Introducing Neuroscience into Initial Teacher Education

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and the PGCE team, Shu Yau and *Tim Jay
University of Bristol, Sheffield-Hallam University

Preliminary outcomes of SoLfITE (Science of Learning for Initial Teacher Education) funded by the Wellcome Trust.
EARLI SIG 22 2018: (Some of the) Research with messages for classroom practice.....

- Moving towards spaced learning in medical education: time to start an instructional revolution?
  Marjolein Versteeg, Paul Steendijk

- A brain-inspired method for second language vocabulary learning
  Peta Baxter, Harold Bekkering, Ton Dijkstra, Mienke Droop, Marianne van den Hurk, Frank Leoné

- The componential nature of arithmetic: implications for interventions for children with arithmetical difficulties.
  Ann Dowker

- Reconsolidation of memory: The case of learning a foreign language
  Ayelet Katzoff, Tehiya Winograd Jean, Carol Goldfus

- The effect of classroom noise on creativity in primary school children
  Jessica Massonnié, Cathy J. Rogers, Denis Mareschal, Natasha Kirkham

- Learning by moving: Unraveling the mechanisms of physical activity’s effect on cognition by examining functional changes in the brain

- Spaced learning: An approach to minimize the forgetting curve, or much more?
  Gili Joseph, Ronit Ram-Tsur, Avigdor Yaakobi, Miri Getz, Ilana Avissar

- Enhancing human spatial skills: neurofeedback, machine learning and optimal performance - the case of upper alpha and mental rotation
  Miriam Reiner

- Integrating memories: How congruency and reactivation aid integration of old and new memories
  Marlijeke van Kesteren, Paul Rignanese, Lydia Krabbendam, Martijn Meeter

- Intervention on mathematics in students with ADHD
  Beatriz Vargas Dorneles, Luciana Vellinho Corso, Jacqueline Raquel Biañchi Enricone, Yasmini, Lais Spindler Sperafico

- Brain space: Improving spatial thinking with instructional videos
  Katie A. Gilligan, Michael S.C. Thomas, Emily K. Farran

- Enhancing human spatial skills: neurofeedback, machine learning and optimal performance - the case of upper alpha and mental rotation
  Miriam Reiner

- Integrating memories: How congruency and reactivation aid integration of old and new memories
  Marlijeke van Kesteren, Paul Rignanese, Lydia Krabbendam, Martijn Meeter

- Enhancement of cognitive control in rewarding contexts in adolescence and adulthood
  Lucía Magis-Weinberg, Ruud Custers, Iroise Dumonthel

AND MORE.....
There is work to be done in understanding and promoting effective teaching ...

Global Primary School Attendance

School enrolment, primary (% net)
Globally, six out of ten children are **not** learning

“6/10 children and adolescents are not achieving minimum proficiency levels in reading and mathematics”

Data by the UNESCO Institute for Statistics

Fact Sheet No. 46 September 2017 UIS/FS/2017/ED/46

Teaching quality also a major issue in Western, Educated, Industrialized, Rich, And Democratic (WEIRD) countries:

E.g., in US, a teacher in the top 16% of effectiveness (in terms of exam outcomes), compared with an average teacher, has been estimated to produce students whose level of achievement is an average between 0.2 and 0.3 standard deviations higher by the end of the school year (Hanushek, 2011).
Quality teachers provide more than just “a performance” to script

• Checklists of desirable practices are poor predictors of teaching effectiveness (Brown, Roediger III, & McDaniel, 2014; Strong, Gargani, & Hacifazlioglu, 2011). Good teaching practices may be important/necessary, but are not sufficient to assure optimal levels of learning.

• Suggests there is no prescription – and adaptation (or “judicious fit to context”) informed by beliefs and understanding are critical

- Implications for RCT’s and interventions!
Apply prescribed approach

Did it work?

Yes

No

Try it more or something else

Try it more something else

Select approach

Identify possible “how” evidence

Why was it (not) working?

Develop and use new understanding to **adapt** approach

Early in Training (Trial and error)

Later in Training (Reflective Practitioner)
Which scientific concepts?

• Latest research in neuroscience? (e.g. default mode network)
• “Big” ideas in neuroscience? (e.g. neurons)
• Concepts that, together, provide a scientific underpinning for basic approaches evidenced as effective in the classroom? (e.g. working memory)
Which scientific concepts?

• Latest research in neuroscience? (e.g. default mode network)
• “Big” ideas in neuroscience? (e.g. neurons)
• Concepts that, together, provide a scientific underpinning for basic approaches evidenced as effective in the classroom? (e.g. working memory)
We found:

- Generally, good practices can be understood scientifically
- Limited “educational-like” examples of science research illustrating/exploring concepts
- More science underlying some practices is needed, e.g. interleaving
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>ENGAGE</td>
<td>Daily review</td>
<td>Understanding emotions</td>
</tr>
<tr>
<td>Individual differences in engagement</td>
<td>Present new material in small steps</td>
<td>Individual and cultural differences</td>
</tr>
<tr>
<td>Approach response</td>
<td>Ask questions</td>
<td>Positive emotions and learning</td>
</tr>
<tr>
<td>Fearfulness and anxiety</td>
<td>Provide models</td>
<td>Negative emotions</td>
</tr>
<tr>
<td>Understanding plasticity</td>
<td>Guide student practice</td>
<td>Self-confidence, task values and emotions</td>
</tr>
<tr>
<td>Prior knowledge</td>
<td>Check for student understanding</td>
<td>Emotion regulation</td>
</tr>
<tr>
<td>Connection-making brain development</td>
<td>Obtain a high success rate</td>
<td>Classroom instruction and teacher emotions</td>
</tr>
<tr>
<td>Multimodal/multisensory representation</td>
<td>Provide scaffolds for difficult tasks</td>
<td>Goal structures and achievement and feedback</td>
</tr>
<tr>
<td>Unconscious communication, MNS</td>
<td>Independent practice</td>
<td>Families, peers and school reform</td>
</tr>
<tr>
<td>Practice, working memory, automatization</td>
<td>Weekly and monthly review</td>
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<tr>
<td>Variable representation of knowledge in brain</td>
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<tr>
<td>Sleep</td>
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</tbody>
</table>

Table 1. Mapping of core scientific concepts (identified in main text) to teaching principles (as identified in Pekrun, 2014; Rosenshine, 2010)
Which scientific concepts?

Also:

• Parsimonious
• Visual
• Non-prescriptive
• Inoculating against neuromyth
• Foundational for further studies such as mathematics and reading, or infant development. Introducing concepts such as attention and control of attention, memory and working memory, the reward system, fear responding, plasticity and individual differences.
• Can interrelate with Vygotsky, Piaget
Which scientific concepts?

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• Can interrelate with Vygotsky, Piaget
  – which tend to emphasise moment of knowledge creation – rather than preceding and subsequent processes
How should concepts be delivered?

• Emphasise processes preceding (“readiness for learning”) and following initial acquisition of knowledge (including consolidation), as much as the initial building of knowledge.

• Provided within a framework that helps associate concepts with classroom practice EBC of learning (Engage, Build, Consolidate):
  • Engagement for Learning
  • Building of Knowledge and Understanding
  • Consolidation of Learning

• Delivered in ways that illustrate the practical significance of the concepts
How should concepts be delivered?

Delivered in ways that illustrate the practical significance of the concepts

...links between different representations and the enactment of learning....
Found the cutting out of the brain a waste of time. People were already doing it in the first part of lecture. Very distracting hearing cutting & people pulling off bits of tape all the time, before being asked to do anything.

Brilliant - found this to be such a useful part of the course and for me is the most interesting of the EPS sessions that we get. Very engaging with building and labelling the brain.
How should concepts be taught/learnt?

Engage
Sharing attention, praise, rewards, novelty
Avoiding anxiety, fear, distraction....

Consolidate
Practicing fresh knowledge until it becomes automatic and represented/connected—freeing up working memory for more learning

Build
Supporting the connection of new ideas to existing knowledge
How should concepts be taught/learnt/monitored?

Postgraduate Certificate of Education (PGCE) (N=193)

<table>
<thead>
<tr>
<th>Time</th>
<th>Content</th>
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<tbody>
<tr>
<td>Term 1</td>
<td>Foundation (2 wks)</td>
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<tr>
<td></td>
<td>University (2 weeks)</td>
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<td></td>
<td>Placement 1 (8 weeks)</td>
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<td>University 2 weeks</td>
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<td>Term 2</td>
<td>Placement 2 (5 weeks) + recall day</td>
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<tr>
<td></td>
<td>Placement 3 (5 weeks) + recall day</td>
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<tr>
<td>Term 3</td>
<td>University 2 weeks</td>
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<tr>
<td>OFSTED</td>
<td>Placement 4 (5 weeks)</td>
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Subject-focused Input (Music, English, Geography, Maths, History, RE)

Lecture 1

Learning Survey 1
Vignette (A or B)

Lecture 2

Learning Survey 2
Vignette (B or A)

Written comment

Initial expectations

Monitoring Assignments, Practice

Interviews

RESEARCHER MEETINGS WITH PGCE TUTORS

Initial expectations

How should concepts be taught/learnt/monitored?
Learning Survey 1
Vignette (A or B)

Lecture 1

Subject-focused Input (Music, English, Geography, Maths, History, RE)
Classwork

Lecture 2

Learning Survey 2
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<table>
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<td>Placement 3 (5 weeks) +recall day</td>
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<th>University 2 weeks</th>
</tr>
</thead>
</table>

| OFSTED      | Placement 4 (5 weeks) |
|-------------| University 2 weeks |

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How should concepts be taught/learnt/monitored?

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RESEARCHER MEETINGS WITH PGCE TUTORS
Lecture Content

Lecture 1
Brain Basics + Neuromyths
*Science of Engage, Build, Consolidate

Lecture 2
Adolescent Brain Development (revision of E, B, C concepts)
Cognitive Neuroscience in Planning and Evaluation

Subject Specific Sessions: English and Music “The Creative Brain”

• 1 hour lecture on what is known about creativity and the brain, explained in the context of drama and music technology

• Need to integrate creative thinking with EBC categories

• Many references to this lecture amongst student English teachers
Subject Specific Sessions: History and Maths
Cognitive Neuroscience meets Vygotsky & Piaget

• Maths: We were asked to create a resource that would allow students to compare the perspective on learning provided by cognitive neuroscience with that provided by Vygotsky and Piaget: An accessible article on the Science of Learning that is in newspaper style.

• History: We were asked to provide a session (and resources) that would allow students to consider classroom learning in terms of the perspectives offered by Cognitive Neuroscience, Vygotsky and Piaget: A description of a history lesson on the Norman Invasion, followed by an exercise to critique this lesson in terms of concepts from Vygotskian, Piagetian and Cognitive Neuroscience perspectives.
Subject Specific Sessions in Religious Education: P4T approach to Neuroscience in Education issues

Philosophy4Teachers (P4T) is
• an educational approach with cognitive and social benefits for children and schools, now being adapted for use in HE
• Centred on philosophical enquiry; a facilitator encourages the participants to think and react as a ‘community of inquiry’.

We were asked to develop resources and stimulus to a support a P4T approach focused on neuroscience and education.

The P4T approach encouraged student teachers to explore more deeply a range “neuro” philosophical questions relevant to practice, e.g.

• How should we think about free-will and the autonomous learner?
• To what extent should teenagers be considered responsible for their behaviour?
• How should we think about the interrelation of mind-brain-behaviour?
Subject Specific Sessions in Geography: Cognitive Neuroscience in Planning and Evaluation

We developed resources and an approach to mapping SoL concepts to planned classroom activities

Planning (Assessment for Learning):

* Identify relevant SoL concepts against each activity
* Be ready to observe evidence of “how” (not just “whether” learning is occurring)

Evaluating:

* Use SoL to explain and understand
### Geography planning

**Focusing on Learning – AsL not just whether it is occurring but how this is supposed to happen**

<table>
<thead>
<tr>
<th>Time (real time)</th>
<th>Task and Management (related to Learning Objectives)</th>
<th>Assessment for Learning</th>
<th>Differentiation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>9:15 (10 mins)</strong></td>
<td>Atlases out on desks. Intro – set scene for new topic with reference to KS3 work – class clip on rainforests – q &amp; a to access prior knowledge. Starter activity of images to identify differences between 3 ecosystems. Debrief – introduce climate as reason.</td>
<td>Student: q &amp; a&lt;br&gt;&lt;br&gt;Teacher: Intro Sol 1, 2, 8 – enthusiasm&lt;br&gt;(own/students)attention – individual differences?&lt;br&gt;Q&amp;A Sol 5, 6, 10 – prior knowledge, links to prior knowledge, applying in new situations, support needed?&lt;br&gt;Sol 7: clip: Linking different representations?</td>
<td>Ensure that JL, TD &amp; MR are engaged with q &amp; a. Provide chart with key terms for each ecosystem for the above pupils</td>
</tr>
<tr>
<td><strong>9:25 (15 mins)</strong></td>
<td>Explain activity 1 – in pairs, identifying global vegetation zone for selected ecosystems. Explanation of how to use atlas to do this.</td>
<td>Student: Guided peer feedback against criteria&lt;br&gt;&lt;br&gt;Teacher: Move round, observe use of atlases Pair work Sol 2 - shared attention?&lt;br&gt;Labelling Sol 10 – applying knowledge?</td>
<td>Teacher support where needed. JL, TD and MR could do 2 instead of 3 ecosystems</td>
</tr>
<tr>
<td><strong>9:40 (15 mins)</strong></td>
<td>Explain activity 2 – in pairs look at climate zones in atlas and match with selected vegetation zones on own map. Hand out textbooks for next activity</td>
<td>Student: Peer feedback&lt;br&gt;&lt;br&gt;Teacher: Sol 2, 10 as above&lt;br&gt;Sol 7: Linking different representations?</td>
<td>As above</td>
</tr>
<tr>
<td><strong>9:55</strong></td>
<td>Plenary - reshow class clip of savannah and check notes to add two more details – q and a on what should have been learnt. Explain Hw as follows on from this</td>
<td>Student: q and a&lt;br&gt;&lt;br&gt;Teacher: Sol 10 – applying knowledge in new situations?&lt;br&gt;Sol 7: clip: Linking different representations?</td>
<td>JL, TD &amp; MR use writing frame. Extension activity for EC &amp; BG</td>
</tr>
</tbody>
</table>

Planning that is reasoned will provide a richer basis for evaluation.
<table>
<thead>
<tr>
<th>Learner activity</th>
<th>Assessment for Learning</th>
<th>Differentiation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intro – responding to q &amp; a; images of Arctic, savannah and hot desert to look for differences in vegetation – describe, notes in exercise book. Add details of climate.</td>
<td><strong>Student:</strong> q &amp; a</td>
<td>Ensure that JL, TD &amp; MR are engaged with q &amp; a. Provide chart with key terms for each ecosystem for detail above pupils.</td>
</tr>
<tr>
<td><strong>Teacher:</strong> Intro SoL: 1, 2, 8 – enthusiasm (own/students)/attention – individual differences? Q&amp;A SoL: 5, 6, 10 – prior knowledge, links to prior knowledge, applying in new situations, support needed? SoL 7: clip: Linking different representations?</td>
<td><strong>Teacher:</strong></td>
<td>Teacher support where needed. JL, TD and MR could do less work and focus instead on 3 ecosystems.</td>
</tr>
<tr>
<td>Pair work - Use atlas and criteria to label map with vegetation zones and with key lines of latitude and longitude,</td>
<td><strong>Student:</strong> Guided peer feedback against criteria</td>
<td>As above</td>
</tr>
<tr>
<td><strong>Teacher:</strong> Move round, observe use of atlases Pair work SoL 2 - shared attention? Labelling SoL 10 – applying knowledge?</td>
<td><strong>Teacher:</strong> SoL 2, 10 as above SoL 7: Linking different representations?</td>
<td>JL, TD &amp; MR use writing framework; Extension activity for EMW</td>
</tr>
<tr>
<td>Pair work - annotate own maps with climate details from atlas</td>
<td><strong>Student:</strong> Peer feedback</td>
<td></td>
</tr>
<tr>
<td><strong>Teacher:</strong></td>
<td><strong>Teacher:</strong> As above – but more challenging so SoL 3 – anxiety?</td>
<td></td>
</tr>
<tr>
<td>Independent – under headings make notes.</td>
<td><strong>Student:</strong> teacher feedback</td>
<td></td>
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# Geography lesson evaluation

**Supposing…..**

<table>
<thead>
<tr>
<th>The introduction did not engage everyone</th>
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</thead>
<tbody>
<tr>
<td>The introductory Q and A required more support than anticipated</td>
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<tr>
<td>Pair work not producing learning</td>
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<td>Difficulty labelling own maps</td>
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<tr>
<td>Some not demonstrating understanding in later Q and A</td>
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</tbody>
</table>
### Geography lesson evaluation

#### Supposing…..

<table>
<thead>
<tr>
<th>Issue</th>
<th>Potential Causes/Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>The introduction did not engage everyone</td>
<td>Teacher emotion? Individual differences? Novelty, anticipation, curiosity?</td>
</tr>
<tr>
<td>The introductory Q and A required more support than anticipated</td>
<td>Where was support needed? Prior learning consolidated? Were they linking new to old, verbal to A/V? Had they previously practised questions, applied knowledge in new situations, discussed, expressed in new forms? Anxiety?</td>
</tr>
<tr>
<td>Pair work not producing learning</td>
<td>Shared attention?</td>
</tr>
<tr>
<td>Difficulty labelling own maps</td>
<td>Making connections between verbal and map representations, exemplar and own maps?</td>
</tr>
<tr>
<td>Some not demonstrating understanding in later Q and A</td>
<td>Prior learning – monitored and built upon? Weak links in building process &amp; actions taken?</td>
</tr>
</tbody>
</table>
Learning Survey (Lectures 1 & 2)

Perceptions of 15 ideas about learning, in terms of validity and usefulness for promoting learning in the classroom:

7 SoL concepts

• The brain’s capacity to pay conscious attention is limited.
• Anxiety reduces the brain’s ability to direct conscious attention.
• The brain is plastic – its connectivity and structure change when we learn
• Practice of freshly-learnt knowledge causes it to become more automatically accessible.
• Making links between representations (e.g. texts, maps, pictures) improves learning.
• Children’s brain circuitry for connecting new information to old is still developing.
• When we apply knowledge, different representations of the knowledge become stored in our brain.
Learning Survey (Lectures 1 & 2)

4 popular ideas about learning with doubtful usefulness

• We naturally tend to absorb the information we are immersed in.
• When we are having fun, we are ready to learn.
• Regular testing helps children become emotionally prepared for the experience of examinations.
• The learner’s potential depends on the brain they are born with.

4 popular ideas about learning with little/no evidence to support them

• Children can helpfully be categorised as left-brain or right-brained.
• Repetition of knowledge and understanding by the teacher reinforces its meaning to the class.
• Children sometimes learn lesson content without attending to it.
• Children benefit from being taught in their preferred learning style (visual, auditory or kinaesthetic).
Learning Survey

One response required for each statement:

<table>
<thead>
<tr>
<th>Place a cross in the first column OR circle a number</th>
</tr>
</thead>
<tbody>
<tr>
<td>If FALSE cross (x)</td>
</tr>
<tr>
<td>If TRUE, circle how useful for classroom?</td>
</tr>
<tr>
<td>Not all useful</td>
</tr>
<tr>
<td>Very useful</td>
</tr>
<tr>
<td>1  2  3  4  5</td>
</tr>
</tbody>
</table>
Mary begins every lesson with a new topic. She provides tasks for the children to practice their knowledge and gives out popular stickers for good effort.

Standing at the front of the class and speaking clearly and concisely, Mary delivers well-rehearsed explanations of key concepts in a work scheme early on. This allows time to repeat her explanations several times.

At the start of lessons, Paula plays the quiz game “Luck and Learning” that reveals what the class has learnt previously, encouraging her students with praise for their diverse abilities. Paula discusses and tests understanding of the same concepts in different contexts. When she feels confident in the topic, she enjoys linking lesson content to things that are happening in the news.

Why are Mary’s pupils doing well?
Why are Mary’s pupils doing poorly?

Why are Paula’s pupils doing well?
Why are Paula’s pupils doing poorly?
Learning Survey: Preliminary results

Ratings generally moved in anticipated directions

3 SoL concepts significantly increased in their usefulness rating:

- Anxiety reduces the brain’s ability to direct conscious attention.
- The brain is plastic – its connectivity and structure change when we learn.
- When we apply knowledge, different representations of the knowledge become stored in our brain.

2 popular ideas with doubtful evidence significantly reduced in their usefulness rating:

- We naturally tend to absorb the information we are immersed in.
- Children sometimes learn lesson content without attending to it.
Mary and Paula Vignettes

Preliminary analysis shows a significant increase in mean number of insights identified between before the first lecture and after the second lecture (N=73):

Pre Test Mean (SD) = 10.96 (4.20)
Post Test Mean (SD) = 13.06 (4.86)
Smattering of references to SoL in assignments

**Engage**
- Rewards, praise, types of praise
- Gamification
- Novelty

**Build** – Vygotsky remained generally dominant
- Prior knowledge

**Consolidate**
- Revisiting freshly learnt concepts (not scaffolding to make connections, novel contexts, sleep)

Also: Creativity
Challenge of focusing on Learners and Learning

Student teachers often find thinking about underlying cognitive/learning processes very challenging, preferring to consider what happens in the classroom in purely behavioural terms.

“Quiz at the beginning of the lesson was too long.”

“Some students weren’t engaging in the practical activity as I had hoped and were messing around – students should be given a warning that not engaging with practical work will lead to them doing textbook work instead.”
Challenge of accessing of primary sources

When referencing SoL, student teachers almost exclusively reference SoL lectures and SoL notes, suggesting they find the accessing of the primary literature challenging:

“Paul Howard-Jones (2018) furthers that when students engage with a new concept the prefrontal cortex is activated and begins to build by supporting the new idea to existing knowledge.”


“The consolidation step hypothesises that the, ‘Practice and rehearsal of freshly-learnt knowledge causes it to become automatically accessible’ (Paul Howard, 2017).”

“These tangible, visual markers of accent and dialect change across the UK provided the “engagement through novelty” stage, as described by Paul Howard-Jones (Howard-Jones, 2017).”
Challenge of boiling down messages

SoL concepts can be further over-simplified by student teachers, and reduced to **prescriptions for what to do**, rather as **tools to help think more critically** about planning and evaluation of lessons.

“Repetition is central to this (spiral) curriculum approach....This aids learning by regularly engaging the consolidation phase of learning outlined by Howard-Jones and Yau (2018) as the stage in which knowledge becomes better retained, accessible and useful for future.

And...between lectures 1 and 2, students increased their ratings (but not significantly so) for:

*Repetition of knowledge & understanding by the teacher reinforces its meaning to the class.*
MOOC

MOOC: https://www.futurelearn.com/courses/science-of-learning

Improve your teaching by discussing the science of learning

What is learning? How does it work? On this course you try and answer these questions, exploring how you can use the science of learning to inform your teaching and support your students’ learning.

Drawing upon educational neuroscience and psychology (and combating neuroscience myths), you will learn how to interpret research to be better informed about how your students learn. Throughout the course, you will reflect on your own practice as a teacher, learning how to justify and improve your approach.
Summary

• Encouraging student teachers to focus critically on learning is challenging.

• We have identified a range of concepts from cognitive neuroscience that offer insight into “everyday” effective teaching practices do/don’t work, and provide a foundation for further scientific understanding.

• After a 4 month period on a PGCE course in which concepts were introduced from cognitive neuroscience, student teachers:
  • increased number of insights identified in classroom vignettes
  • attributed greater value to scientific principles of learning
  • began introducing scientific principles of learning into their assignments (in a minority of cases)
There are some serious questions/gaps in our understanding when it comes to introducing cognitive neuroscience into initial teacher education:

- How do teachers think about learning?
- Which concepts from cognitive neuroscience? (which relies on answers to other questions...)
- How should concepts be taught/learnt?
- How do concepts impact on how teachers think about learning?
- How do concepts impact on practice?
- How does this impact on learning?

Some starters for our PGCE for next year:

- Provide primary sources in a more accessible manner
- Develop concepts more into a form that can be easily applied in lesson planning and evaluation – deliver earlier.
- Why did English (but not Music) students take up creativity concepts
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- Learning by moving: Unraveling the mechanisms of physical activity's effect on cognition by examining functional changes in the brain

- Spaced learning: An approach to minimize the forgetting curve, or much more?
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- Integrating memories: How congruency and reactivation aid integration of old and new memories
  Marlieke van Kesteren, Paul Rignanese, Lydia Krabbendam, Martijn Meeter

- Intervention on mathematics in students with ADHD
  Beatriz Vargas Dorneles, Luciana Vellinho Corso, Jacqueline Raquel Biañchi Enricone, Yasmini, Lais Spindler Sperafico

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AND MORE.....
Finally, the meaning of our learning biology...

"Nothing in biology makes sense except in the light of evolution"

Theodosius Dobzhansky, 1973

Originally written for educators....to introduce understanding of how the brain learns through the narrative of evolution.....