINES

Humans did a pretty good job to evolve this far, but these were only the early stages and big changes are still ahead.

Influenced by:
- Alice Roberts: The Incredible Uniqueness of Being
- David Eagleman: The Brain
- Oliver James: They F*** You Up
- Yuval Noah Harari: Sapiens

Prior knowledge required:
- KS2 Science on the human body.
- Curiosity about how our bodies and minds work.
- Basic literacy and data analysis skills.

Educational purpose:
To broaden children’s minds about how our bodies work. To highlight recent advances in our understanding of our minds, of genetics, of disease and of health and diet.
To consider the unique range of influences that make you you, and me me!
To deepen understanding of the human condition, of our origins and our possible futures...

Building foundations for:
- Biology GCSE & A Level. Also Sport and PE.
- Future careers in the life sciences, medicine, psychology & the social sciences.
- Becoming a responsible and contributing member of human society.
DISCOVERY & IDEAS

Influenced by:

Prior knowledge required:
Awareness that Science is a way of finding out, not just a way of knowing...
Curiosity about the world around them.
Basic literacy and numeracy skills.

Educational purpose:
To highlight some of the most important scientific discoveries and ideas; and how they came about.
To emphasize how recent most of our scientific advances have been and the hugely influential impact science has had upon the rampant advances (and failings) of human civilisation.
To develop a sense of scale and perspective from inside an atom to the whole universe.

Building foundations for:
Biology, chemistry and physics GCSE & A levels.
Future careers in research or science education & media.
Developing a sense of purpose and place in the world.
Increased cultural capital.
Influenced by:

David Attenborough (Obvs) & Chris Packham
Who put humans into Room 101...

Prior knowledge required:
KS2 Science and Geography. Nature exploration and investigation.
Curiosity about the world around them. Some awareness of environmental issues. Basic literacy and numeracy skills.

Educational purpose:
To develop deeper understanding of the human influence on the Earth’s ecosystems and atmosphere. To highlight the interdependence of species in nature and the delicate balance of conditions that enable life on Earth.
To encourage greater respect for the natural environment and the riches it provides for humanity to thrive.
To promote sustainability in all aspects of our lives for the benefit of future generations.

Building foundations for:
Biology & chemistry GCSE & A levels.
Future careers in farming, minerals, refining, ecology, environmental protection. Also for political and economic leaders.
Being part of a more sustainable, global human society...
INDUSTRY & INVENTION

Influenced by:
My industrial science career “previous”

Prior knowledge required:
Awareness of the concept of a chemical substance.
Some awareness of the significance of the industrial revolution and the inventions which have changed our lives. Basic literacy and numeracy skills.

Educational purpose:
To understand how some key inventions have completely transformed society (the printing press, steam engine, electricity, internal combustion engine, photographic film, telecoms, computers, the internet).
To understand the origins and importance of the chemical industry from Mauve dye, via the Haber process and the modern chemical, food & pharma Industries.
An introduction to the concepts of chemical reactions, energy & forces.

Building foundations for:
Chemistry and physics GCSE & A levels.
Future careers in industry, chemistry, physics & engineering.
Developing greater awareness of the complex links between economics, consumerism and environmental impact.
HOME & THE BUILT ENVIRONMENT

Influenced by:

Prior knowledge required:
Some knowledge of electrical circuits, cooking and gardening. Basic literacy and numeracy skills.

Educational purpose:
To appreciate how Science infuses with our everyday lives; how advances in technology & medicine shape the way we live, design and use our homes.

To develop a deeper understanding of the science behind cooking, gardening, playing and sheltering.

To make links to energy consumption & materials from Earth & Sustainability to energy efficiency / electricity use in our homes.

Building foundations for:
Biology, chemistry and physics GCSE & A levels. Future careers in construction, electronics, digital technology, medicine, architecture & sustainable development. Also Economics / Politics. Becoming a more scientifically literate member of society.
INNOVATION & THE FUTURE

Influenced by:

Prior knowledge required:
Awareness of some topical issues in Science & Technology, and their advantages and disadvantages. Deep curiosity about the future, their possible futures and the challenges facing humanity & our planet.

Educational purpose:
To bridge the mental gap between romanticism for the past and fear of the future. To explore how technology frequently advances faster than culture can adapt to.
To explore the ethics, advantages and disadvantages of biotechnology (in medicine and farming). Greater awareness of food & pharma industries...
To understand the impact new materials and technologies have on our lives, and explore links between scientific innovation and economics.

Building foundations for:
Studying biology, chemistry, physics, computer science or engineering post 16. Future careers in biotech, infotech, materials science and digital technology. A society far more engaged with the ethical and philosophical aspects of rapid advances in science & technology.
Summary and Key Points

• Science is a multifarious beast of a collection of subjects
• There are many conflicting perspectives about the purpose of teaching Science at school
• The school science curriculum (KS2 – 5) is far too heavily wagged by an assessment and exam specification tail
• A quality, purposeful, meaningful and accessible science curriculum has been hindered by excessive focus on how to teach rather than what to teach
• Our top down approach to the science curriculum assumes a linear trajectory to science based academia for all...
• A bottom up approach would provide a platform for future scientific endeavour BUT ALSO create a broader, deeper, foundational knowledge base for ALL – to build a more scientifically literate society
• I propose maintaining a lot of current KS3 Science, but focusing & theming it to place the content in context for all
• Each term in Year 7 & 8 would be weighted approximately (in sequence) 60% core knowledge; 20% investigation & practical skills; 20% curriculum in context (culture, ethics, curiosity, stories & hinterland...)
Appendix / Extra slides / After thoughts / Epilogue

Post 14
Example (embryonic) Scheme of Work
The Knowledge Engine
  • Toolbox for Learning
  • Toolbox for Life
Post 14 (in @CREducATE Utopia)

• Bin 16+ public exams (replace with national standard exams in Maths, English & Citizenship – taken when ready between 14 & 18)

• Four 14 – 18 pathways for Science
  – Academic (Science specialist) – 9 hours per week
    • Theory & practical focus
  – Academic (Arts/English/Humanities specialist) – 6 hours per week
    • Theory focus
  – Vocational (Technology/engineering specialist) – 7 hours per week
    • Practical and scientific literacy focus
  – Vocational (scientific literacy only) – 3 hours per week
    • Scientific literacy focus only
### Science Scheme of Work 2019 - 2020

<table>
<thead>
<tr>
<th>Year group: 7</th>
<th>Term: Autumn</th>
<th>Theme (if applicable): across STEAM faculty – “Humans &amp; Machines” -</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Topic or Sub-topic</strong></td>
<td><strong>Approx. number of lessons</strong></td>
<td><strong>What will be covered? (Curriculum headlines including subject specific knowledge and/or skills)</strong></td>
</tr>
<tr>
<td>Learning intention(s)</td>
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<td>To include any key questions</td>
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<tr>
<td>Core knowledge</td>
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<tr>
<td>Investigation skills</td>
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<tr>
<td>Cultural Enrichment</td>
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<tr>
<td>Classroom expectations, targets &amp; assessment</td>
<td>0.2</td>
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<tr>
<td>New Curriculum Introduction</td>
<td>0.8</td>
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</tbody>
</table>

**Topic introduction: Humans**

<table>
<thead>
<tr>
<th>1</th>
<th>What is a human?</th>
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<tbody>
<tr>
<td></td>
<td>What makes me human?</td>
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<tr>
<td></td>
<td><strong>How do humans work?</strong></td>
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<td></td>
<td>How are humans and machines the same?</td>
</tr>
<tr>
<td></td>
<td>How are humans and machines different?</td>
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</tbody>
</table>

**Anthropology & Evolution**

<table>
<thead>
<tr>
<th>2</th>
<th>Where do humans come from?</th>
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<tbody>
<tr>
<td></td>
<td>How did we evolve?</td>
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<td></td>
<td>How are we similar to other animals; how are we different?</td>
</tr>
</tbody>
</table>

**Anatomy: Skeleton & Muscles**

<table>
<thead>
<tr>
<th>1</th>
<th>Main parts of the skeleton &amp; its 3 functions. Joints.</th>
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<tbody>
<tr>
<td></td>
<td>Muscles, ligaments and tendons &amp; cartilage.</td>
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<tr>
<td>Topic</td>
<td>Weeks</td>
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<td>--------------------------------------------</td>
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<tr>
<td>Anatomy: Internal organs</td>
<td>1</td>
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<tr>
<td>Physiology: The Respiratory System</td>
<td>2</td>
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<tr>
<td>Physiology: The Digestive system</td>
<td>1</td>
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<tr>
<td>Nutrition: Food &amp; Diet</td>
<td>3</td>
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<tr>
<td>The Big investigation: Energy in food</td>
<td>5</td>
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<tr>
<td>Healthy Living</td>
<td>2</td>
</tr>
<tr>
<td>Physiology: The Reproductive system</td>
<td>5</td>
</tr>
<tr>
<td>Termly core knowledge assessment</td>
<td>2</td>
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<tr>
<td>Genes &amp; Inheritance</td>
<td>2</td>
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<tr>
<td>Environmental variation</td>
<td>2</td>
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<tr>
<td>The Human Mind</td>
<td>3</td>
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<tr>
<td>Learning habits</td>
<td>Generic skills</td>
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<td><strong>Self-discipline [HD]</strong> (incorporating Focus, Concentration &amp; Reflection)</td>
<td><strong>Organisation &amp; Time management [SO]</strong> (preparation, punctuality, equipment, planning, project / report structure, work completed on time and in full)</td>
</tr>
<tr>
<td><strong>Perseverance [HP]</strong> (incorporating Courage, Resilience, Independence &amp; Risk-taking)</td>
<td><strong>Initiative [SI]</strong> (self-starting, independent, practical, “common sense”)</td>
</tr>
<tr>
<td><strong>Collaboration [HCo]</strong> (incorporating Listening, Communication, Tolerance, Empathy &amp; Adaptability)</td>
<td><strong>Communication [SC]</strong> (listening, summarising, describing, explaining, presenting, vocabulary &amp; language skills)</td>
</tr>
<tr>
<td><strong>Curiosity [HCu]</strong> (incorporating Open-mindedness &amp; Resourcefulness)</td>
<td><strong>Critical Thinking [SCri]</strong> (logical reasoning, methodical, analytical, problem solving, developing arguments, discursive, resourceful, researching, critiquing, scepticism)</td>
</tr>
<tr>
<td><strong>Imaginative [HI]</strong> (incorporating Originality, Idea generation, Intuition &amp; Making connections)</td>
<td><strong>Creative Thinking [SCre]</strong> (unorthodox, lateral thinking, divergent thinking, idea generation, making connections, links with imagination, originality and open-mindedness)</td>
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<tr>
<td><strong>Manual Dexterity [SM]</strong> (handwriting, art &amp; design techniques, musical instruments, sport including hand/eye co-ordination, cooking, electronics, gardening, woodwork, practical science)</td>
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</tbody>
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Teaching is the lubricant in the engine of knowledge

The Fuel to Learn

Learning inputs

The Skills for Performance

Skills outputs

A toolbox for learning

- Self-discipline
- Perseverance
- Collaboration
- Inquisitiveness
- Imagination

At school, to build the foundational
we first have engine from knowledge

A toolbox for life

- Manual dexterity
- Organisation & Time Management
  - Initiative
  - Communication
- Critical thinking
- Creative thinking