An ARC funded Special Research Initiative
OUR GOALS

**UNDERSTAND** the neural mechanisms that underpin learning and develop robust methods to

**MEASURE** outcomes in order to identify and develop evidence-based strategies that

**PROMOTE** learning

Use cross-disciplinary **COLLABORATIONS** between neuroscience, education, cognitive psychology and practising teachers to accelerate research outcomes in learning

**DEVELOP**

1. tools and strategies that promote learning in formal and informal settings, and resources for educating students and teachers about how the brain learns

2. future researchers and teachers with an understanding of neuroscience, psychology and education who will continue to scrutinise and develop new learning strategies in a constantly evolving environment

**TRANSLATE** research outcomes into the classroom by incorporating new knowledge into pre-service teacher training and professional development programs
In situ

- remote
- Indigenous
- public schools
- adult
- early years
- private schools
- physiological monitoring
- social monitoring
- video

Educational Neuroscience Classroom
- physiological monitoring
- eye-tracking
- EEG
- fMRI
- resting state
- MRI

Learning Interaction Classroom
- video and audio
- interview rooms
- molecular
- animal models
- cellular
- electrophysiology

Imaging
- Laboratory
The Brain in the Classroom?
An introduction to educational neuroscience

Gregory M. Donoghue
Jared C. Horvath
Stephanie McMahon
Science of Learning Research Centre

27th June, 2016
Our learning objectives

An introduction to Neuroscience

An introduction to the Science of Learning

Classroom Applications
Three themes

Your purpose in teaching
Three themes

Your purpose in teaching

Translation of neuroscience to education
Three themes

Your purpose in teaching

Translation of neuroscience to education

Spotting the learning & teaching strategies
So exactly what is learning?

A behavioural psychologist:

“The relatively permanent change in behaviour brought about as a result of experience or practice.”

(Mayer 2008)
So exactly what is learning?

A cognitive psychologist:

“the process by which a relatively stable modification in stimulus-response relation is developed as a consequence of functional environmental interaction via the senses.”

(Sheldon 1996)
So exactly what is learning?

An educator:

“A process whereby knowledge is created through the transformation of experience.”

(Kolb 1984)
And what happens during learning?

A neuroscientist:

“When an axon of cell A is near enough to excite a cell B and repeatedly or persistently takes part in firing it, some growth process or metabolic change takes place in one or both cells such that A's efficiency, as one of the cells firing B, is increased.”

(Hebb 1961)
Neuroscience Essentials
The CELL
The PRIMITIVE NEURON
The NEURON
The DENDRITE and the AXON
The SYNAPSE: neuron-neuron
The SYNAPSE: neuron-muscle
The PERSON

SENSEORY INPUTS

COGNITION

BEHAVIOURAL OUTPUTS
The POPULATION
Triune Brain Theory

<table>
<thead>
<tr>
<th>Lizard Brain</th>
<th>Mammal Brain</th>
<th>Human Brain</th>
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<tbody>
<tr>
<td>Brain stem &amp; cerebelum</td>
<td>Limbic System</td>
<td>Neocortex</td>
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</table>

The Triune Brain in Evolution, Paul MacLean, 1960
Neuroeducation Quiz

Please rate how this neuroscience knowledge will change the way you teach in your classroom?

(a) A lot
(b) Some
(c) A little
(d) None
(e) Don’t know
Translating Learning Science

World’s best neuroscientists working on learning
Translating Learning Science

World’s best neuroscientists working on learning

And yet
Translating Learning Science

World’s best neuroscientists working on learning

And yet

Neuromyths still abound
Translating Learning Science

World’s best neuroscientists working on learning

And yet

Neuromyths still abound

Ineffective teaching practices still in use
Translating Learning Science

World’s best neuroscientists working on learning ✅

And yet ✗

Neuromyths still abound ✗

Ineffective teaching practices still in use ✗

Proven practices not being used ✗
Translating Learning Science

Why?
### An Abstracted Learning Framework

<table>
<thead>
<tr>
<th>Layer No.</th>
<th>Developmental Phase</th>
<th>Layer Name</th>
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Drink bottles in the classroom?

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Three Themes

1. Translation – brain to classroom

2. Primary Purpose

3. Spot the Learning & Teaching strategy
The Scientific Method

1. Make some assumptions
The Scientific Method

1. Make some assumptions
2. Make some observations
The Scientific Method

1. Make some assumptions
2. Makes some observations
3. Develop a theory or hypothesis
The Scientific Method

1. Make some assumptions
2. Makes some observations
3. Develop a theory or hypothesis
4. Make some predictions
The Scientific Method

1. Make some assumptions
2. Make some observations
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4. Make some predictions
5. Do an experiment
The Scientific Method

1. Make some assumptions
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5. Do an experiment
6. Take some measurements
The Scientific Method

1. Make some assumptions
2. Make some observations
3. Develop a theory or hypothesis
4. Make some predictions
5. Do an experiment
6. Take some measurements
7. Question your assumptions and hypotheses.
The Scientific Method

1. Make some assumptions
2. Make some observations
3. Develop a theory or hypothesis
4. Make some predictions
5. Do an experiment
6. Take some measurements
7. Question your assumptions and hypotheses
And in the classroom . . .

1. Decide what you want to get
And more practically . . .

1. Decide what you want to get
2. Decide what you will do to get it
And more practically . . .

1. Decide what you want to get,
2. Decide what you will do to get it
3. Measure it before you do anything
And more practically . . .

1. Decide what you want to get,
2. Decide what you will do to get it
3. Measure it before you do anything
4. Do something
1. Decide what you want to get,
2. Decide what you will do to get it
3. Measure it before you do anything
4. Do something
5. Measure it after you’ve done something

And more practically . . .
And more practically . . .

1. Decide what you want to achieve
2. Decide what you will do to get it
3. Measure it before you do anything
4. Do something
5. Measure it after you’ve done something
6. Do more of what worked & less of what didn’t
And more practically . . .

1. Decide what you want to achieve
2. Decide what you will do to get it
3. Measure it before you do anything
4. Do something
5. Measure it after you’ve done something
6. Do more of what worked & less of what didn’t
7. Say “Duh!” (Peterson, C. 2006)
An example of good science: Hattie’s effect sizes

Class average before teaching (e.g. 45%)
An example of good science: Hattie’s effect sizes

Class average before teaching (e.g. 45%)

Class average after teaching (e.g. 90%)
An example of good science: Hattie’s effect sizes

Class average before teaching (e.g. 45%)

Class average after teaching (e.g. 90%)

Effect (of your teaching) (e.g. 100% improvement)
An example of good science: Hattie’s effect sizes

The measurement of effect sizes (simple version)

• Class average before teaching (e.g. 45%)

• Class average after teaching (e.g. 90%)

• Effect (of your teaching) (e.g. 100% improvement)
An example of good science: Hattie’s effect sizes

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An example of good science: Hattie’s effect sizes

The measurement of effect (*Cohens’ d*)

\[
\text{Effect size} = \frac{\text{Average}_{\text{after}} - \text{Average}_{\text{before}}}{\text{SD}_{\text{before}}}
\]
An example of good science: Hattie’s effect sizes

The measurement of effect (Cohen’s $d$)

$$\text{Effect size} = \text{Average}_{\text{after}} - \text{before}$$
An example of good science: Hattie’s effect sizes

The measurement of effect (\textit{Cohen’s d})

\[
\text{Effect size} = \frac{\text{Average}_{\text{after}}}{\text{Average}_{\text{before}}} - 1
\]
An example of good science: Hattie’s effect sizes

The measurement of effect ($Cohens’ \ d$)

Effect size = \[
\frac{\text{Average}_{\text{after}} \ minus \ \text{Average}_{\text{before}}}{\text{Variation}}
\]
An example of good science: Hattie’s effect sizes

Zero – you’ve made no difference

Positive – you’ve increased learning

Negative – you’ve decreased learning
An example of good science: Hattie’s effect sizes

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An example of good science: Hattie’s effect sizes

0.0 – 0.3  normal development effect
An example of good science: Hattie’s effect sizes

0.0 – 0.3 normal development effect

0.3 – 0.4 average teacher effect
An example of good science: Hattie’s effect sizes

- 0.0 – 0.3    normal development effect
- 0.3 – 0.4    average teacher effect
- 0.4 - 0.6    minimum desirable range
An example of good science: Hattie’s effect sizes

0.0 – 0.3    normal development effect
0.3 – 0.4    average teacher effect
0.4 - 0.6    minimum desirable range
0.6 +        best practice
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<th>Effect</th>
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<td></td>
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<td>Score</td>
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In what layer is Hattie’s research conducted?

(a) Sociocultural
(b) Individual
(c) Cerebral
(d) Cellular
(e) Physical
To what layer is Hattie’s research applied?

(a) Sociocultural
(b) Individual
(c) Cerebral
(d) Cellular
(e) Physical
To what layer is Hattie’s research *applied*?

(a) Sociocultural
(b) Individual
(c) Cerebral
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(e) Physical
Learning Strategies

1. Re-reading
2. Self-explanation
3. Elaborative Interrogation
4. Practice Testing
5. Distributed Practice
6. Interleaved Practice
7. Imagery for Text
8. Mnemonics
9. Summarisation
10. Highlighting / Underlining
Classroom Science of Learning

Basic Phonemes (EAL Students)

Term 1

LOW

x x x x x x x x x
x x x x x x x x x

MEDIUM

x x x
x x

HIGH

x x x
Basic Phonemes (EAL Students)

Term 1

LOW

MEDIUM

HIGH

Term 2

LOW

MEDIUM

HIGH

Classroom Science of Learning
Classroom Science of Wellbeing

Free sociogram software: GraphViz
Scenario for Discussion

Music has a large and visible impact on activity in the brain.
Music instruction has a 0.29 effect size on academic achievement
The Effects of Heavy Drinking on the Teen Brain

15 Year-old Non-Drinker

Functional MRI scans of two teens while they took a working memory test. The images show that the heavy drinker isn't using those brain areas normally used to complete a memory test, while the non-drinker is. Researchers suggest that in school, heavy drinkers may not be activating those regions of the brain required to remember a lesson.

15 Year-old Heavy Drinker

Image credit: © American Association of Neurology, used in accordance with http://patients.aan.com/go/about/terms.
Learning Strategies

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10. Highlighting / Underlining
Another example

Massed Practice

1. Pre-test
2. Training
3. Practice (repeat)
4. Delay
5. Post-test
Another example

Massed Practice

Pre-test → Training → Practice → Practice → Practice → Delay → Post-test

Spaced Practice

Pre-test → Training → Practice → ISI → Practice → ISI → Practice → ISI → Delay → Post-test
Spaced Practice

Sociocultural Layer - effect size > 0.80
Spaced Practice

Sociocultural Layer – ES > 0.80

Individual layer – ES > 0.80
Spaced Practice

Sociocultural Layer – ES > 0.80

Individual layer – ES > 0.80

Cerebral & Cellular layer

Image http://upload.wikimedia.org/wikipedia/commons/7/71/Aplysia_punctata.jpg 2015 Creative Commons Licence
Free educator resources

PEN Principles


• [Gregory.Donoghue@uniMelb.edu.au](mailto:Gregory.Donoghue@uniMelb.edu.au)
Coming up

UQ Seminar
Thursday 14th May
Associate Professor Ross Cunnington
Motor Learning and Mirror Learning
PD: Bringing the Science of Learning into the Classroom

Brisbane 30th June – 1st July
Melbourne July 6th – July 7th
Webinars

2\textsuperscript{nd} June    Brain Development across the lifespan
20\textsuperscript{th} August Memory and attention
3\textsuperscript{rd} October Emotions and learning