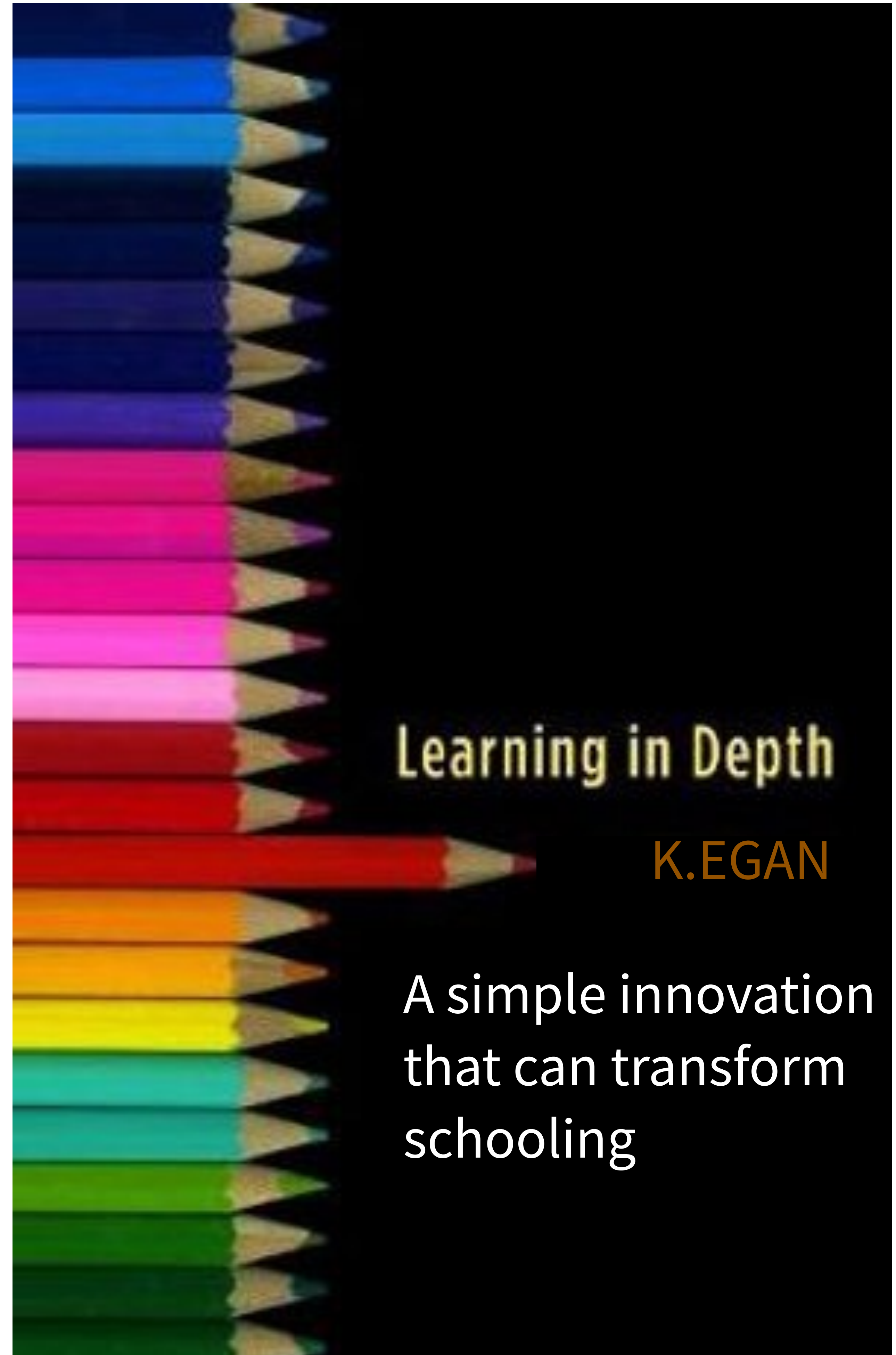
LEARNING IN DEPTH

MUSINGS ON KIERAN EGAN'S PROPOSAL

Baptiste Auguié
Victoria University of Wellington

Crayola colours 1903–today

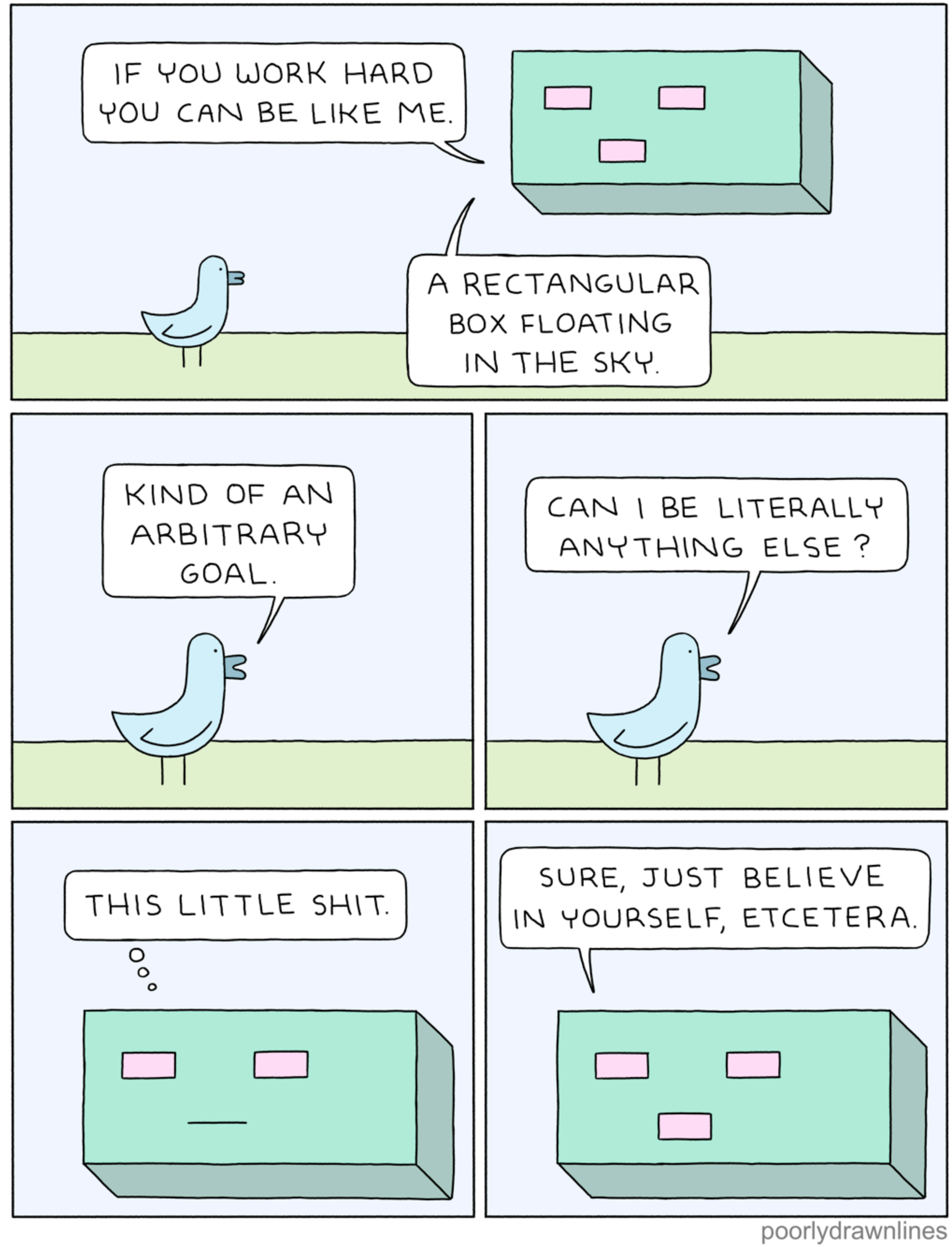


LEARNING IN DEPTH: KEY IDEAS

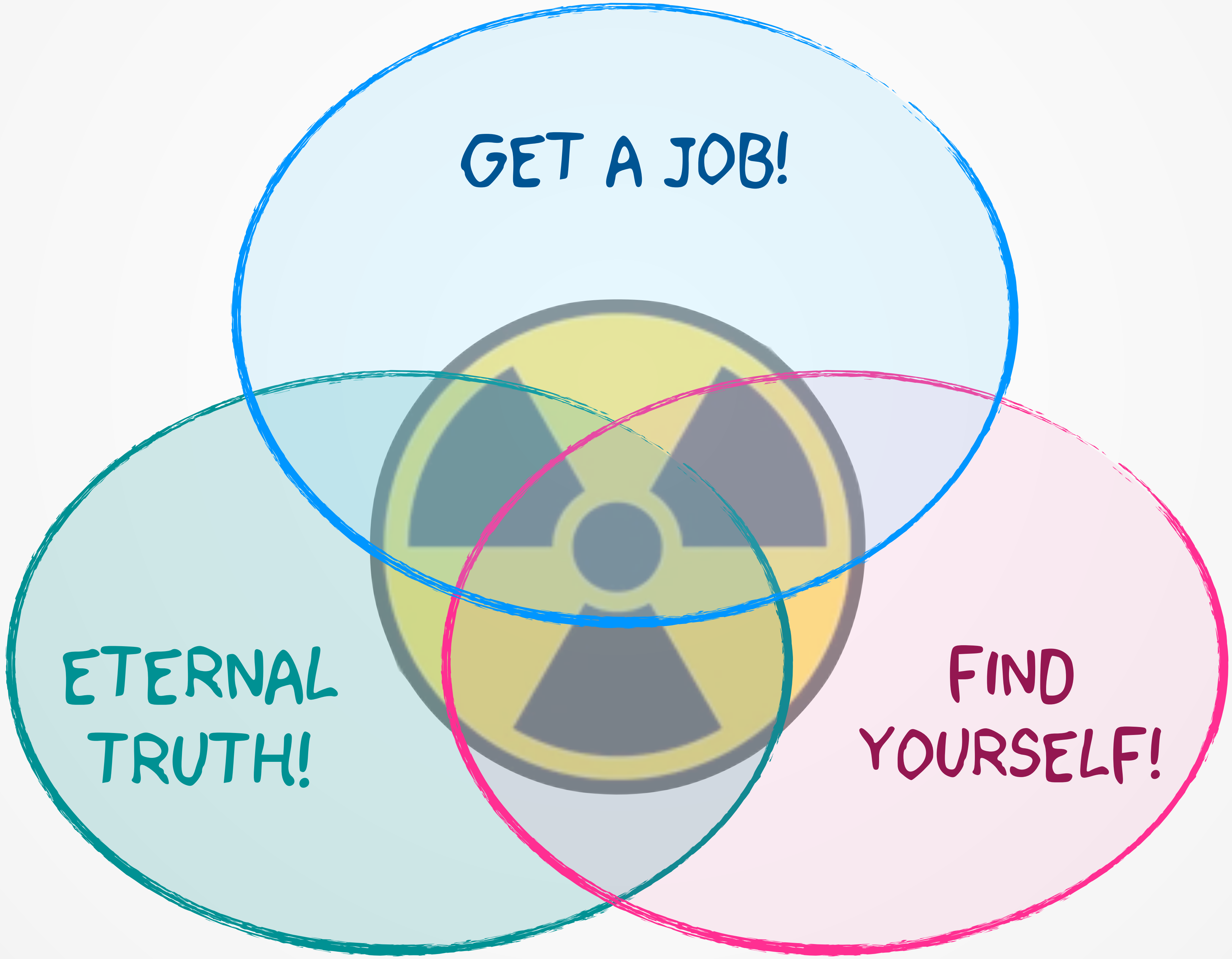
1. **non-graded** project
2. duration of **several years**
3. become an **expert in something**
4. **complement** standard curriculum
5. **fun, personal**
6. **holistic, pervasive, subversive**

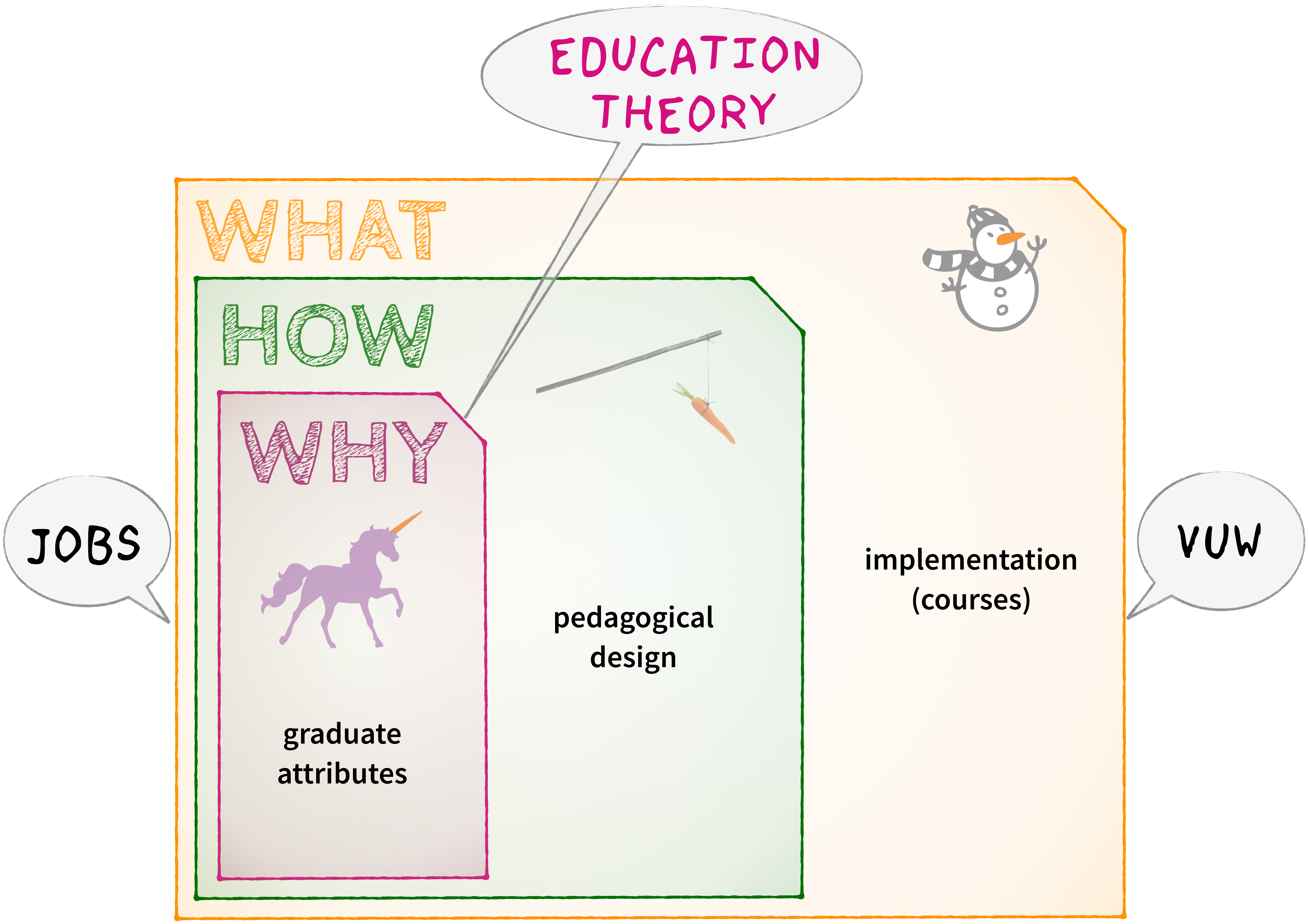
ACADEMIC DISCIPLINES
TEND TO PUT US
IN BOXES

■



THEORISING EDUCATION – VAIN DIAGRAM




EDUCATION THEORY
WHAT
HOW
WHY
JOBS
VUW
graduate attributes
pedagogical design
implementation (courses)

EDUCATION THEORY

KINDS OF UNDERSTANDING

Somatic
- somaesthetics
- arts, craft
- play, kinesthetics
- 3D awareness
- matauranga?

Mythic
- legends, stories, mysteries
- metaphors, mental images
- binary oppositions
- rythms and patterns
- jokes
- puzzles and problems

Romantic
- extremes of experience
- limits of reality
- transcendent qualities of things
- human emotions and intentions
- association with heroes
- collections and hobbies
- sense of wonder

Philosophic
- general principles and their anomalies (leading to refinements)
- patterns, logic
- ordering knowledge
- theoretic understanding
- authority and truth
- meta-narratives

Ironic
- recognising inadequacies of general schemes
- consider alternative worldviews
- reflexiveness

Academia
- physics, research
- technical staff

Government
- science policy
- transport, etc.
- data analytics

IT & software
- programming
- web technologies

Research
- measurement (MSL)
- high-tech
- climate
- environment
- aerospace
- geophysics
- energy
- medical
- agribusiness

Industry
- data science
- mathematical modelling
- patent examiner
- lab or field technician

Education
- science education
- school teacher
- journalism

WHAT

... do we do, concretely?

Specific content, organised in courses, units, topics, activities, etc.

HOW

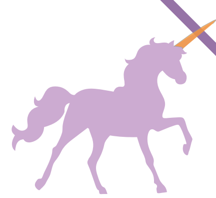
... do we foster these qualities?

What structures and environments encourage such learnings?
How do we choose and organise the content?

WHY

... do we teach Physics?

Foundations of the degree –
What is the objective of the training?
What qualities are pursued and nurtured during the programme?



adept learners
- robust work habits
- organisational skills, ability to cope with stress and rise to challenges
- critical thinking
- inquisitive mind, independent thinking
- trained imaginative intellectual activity, creativity

scholars of rich knowledge
- mastery of core physical concepts
- applying abstract ideas all the way through to quantitative answers
- broad, high-level scientific literacy
- familiarity with the scientific ecosystem

communicators
- can navigate abstract theories & relate them to the real world
- get to the essence of an argument or problem
- technical, quantitative, structured reporting
- synthesise complex issues with quantitative arguments

engaged scientists
- sense of purpose
- equity issues in science, deontology
- ethics and impact of science in broader society
- awareness of the broader & international scientific ecosystem

integration of concepts
- structure: from basic laws to applications
- core components (EM, QM, etc.) introduced at multiple levels
- gradual layers of abstraction

research-inspired teaching
- MacDiarmid Institute, nanotechnologies
- Projects in: spintronics, superconductivity • Optical spectroscopy • NMR • geophysics • astrophysics

in-depth studies
- Freedom to fail • Curiosity-first • Active learning • "Learning-in-depth"

interconnections
- wave propagation
- materials science, properties
- analogies, e.g. Laplace's equation

dedicated toolset
- mathematics
- programming
- scientific computing environment & good practice

practice
- instrumentation, data acquisition
- temperature, vacuum, optics, electronics, probes, etc.

visual explorations
- 3D spatial awareness & intuition
- direct interaction with models & systems

team-work
- group work, discussions
- demonstrating
- teaching

communication
- regular practice & gradual build-up of skills
- group activities, peer feedback and encouragement
- guest lectures, seminars, outreach activities

multiple assessement strategies
- self- and peer-assessment • personalised test units & granular feedback

ethics
- Raise awareness & highlight examples with regards to: scientific integrity • moral issues • te tiriti o waitangi

core topics

Mechanics
Newton's laws • Lagrangian & Hamiltonian formalisms • fluid dynamics • Relativity (Special & intro to General)

Thermodynamics
Work • heat • entropy • 4 laws • kinetic theory • statistics •

Quantum
Postulates • Schrodinger's equation • Dirac notation • spin • superposition, complementarity • entanglement • perturbation theory

Electromagnetism
Maxwell's equations • circuits • EM waves • optics • photonics

applied topics

Solid state & materials science
Properties of semi-conductors • spectroscopy • magnetism • applications in devices

Astrophysics
Solar system • Earth • ??

Geophysics
?? • ??

experiments

instrumentation • experiment design • data acquisition • electronics • vacuum • low temperatures • optics • magnetic fields

mathematics

vector calculus • algebra, vector spaces • differential equations • Fourier analysis

data science

statistics • reproducibility, replicability • design of experiments

programming
- high-level numerical programming •
- numerical models
- specialised software, e.g. FEM
- symbolic solver
- interactives (mathematica / Pluto.jl / Shiny) – available to students

computing environment

shell • computing cluster • version control

soft skills

scientific writing • bibliography • graphics & data presentation • oral presentation

ethics

?? cf DATA 101, PHIL 269, but also scientific integrity
https://www.sciencelearn.org.nz/resources/2150-teaching-ethics
http://calteches.library.caltech.edu/51/2/CargoCult.htm

broader engagement

science of climate change • structure of the science ecosystem • outreach activities • internships (MSL, GNS, etc.)

- other unis
- science in society
- data science
- applied maths
- physical chemistry
- biophysics
- geophysics
- engineering
- architecture

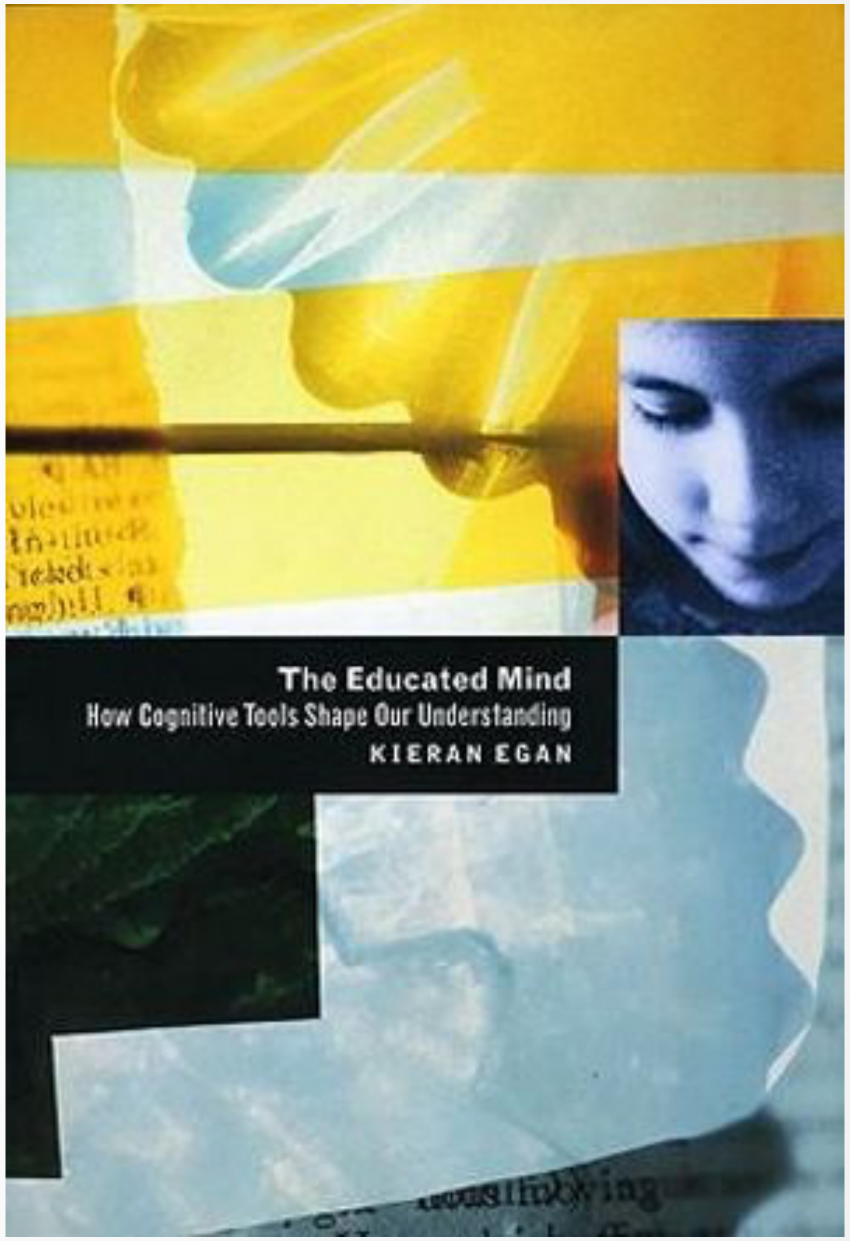
UNDERPINNING: *THE EDUCATED MIND*

Theories of education:

1. Socialisation – *Utility*
2. Plato – *Truth*
3. Rousseau – *Nature*

Incompatible goals!

Focus on **kinds of understanding**



SOMATIC → MYTHIC → ROMANTIC → PHILOSOPHIC → IRONIC

UNDERPINNING: THE EDUCATED MIND

SOMATIC
body experience • somaesthetics • arts, craft •
play, kinesthetics • **3D awareness** • matauranga?

MYTHIC
legends, stories, mysteries • metaphors, mental images
binary oppositions • rythms and patterns
jokes • puzzles and problems

ROMANTIC
extremes of experience • **limits of reality** • transcendent
qualities of things • **human emotions** and intentions •
collections and hobbies • **sense of wonder** • **heroes**

PHILOSOPHIC
general principles and their anomalies (leading to refinements)
patterns, logic • **ordering knowledge** • theoretic understanding
authority and truth • meta-narratives

IRONIC
recognising inadequacies of general schemes •
consider **alternative worldviews** • **reflexiveness**

MOTIVATION FOR LEARNING IN DEPTH

- **material to think about**
  while developing an array of cognitive tools
- **knowledge about knowledge**
  what it means to become an expert in something
- **illuminates the rest**

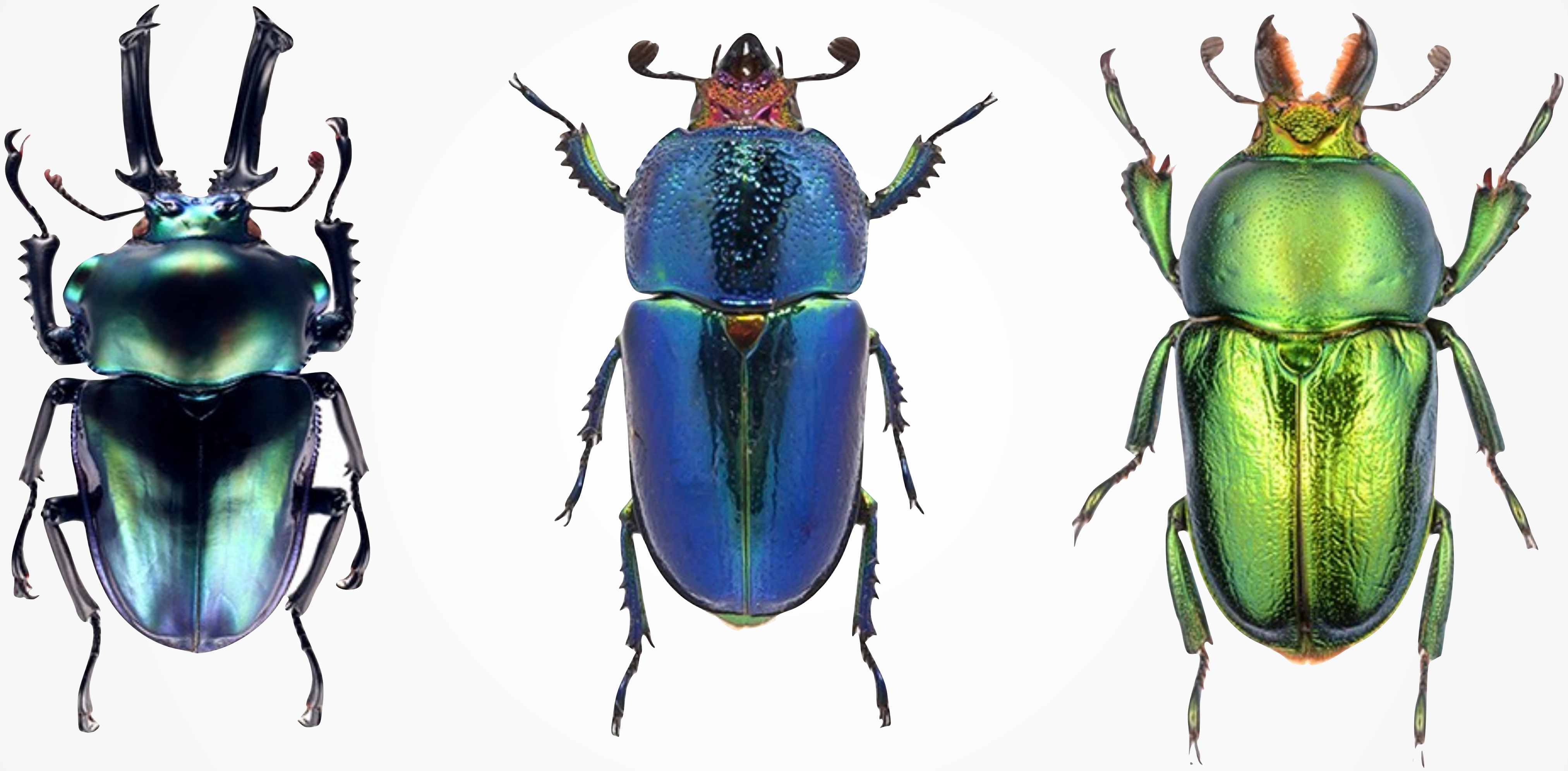
“

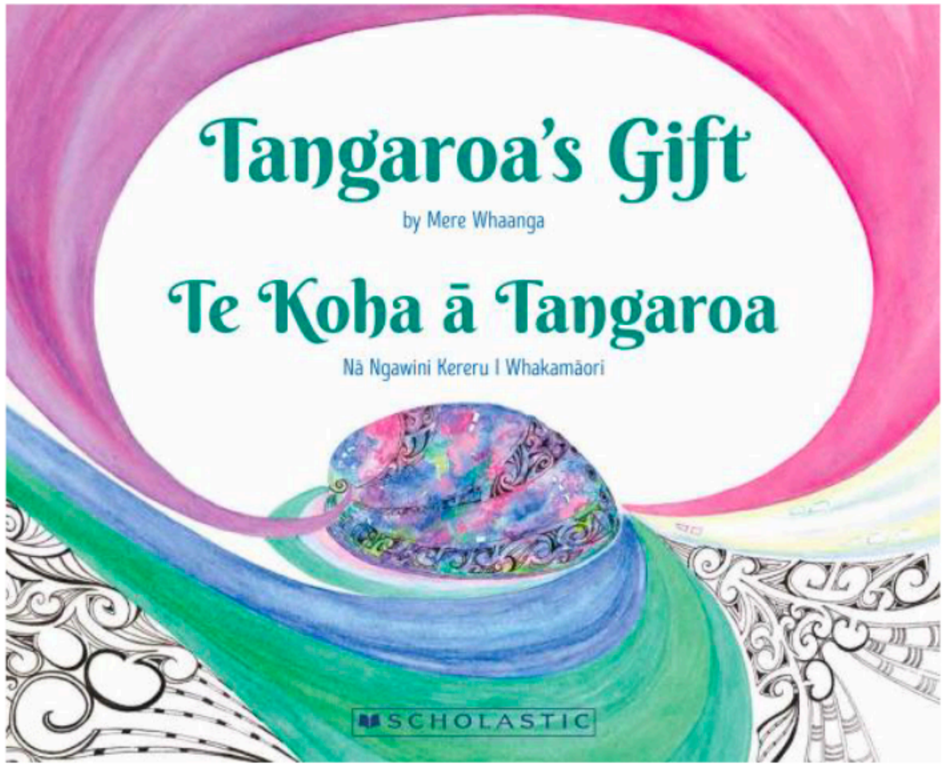
To develop a complete mind
study the science of art,
study the art of science.

Develop your senses, learn how to see.
Understand that everything is connected.

Leonardo da Vinci

高行健





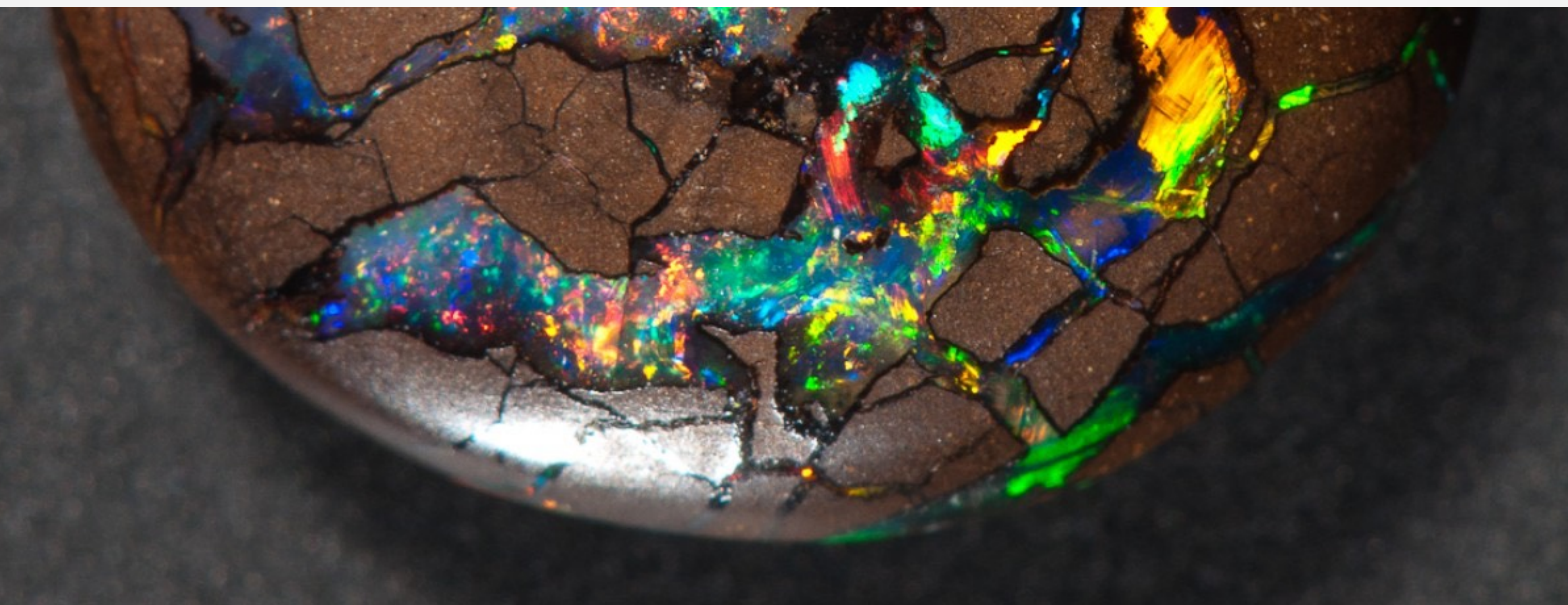
Tangaroa's Gift

by Mere Whaanga

Te Koha ā Tangaroa

Nā Ngawini Kereru I Whakamāori

The story of how Paua came to have his colours.



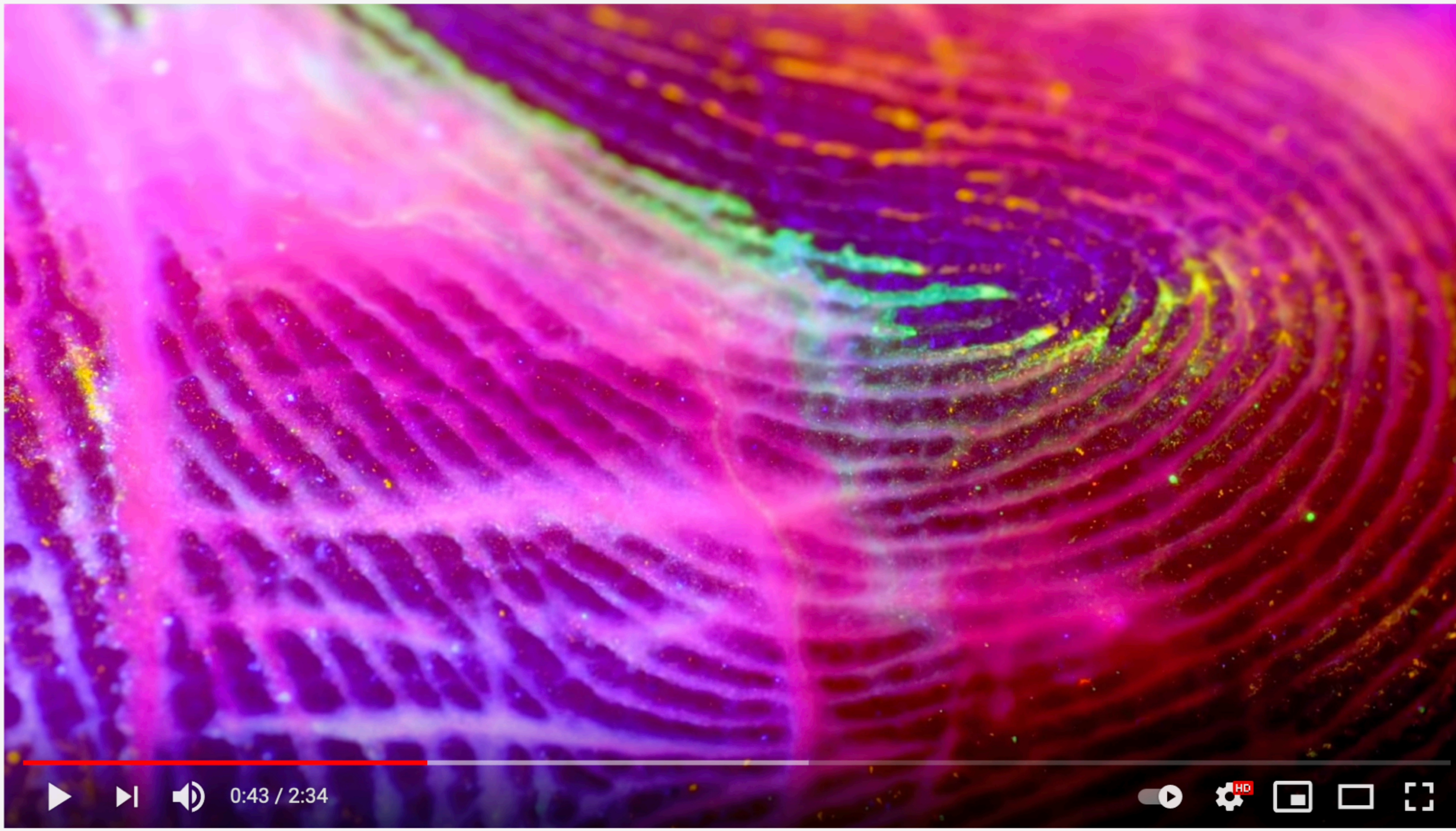
Avatar (series)

Ig-Nobel prize 2000
levitating frog

Avatar (movie)

glowing blue bike lane
instytut badan
technicznych
Poland

NEXT-GENERATION TATTOO ARTIST?



Over Your Skin (2017)

LEARNING IN DEPTH

Opportunity to explore something on all levels, more holistically, and make it personal

Think of *hobbies* (*at any age*):

- **freedom to play**, no-one forces you
- **permeates your thinking**, deep connections
- **gets your full attention**, curiosity, excitement

“

It is useful to remember that there is no knowledge in a library.
Knowledge exists only in living human tissue, in our brains.

Kieran Egan

SUPPLEMENTARY SLIDES

Baptiste Auguié

learning in depth: musings

THE PROPOSAL

1. Students will be randomly assigned a particular topic to learn about through their whole school career, in addition to the usual curriculum
2. Regular guidance, suggestions, to build a personal "portfolio"
3. End-result: immensely knowledgeable *about something* (and about the nature of knowledge)
4. Important ceremony at the start – an unusual lifelong relationship

FAQ / FO

1. Students will soon become bored with their topics.
2. The arbitrariness is absurd. Student choice is important to such a scheme.
3. The students will drop out or revolt against it.
4. It would be too complicated to organize.
5. There’s no adequate research basis for the proposal.
6. This proposal won’t deliver what it claims.
7. The Internet will undermine this project.

Why Depth?

1. Expertise and Learning How Knowledge Works
2. The Pleasure of Learning
3. Stimulating the Imagination
4. Projects and Their Focus
5. Deep Learning and the Sense of Self
6. Learning in Depth and Humility
7. Oral and Literate Cultures' Knowledge

SUITABLE TOPICS? (CH. 4)

	BREADTH	DEPTH	PARTICIPATION
DUST	✔	✔	✘
APPLES	✔	✔	✔
WHEEL	✔✘	✘	✔
MOLLUSKS	✔	✔	✔
LEAVES	✔	✔	✔
SHIPS	✔	✔	✔

DISCUSSION: UNIVERSITY ENVIRONMENT

1. SHORTER TIMESCALE
2. DIFFERENT AGE RANGE
3. INSTITUTIONAL CONSTRAINTS