Cognitive Science and the Psychology of learning

Simon Moore
Science teacher
Wymondham High Academy

Dr Niki Kaiser
Chemistry teacher and Research Lead
Norwich Research School
@chemDrK
• What can science teachers do?

• How can Cognitive Science help?

• How can Psychology help?
Tell the person next to you…

5 x 5
Tell the person next to you…

Your phone number when you were growing up
Tell the person next to you…

488 x 7
Tell the person next to you…

What you had for dinner last Thursday…
Learning: one definition

To learn, students must transfer information from the working memory to the long-term memory.
Karpicke & Roediger, Science 2008
Image: Efrat Furst
sites.google.com/view/efratfurst
Retrieval practice and curriculum

What do students need to have ‘at their fingertips’?

Which skills need to be automatic?

Which vocabulary must be used and understood fluently?

What did you do last year that links to today?
Memorise this sequence

352974310485
Memorise this sequence

106618121984
Memorise this sequence
Cognitive Load Theory

How can I help my students transfer information from the working memory to the long-term memory.
Cognitive Load Theory

How can I help my students do the more interesting stuff/more creative stuff?...
Cognitive Load Theory

Intrinsic Load + Extraneous Load + Germaine Load

Manage
Minimize
Maximize
Read these sentences to yourself (in silence)

“I ate his liver with a side of fava beans and a nice Chianti.”

“I did not have sexual relations with that woman.”

“That’s one small step for man, one giant leap for mankind.”

*Jared Cooney Horvath: Stop Talking, Start*
Cognitive Load and curriculum

Are students focussing on what you want them to focus on?

What prior knowledge will give students a ‘foothold’?

How can you break this up into small steps?

Are you allowing students to practice?

Are you ensuring students really think hard?

Really..
1. Use regular retrieval practice, but
   i. Be strategic
   ii. Ensure that it’s actually retrieval practice
   iii. Don’t (necessarily) use as for assessment

2. Consider cognitive load theory, and
   i. Minimise ‘distractions’
   ii. Support understanding: foothold, scaffold, practice
   iii. Allow students time and space to think hard
Remembering
Focus

hippocampus
Sleep
Sleep networks related memories

(Tham et. al., 2015)
Schema form from consolidated memories that are independent of the hippocampus

(Gilboa and Marlatte, 2017)
Schema interlinking
Schema interlinking
Schema interlinking
Schema interlinking

Amygdala

(Based on Efrat Furst 2018)
Engagement

The Cognitive zone

The Affective Zone

Teaching

Schema interlinking

(Based on Efrat Furst 2018)
The Cognitive zone

- Preconceptions
- Misconceptions
- Prior learning
- Retrieval Practice
- Vocabulary
- Knowledge & Understanding
- Use of Models
- Modelling answers
- Feedback
- Cognitive Load
The Affective Zone

Difficulty → Culture

Self Efficacy → Self Recognition

Enjoyment

Recognition by others

Interest

Motivation

Schema interlinking (Based on Efrat Furst 2018)
Social Identity
The Affective Zone

- Difficulty
- Culture
- Self Efficacy
- Self Recognition
- Identity
- Recognition by others
- Enjoyment
- Interest
- Motivation

Boring
Irrelevant
Difficult
Mathematical
Masculine

Schema interlinking (Based on Efrat Furst 2018)
Episodic Memories

“high school physics experiences emerged in our study as the most meaningful for helping to explain patterns in physics identity longitudinally for the female students in our study”

Who wants to do science?

“Girls gave the highest rankings to ‘topics related to the self, and more particularly to health, mind, and well-being’. The popularity of these issues was found to be not as strong for boys who expressed more interest in ‘destructive technologies and events’.”

Rodger Bybee & Barry McCrae (2011) Scientific Literacy and Student Attitudes: Perspectives from PISA 2006 science, International Journal of Science Education
Recipe or Creativity?

**Scanning a recipe**

**Mild chicken tikka masala**

By Matthew Martin

10 minutes preparation time

30 minutes cooking time

Serves 4-6

**Ingredients**
- 500g boneless chicken
- 2 tbsp vegetable oil
- Half an onion or 2 shallots
- 2 cloves garlic
- 1 large jar tikka masala sauce
- 100ml plain yoghurt

**To garnish**
- Flat leaf parsley
- A lemon (cut into wedges)

**Method**
1. Fry the onion and garlic gently in the oil. Add the chicken pieces and fry until golden brown and cooked all the way through.
2. Add the sauce and simmer for 5 minutes.
3. Add the yoghurt and stir through the sauce.
4. Serve the chicken with rice.
And Also....
... and finally
Discovery Learning

“evidence from empirical studies over the past half-century … consistently indicate that minimally guided instruction is less effective and less efficient than instructional approaches that place a strong emphasis on guidance of the student learning process”

The Psychology of Motivation
Self Determination Theory

- **Basic Human Needs**
  - **Competence**
    - Effective dealing with environment
  - **Autonomy**
    - Control the course of our lives
  - **Relatedness**
    - Close relationships with peers
Affective Teaching

Is feedback to students positive about their competence?

Do students have a positive relationship with the teacher?

Are students “recognised” as a science person?

Do students have some autonomy when they are learning science?

Really..?
1. Give students some control over their learning
   i. Make time
   ii. Train them in how to work independently
   iii. A choice of measuring cylinders is not autonomy.

2. Think about relationships
   i. Talk one-to-one with each student
   ii. Give positive feedback on something - even if it is not science related
   iii. Recognise them (individually) as “science people” whenever possible