



Should we be more creative when teaching science?

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Overview

How we learn

Traditional way science is taught

Drivers for change

Ways of embedding creativity within the curriculum

Challenges

Should we redesign the curriculum to provide students with more time and space to be creative?

“The great engine of academic creativity is intellectual curiosity - the desire to find out, understand, explain, prove or disprove something or simply to imagine something different”

Jackson et al, 2006



<http://naturalstart.org/>



<https://performanceandlearning.ca>

Sugata Mitra, 2016



Tom Woodward @ bionic teaching



<http://www.mountainhome.af.mil/>

Sugata Mitra, 2016

“Schools teach how to answer, not to question”

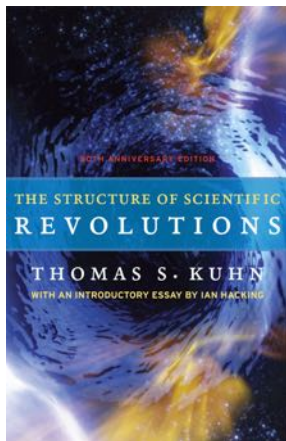
Csikszentmihali, 2006



<https://www.scienceabc.com/>

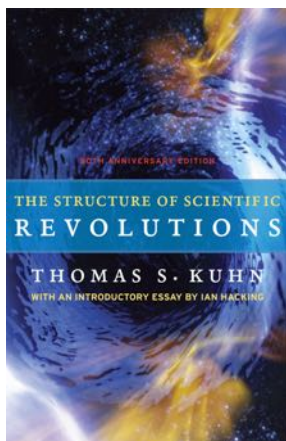
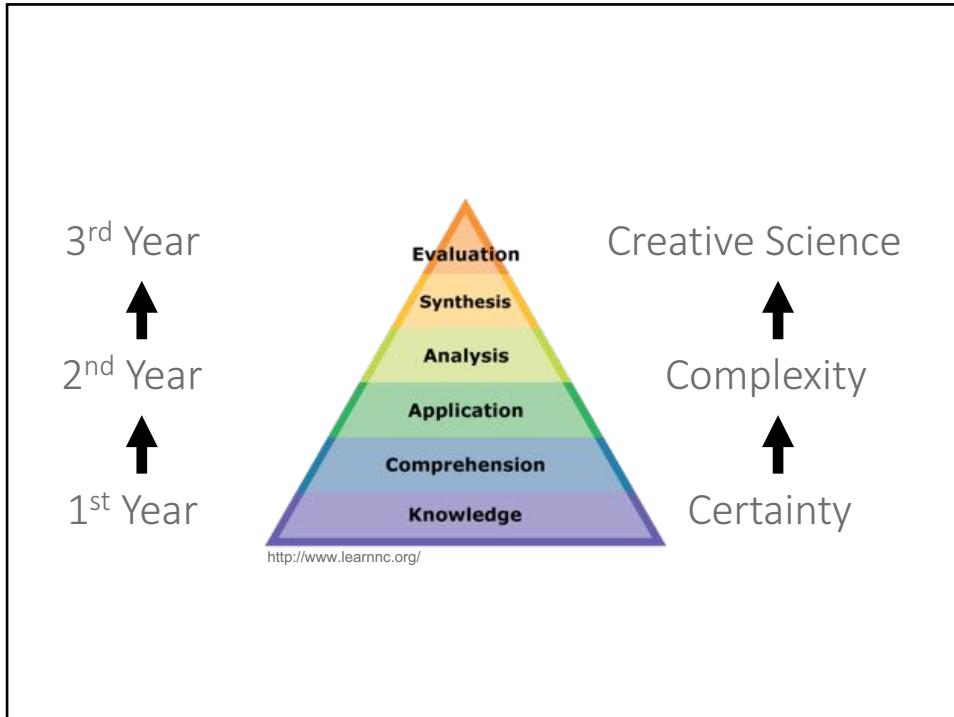
In the early stage of science education we unconsciously discourage students from questioning by indoctrinate them with facts and certainty

Jenny Waller, 2016



“For students of particular disciplines, the invisible, taken-for-granted nature of paradigms has obvious functional advantages since it means they can work within their chosen field without wasting time attempting to redefine or defect the 'hypothetical rules of the game'.”

Kuhn, 1974



“Until the very last stages in the education of a scientist, textbooks are systematically substituted for the creative scientific literature that made them possible”

Kuhn, 1974

“Creativity is inhibited by predictive outcome-based course designs, which sets out what students will be expected to have learned with no room for unanticipated or student-determined outcomes”

Jackson, 2006



<https://www.scienceabc.com/>

“There is a general disengagement from science through tedium”

Brooks, 2011

We have been teaching science this way for centuries so why should we change this approach now?



<https://jamesaltucher.com/>



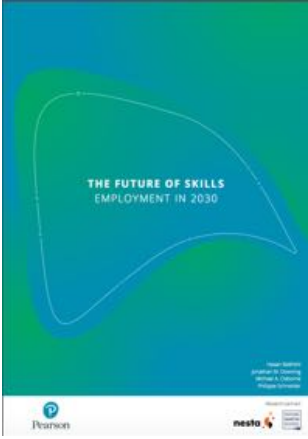
<https://media.linkedin.com/>



<http://www.tomdoctoroff.com/>


“social and creative skills; decision-making under pressure and the development of novel ideas”

*Klaus Schwab
World Economic Forum*



Judgement and Decision Making
Fluency of ideas
Active learning
Systems evaluation
Originality
Learning Strategies
Deductive reasoning
Complex problem solving
Systems analysis
Monitoring

<https://www.nesta.org.uk/publications/future-skills-employment-2030>

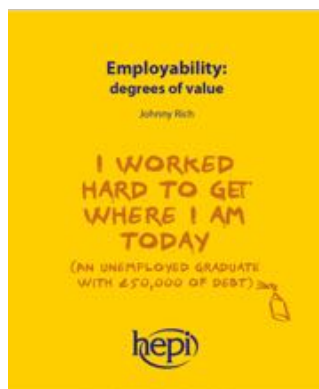


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<https://www.nesta.org.uk/publications/future-skills-employment-2030>



“Interdisciplinary view - original thinkers and problem solvers”



<http://www.hepi.ac.uk/wp-content/uploads/2015/12/Employability-Degrees-of-value.pdf>

‘Soft Skills’

Initiative	Resourcefulness
Communication	Mathematical Skills
IT Skills	Teamwork
Organisation Skills	Enterprise
Creativity	Lifelong Learning



**Employability:
degrees of value**
Johnny Rich

**I WORKED
HARD TO GET
WHERE I AM
TODAY**
(AN UNEMPLOYED GRADUATE
WITH £50,000 OF DEBT)

hepi

<http://www.hepi.ac.uk/wp-content/uploads/2015/12/Employability-Degrees-of-value.pdf>

'Soft Skills'

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Can we learn from the way
design based art disciplines are
taught?

Principles of practice based arts teaching

Teach method, not content

Principles of practice based arts teaching

Encourages exploration and
experimentation

Principles of practice based arts teaching

Provides a safe space to fail

Principles of practice based arts teaching

Assessments focused on
process not outcome

Principles of practice based arts teaching

Educators are tutors; role is as a facilitator rather than teacher

Can we adopt similar approaches within the sciences?

Traditional Practical Session



Barnett, 2014

Reagents supplied

2 mM disodium p-nitrophenyl phosphate (substrate)
 Diluted wheat germ extract (enzyme extract)
 1.0 M sodium hydroxide
 Citrate buffer, pH 5
 0.9 mM sodium molybdate (inhibitor)

Information: To obtain the enzyme extract the following extraction was carried out for you. 5 g of wheat germ were weighed out and suspended in 100 mL of distilled water. After stirring the mixture for 20 minutes the suspension was centrifuged at 2000 g for 10 minutes at 40 °C. The supernatant was decanted and diluted to 1/10 with distilled water.

Procedure

1. First prepare a 10 mL volume of 0.3 mM disodium p-nitrophenyl phosphate (substrate) using the 2 mM disodium p-nitrophenyl phosphate (substrate) that has been provided.
 2. Clearly label a series of twenty-two test tubes. Next add each of the solutions as detailed in the following tables
NOTE: For tubes 2-9 and 11-20 use the 0.3 mM substrate but for tubes 10 and 11 and tubes 21 and 22 use the 2 mM substrate

Tube no.	1	2	3	4	5	6	7	8	9	10	11
Substrate (mL)	0	0.06	0.12	0.24	0.36	0.48	0.66	0.9	1.2	0.6*	1.2*
Water (mL)	1.4	1.34	1.28	1.16	1.04	0.92	0.74	0.5	0.2	0.8	0.2
Buffer (mL)	1	1	1	1	1	1	1	1	1	1	1

* Use 2 mM substrate solution.

Tube no.	12	13	14	15	16	17	18	19	20	21	22
Substrate (mL)	0	0.06	0.12	0.24	0.36	0.48	0.66	0.9	1.2	0.6*	1.2*
Water (mL)	1.3	1.24	1.18	1.06	0.94	0.82	0.64	0.4	0.1	0.7	0.1
Buffer (mL)	1	1	1	1	1	1	1	1	1	1	1
Sodium molybdate (mL)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

* Use 2 mM substrate solution.

Traditional Lab Skills Development

Initiative

Resourcefulness

Communication

Mathematical Skills

IT Skills

Teamwork

Organisation Skills

Enterprise

Creativity

Lifelong Learning

Design Based Practical



<https://www.youtube.com/watch?v=BqSfpOuDsIY>

Each group provided with:

10 ml 3% Hydrogen Peroxide Solution
10 ml 1% Potassium Iodide Solution
5 ml 50 mM Ascorbic Acid
5 ml Starch Water
Distilled Water

20 Test Tubes

A Stopwatch

A P1000 Micropipette and blue tips

A P200 Micropipette and yellow tips

Graph Paper

S.Thompson, J. Vernon & J. Murray (University of Westminster)

Recall, Adapt & Apply



Alison Sinclair

<http://tinyurl.com/hlkp3wt>



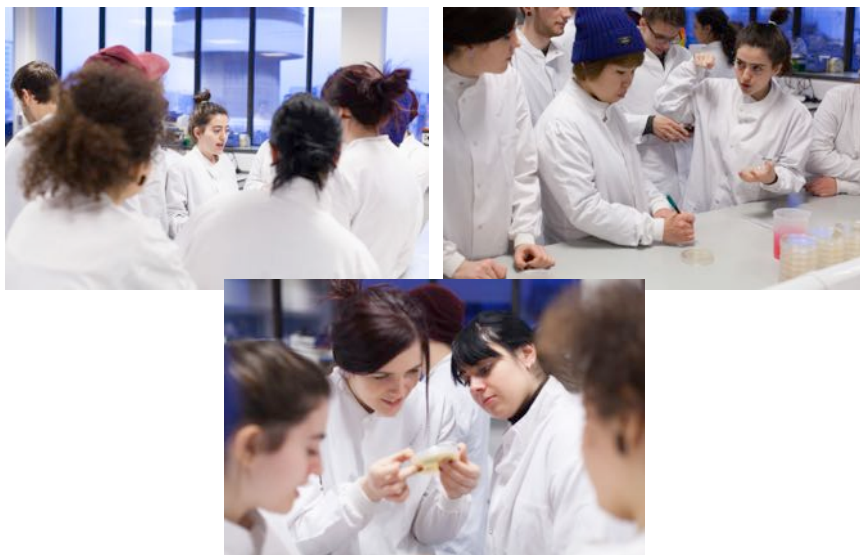
“Provide all equipment and reagents - but limited instruction so they need to recall prior knowledge & experience”

Design Based Practical

Initiative	Resourcefulness
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Creativity	Lifelong Learning

What happens if you allow students become teachers?

Broad Vision
Art/ Science Research & Learning
at the University of Westminster



Broad Vision
Art/ Science Research & Learning
at the University of Westminster

“It’s really valuable to have the opportunity to try and teach others what you have been taught, helps to condense and revise”

Student Quote



School Outreach Activities



STEM Festival



Explain Everything

Adobe Voice

YouTube

BOOK CREATOR

Pinterest

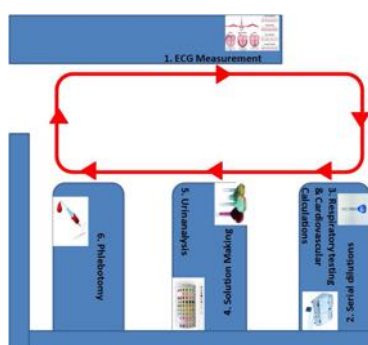
Students as teachers

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Can we rethink the way we assess skills?

Objective Structured Practical Examination (OSPE)

Based on approach commonly used in medical and pharmacy education



ECG Measurement
Serial Dilutions
Respiratory Testing
(calculations)
Solution making
Urine analysis
Phlebotomy



Student Observable Behaviors

Learning Design

Practical problem-led holistic workshops
Challenges, mini-projects and case studies

Self-paced

Students dictate pace and order of which learning outcomes are demonstrated
SOB Online tool

Assessment

Competency based (Pass/Fail)
Stretch and Challenge
(Threshold, Typical or Excellent)
Assessed Labs, group sessions, presentations or one-to-one tutorials

What happens if you give students the choice to learn through creativity?



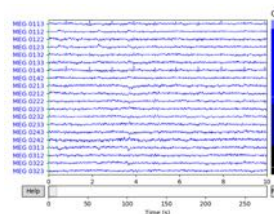
Mark Feltham



Research Methods Module

Students can chose traditional lectures or a 'creative' alternative

THINK MAKE LEARN SHARE





Mark Feltham



Research Methods Module

Students can chose traditional lectures or a 'creative' alternative

THINK MAKE LEARN SHARE

Ambitious when given their freedom

Take ownership of the learning process

Willing to take risks and try things out

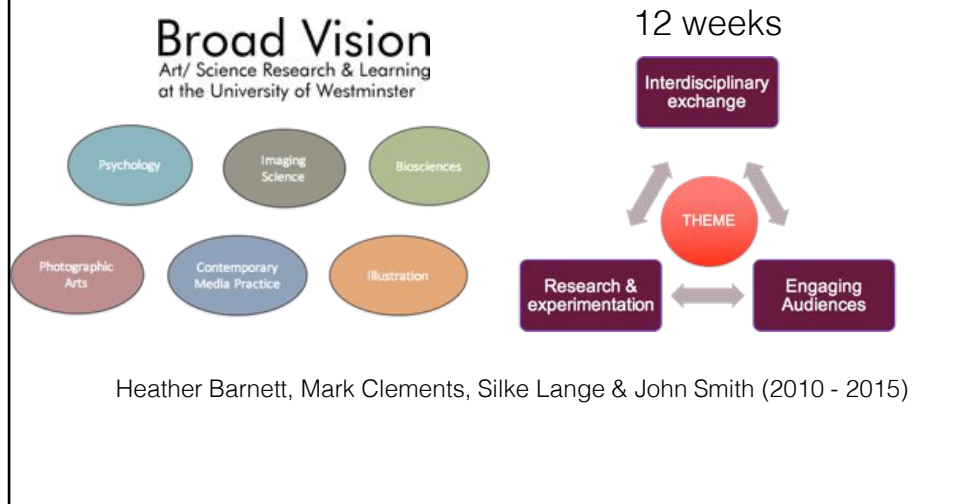
Learning through the doing - learning from their mistakes

Motivated by being able to share what they had created

[Mark Feltham on Who-topia](#)

What happens you allow students to collaborate across disciplines?

Interdisciplinary Art/Science Module



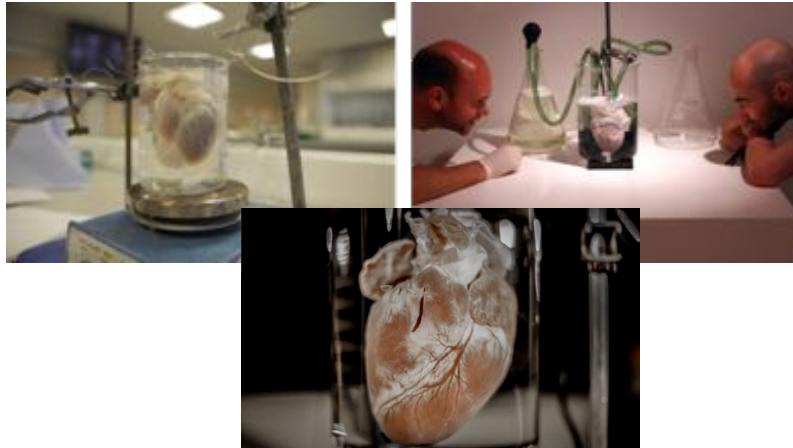
Broad Vision

Art/ Science Research & Learning
at the University of Westminster



*Mell Fisher, Kitti
Edwards & Freddie
Bell*

Broad Vision
 Art/ Science Research & Learning
 at the University of Westminster



Judd Welland, Malgorzata Stasiewicz & JJ Hastings

Idea Translation Lab



Dublin



Trinity
 College
 Dublin

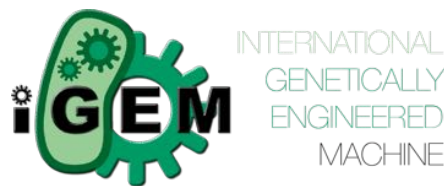
The University of Dublin

2015 - Future Farm	1 theme
2014 - Strange Weather	12 weeks
2013 - Synthetic Biology	1 lecture + 1 'lab' per week
2012 - Hack the City	A final pitch
2011 - The Future of Water	Public output - cultural/social/scientific value

Emergent Team Projects


Initiative	Resourcefulness
Communication	Mathematical Skills
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Extracurricular team competitions



LEARN.BUILD.SHARE.
WITH THE OFFICIAL STUDENT HACKATHON LEAGUE





INTERNATIONAL
GENETICALLY
ENGINEERED
MACHINE

International competition

8 weeks

**Open community for synthetic biology
collaboration**

Fundraising and Sponsorship

Public engagement

<http://2015.igem.org/Team:Westminster>



Extracurricular Team Projects

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Olin College
of Engineering

iFOUNDRY
ILLINOIS
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

New model for
engineering education

Curriculum built around
designed based projects

Should we redesign the
science curriculum to
provide students with
more time and space to
be creative?



“You need time and space in your mind to be creative and if your mind is full of studying this that and the other then there's no space for it”

Student quote in Jackson, 2006

Getting the balance right



Challenges

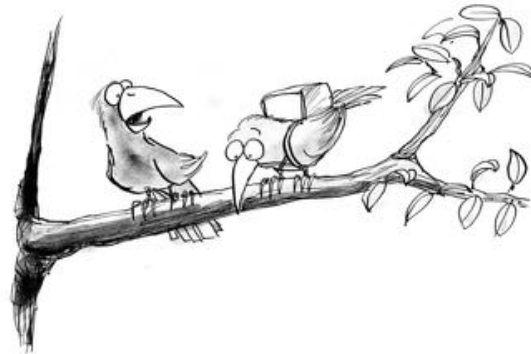
Setting Expectations



Teamwork & Project Management



Creating a safe space to fail



“Let’s try it without the parachute.”

<http://nelsoncolumn.co/>

Assessment

**Research
Journal**

**Critical
Evaluation**

Focus on process not output

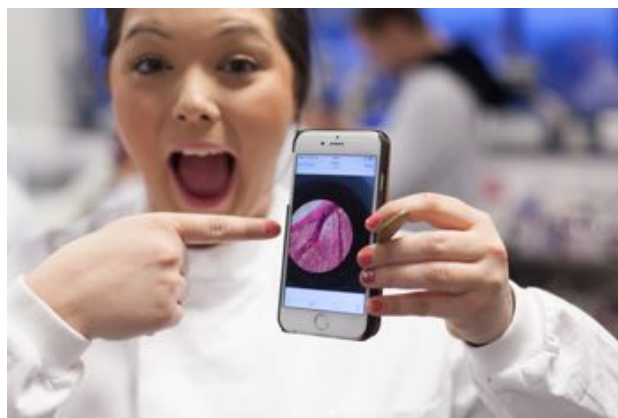
Summary

Traditional teaching approaches often provide limited opportunities for creativity

Redesign of the curriculum can reawaken curiosity and tap into intrinsic motivation to learn

Expand opportunities for original thinking and problem-solving

Requires time and space in the curriculum as well as a safe environment to fail



Melissa Fisher, 2015

