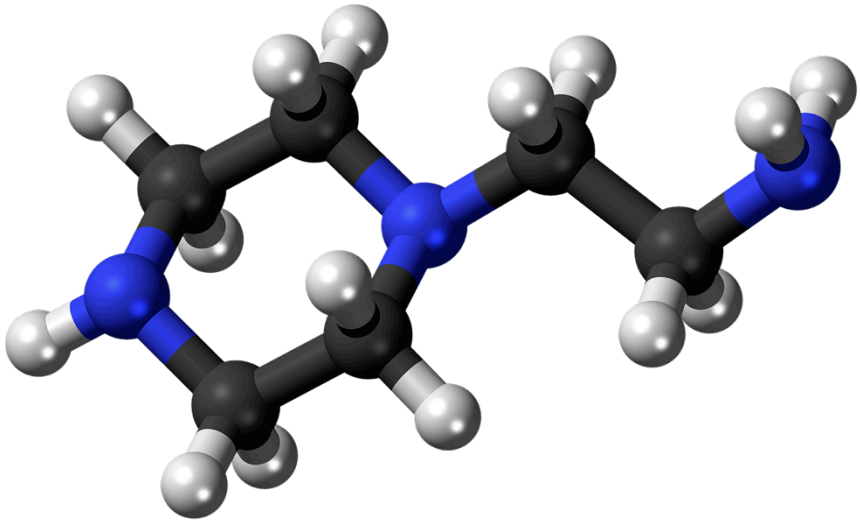
How Learning Works: The Importance of Practice

Carpentries' Pedagogical Model

- Favour **practical** and **hands-on**
  - Teach, practise, feedback, next step -> loop
- Develop learners' **confidence**
- Lay foundation for **future learning**

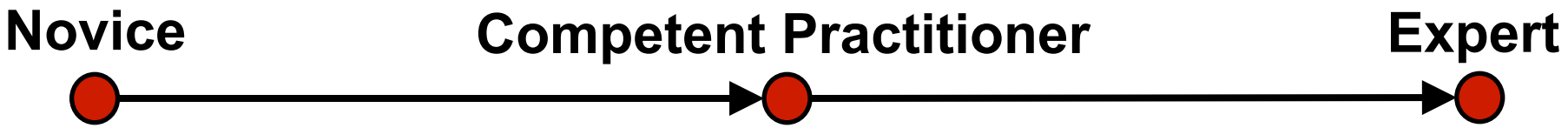
Cognitive Development and Mental Models

- **Mental model**: concepts/facts + relationships
- Effective learning happens when a learner creates a mental model of the domain
- Characterise the **skill level** to know how best to teach them to develop a mental model



How to Characterise Skill?

- Differences in skill – mental model 'big picture'
- Dreyfus model of skill acquisition simplified:



Doesn't know what they don't know – no **mental model** (key ideas) of domain

Reason by analogy and guesswork

Borrow from other mental models that seem similar

Good **mental model** for everyday purposes, e.g. driver and car

Model perhaps not completely accurate

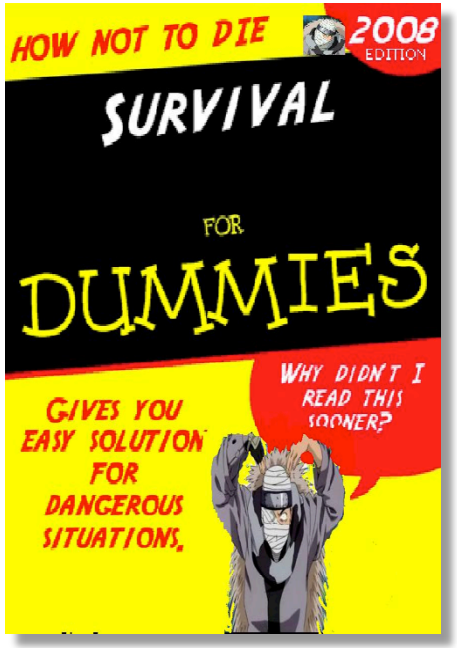
Can do normal tasks with normal effort under normal circumstances

Can handle out of the ordinary situations

Diagnose problem causes

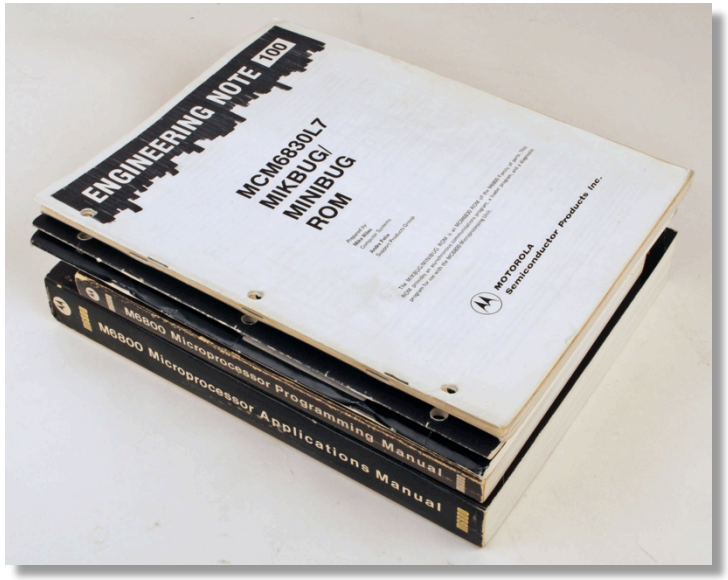
Tutorial vs Manual

- Novices, competent practitioners & experts need to be taught **differently**



Tutorial

vs



Reference Manual

Carpentry Learners are Novices

5-15% use GPU clusters to analyze petabytes in the cloud

85-95% send each other spreadsheets by email

- Help them develop a **working mental model**
- Easy to overload novices with too many facts
  - Unix shell lesson – 16 commands in 3 hours!

The Importance of Going Slowly

"If someone feels it's too slow, they'll be bored. If they feel it's too fast, they'll never come back to programming." - a Carpentry instructor

- Meet learners where they are at, whatever the starting point or current skillset
- Adjust our teaching to their skill level to aid learning, **without making them feel inferior**

Exercise 1: Mental models

- Write some aspects of the mental model you use to frame and understand your work
- What concepts/facts are included? What types of relationships are included?

How "Knowledge" Gets in the Way

"It ain't what you don't know that gets you into trouble, it's what you know for sure that just ain't so" – Mark Twain

- Clearing up learners' misconceptions:
  - **Simple factual errors** – easiest to correct
  - **Broken models** – correct by reasoning, address contradictions
  - **Fundamental beliefs** – e.g. "world is only a few thousand years old", can't really address these

Our focus!

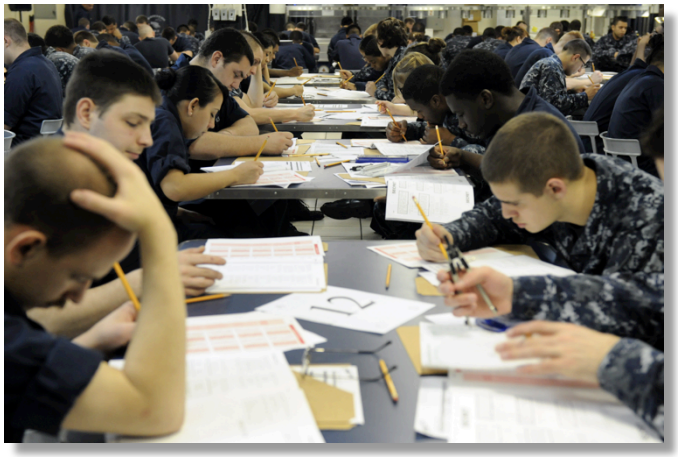
Identifying and Correcting Misconceptions

- Instructors need feedback!
- Need an insight into/to assess mental model of students
- Should be done frequently!

Assessing Mental Models

- To expose incomplete/broken mental models
- Repetition vs. reflective practice

Summative Assessment



Did desired learning take place?
Can learner move on?
e.g. a driving test
Pass or fail

Formative Assessment

Guide learning by informing instructor and learner what to focus on
Takes place during teaching
No pass or fail

Our focus!

Multiple Choice Questions

- Formative assessment needs to be quick to administer and evaluate and comes in many forms – e.g. MCQs

Q: what is 27 + 15?

a) 42
b) 32
c) 312
d) 33

Exercise 2: Identifying Misconceptions

Q: what is 27 + 15?

a) 42
b) 32
c) 312
d) 33

Choose one wrong answer and write what the misconception is associated with it

Applying MCQs

1. Teach some stuff
2. Present MCQ probing for misconceptions
3. Students vote on MCQ answers
   - Mostly all right answers, move on
   - Mostly all same wrong answer, address misconception
   - Mix of right and wrong, rewind to previous point where all were on the same page, or get them to discuss

- Do it frequently - e.g every 15 mins or so
- Preemptively!
- Break-up teaching and re-focus attention

Notes on MCQs

- A good MCQ tests for **conceptual misunderstanding**, not factual knowledge
- For distractors, think about problems from previous training events
- MCQs are useful even if not used in class!

Exercise 3: Design a MCQ

- Create multiple choice question related to topic you intend to teach
- Explain diagnostic power of each distractor, i.e. what misconception is each distractor meant to identify?
- Pair up with your neighbour and discuss your MCQs, providing feedback

Summary

- Our goal as experts when teaching novices is to help them build useful **mental models** and correct misconceptions
- Use **reflective practice**
- **Formative assessment** provides feedback for both instructors and learners
- Formative assessment is most powerful when instructor modifies her teaching (change pace, rewind, refocus) based on the result