



Using Cognitive Science to Make Training Stick

What we'll talk about today

- ▶ Presenting information clearly using cognitive science
- ▶ Reducing external distractions
- ▶ Active Learning

Who am I?

- ▶ Bioinformatics Trainer for DNAnexus Academy
- ▶ Bioinformatician with 18+ years of experience
 - ▶ Systems Biology / Systems Science
 - ▶ Microarray
 - ▶ Proteomics
 - ▶ Microbiome (16S)
 - ▶ Flow Cytometry
 - ▶ Clinical Data
- ▶ Former assistant professor, Oregon Health & Science University
 - ▶ Clinical Informatics / Data Analytics
 - ▶ Bioinformatics / Machine Learning
 - ▶ Data Science / Statistics
- ▶ **Passionate about data science education and inclusion**





DANIEL T. WILLINGHAM

WHY DON'T
STUDENTS

Like
SCHOOL?

SECOND EDITION

DANIEL T. WILLINGHAM

WHY DON'T

S CUSTOMERS S

Like

TRAINING?

SECOND EDITION

**Learners new to a topic
experience information overload;
difficult for them to understand
what details are relevant**

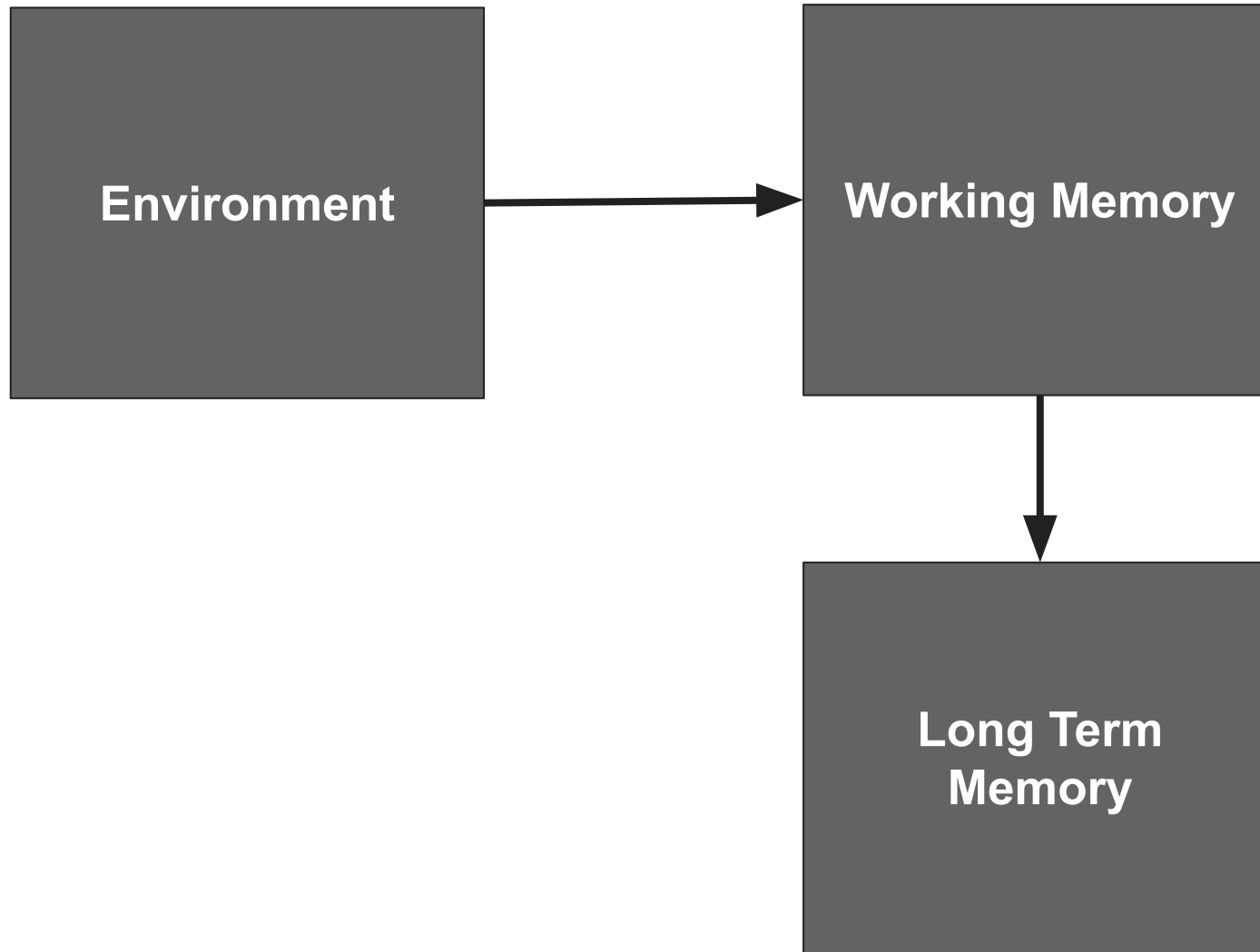
Learners new to a topic
experience information overload;
**difficult for them to understand
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**Effective Teachers manage
cognitive load and make an
emotional connection**

Willingham

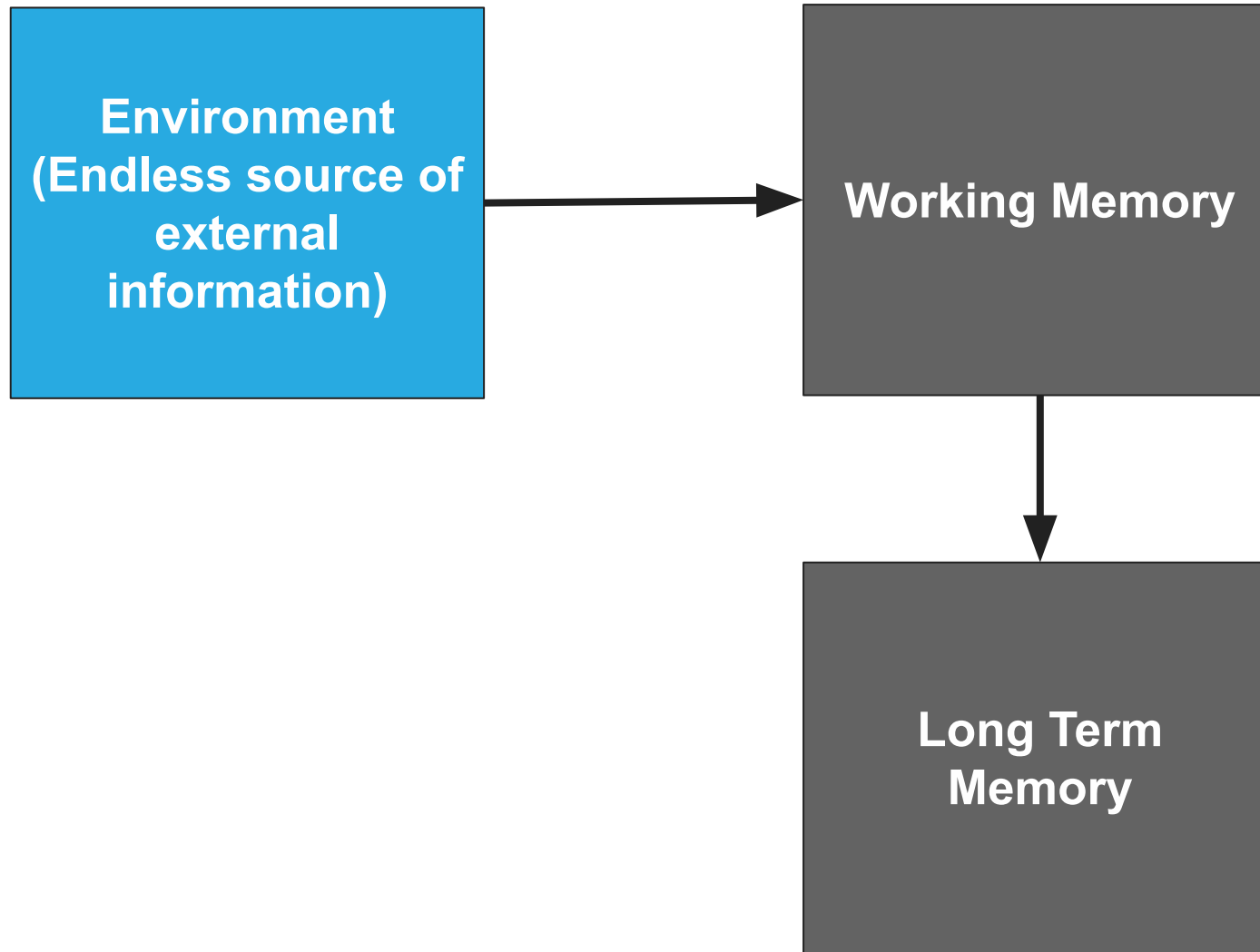
Effective Teachers **manage
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Simplest Model of the Mind

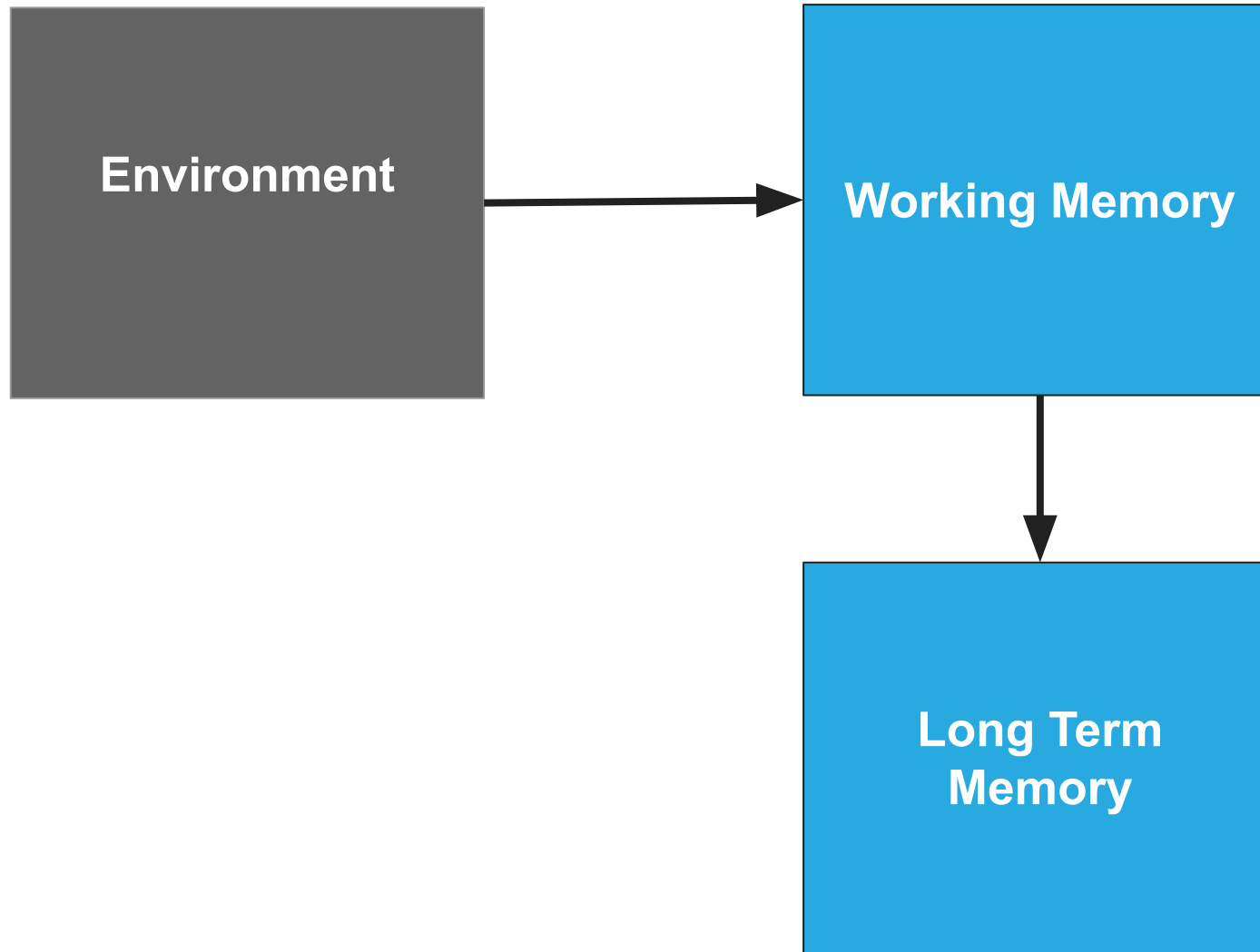


Lovell

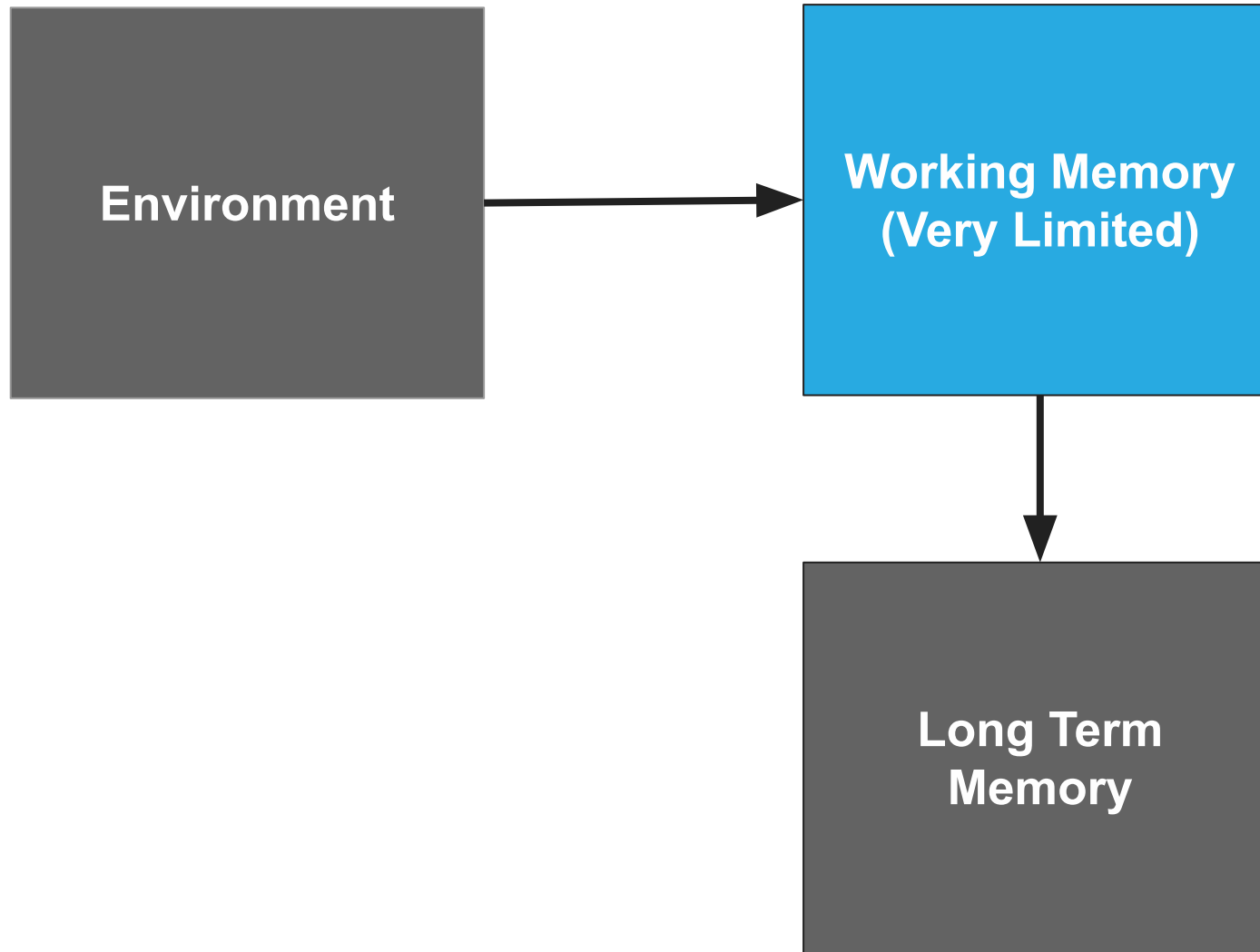
Simplest Model of the Mind

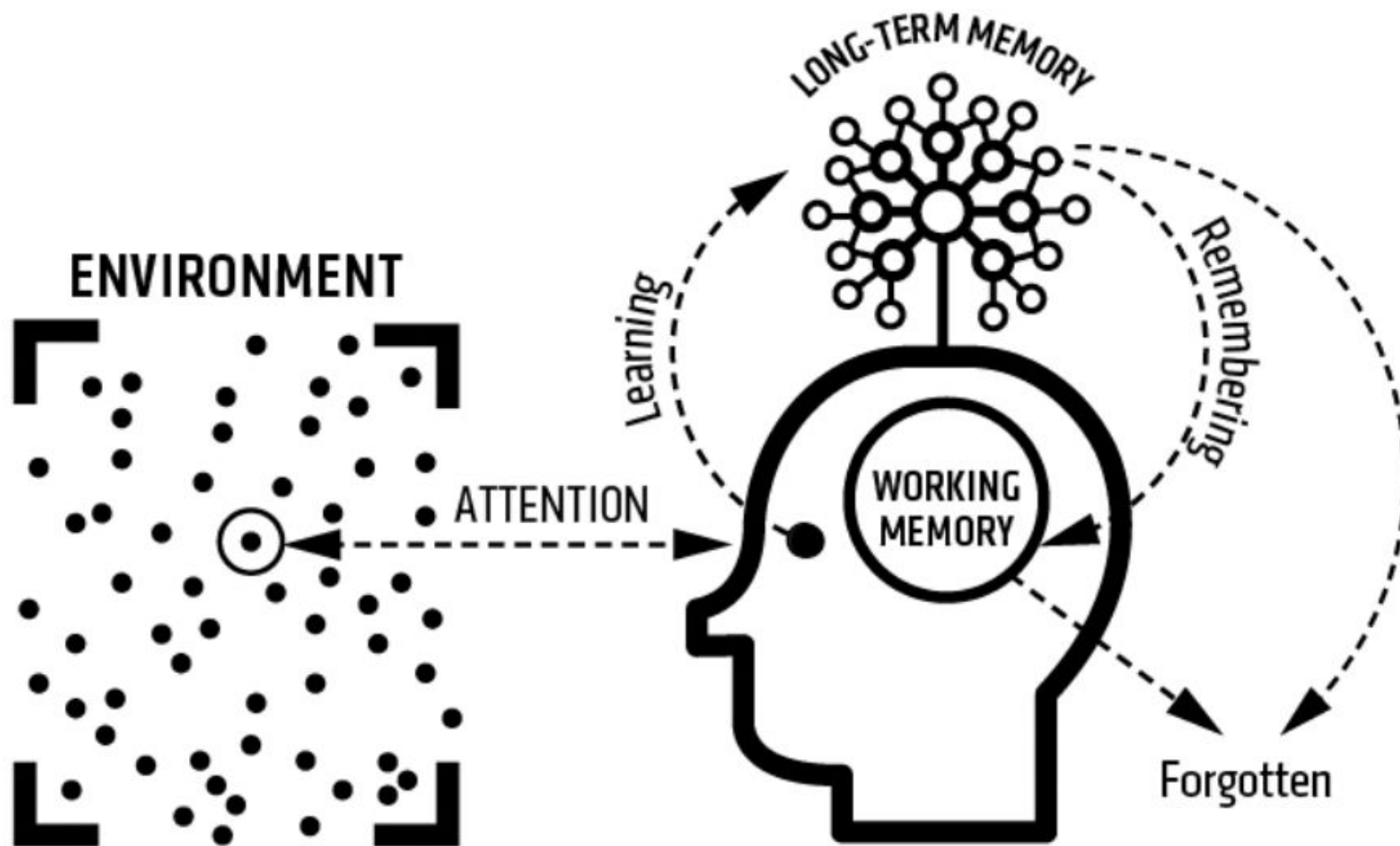


Our Goal: Transfer



What we need to accommodate





Lovell

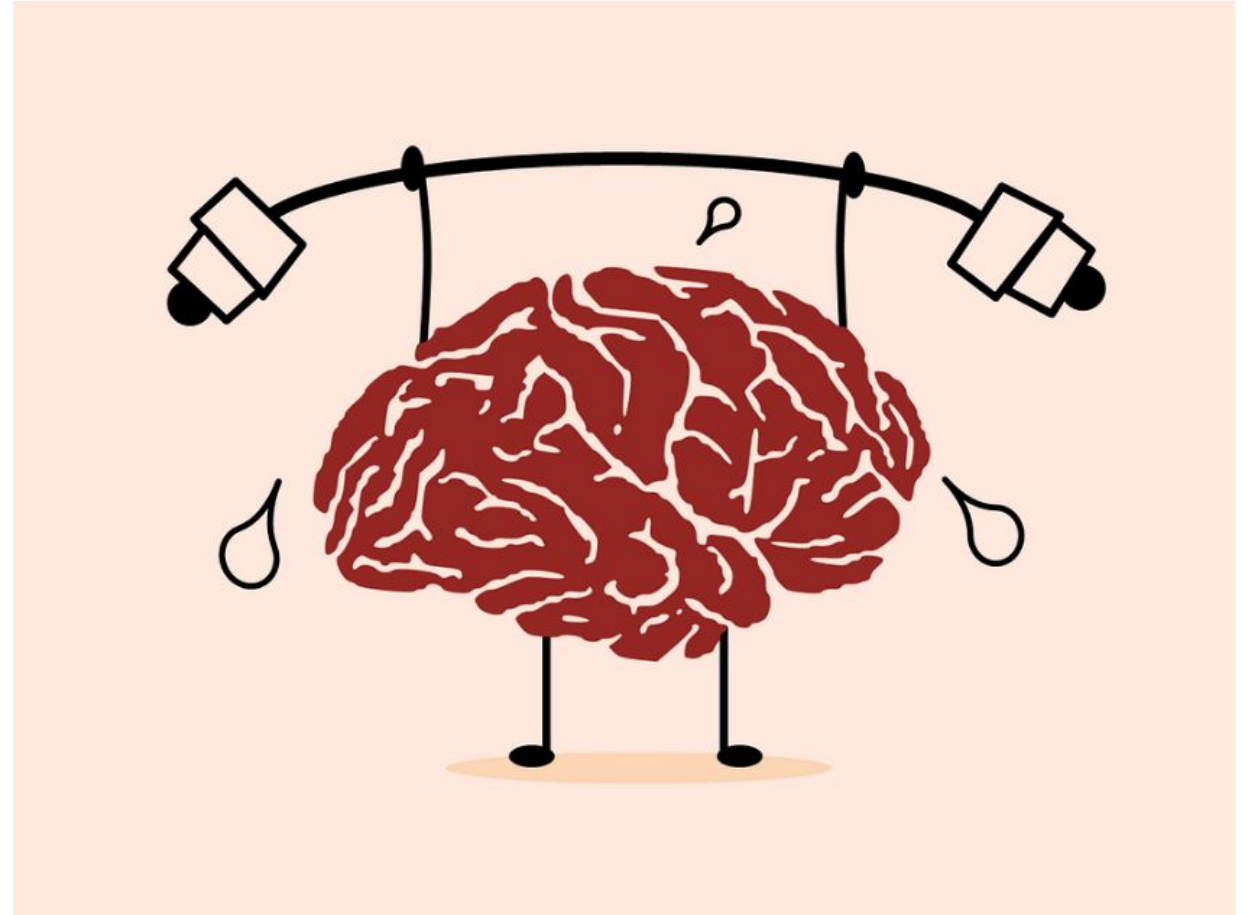
Working Memory is Limited

People are Tired and Cranky

Too much overwhelms us

Teaching is about managing working memory

5-7 Objects/relationships at once



<https://cogbites.org/2019/02/18/what-is-working-memory-training-and-what-makes-it-work/>

What is cognitive load?

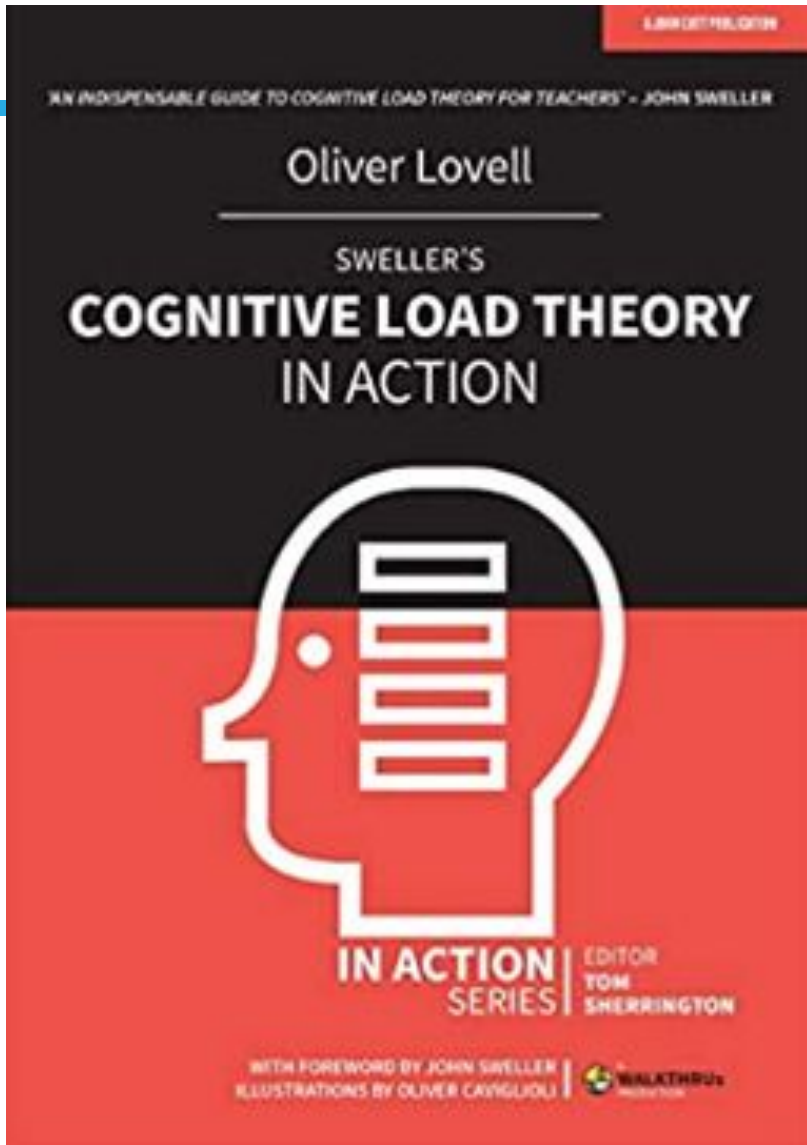
We are limited by our working memory

More than that, learners get overwhelmed and don't learn

As educators, we need to help manage students' cognitive load



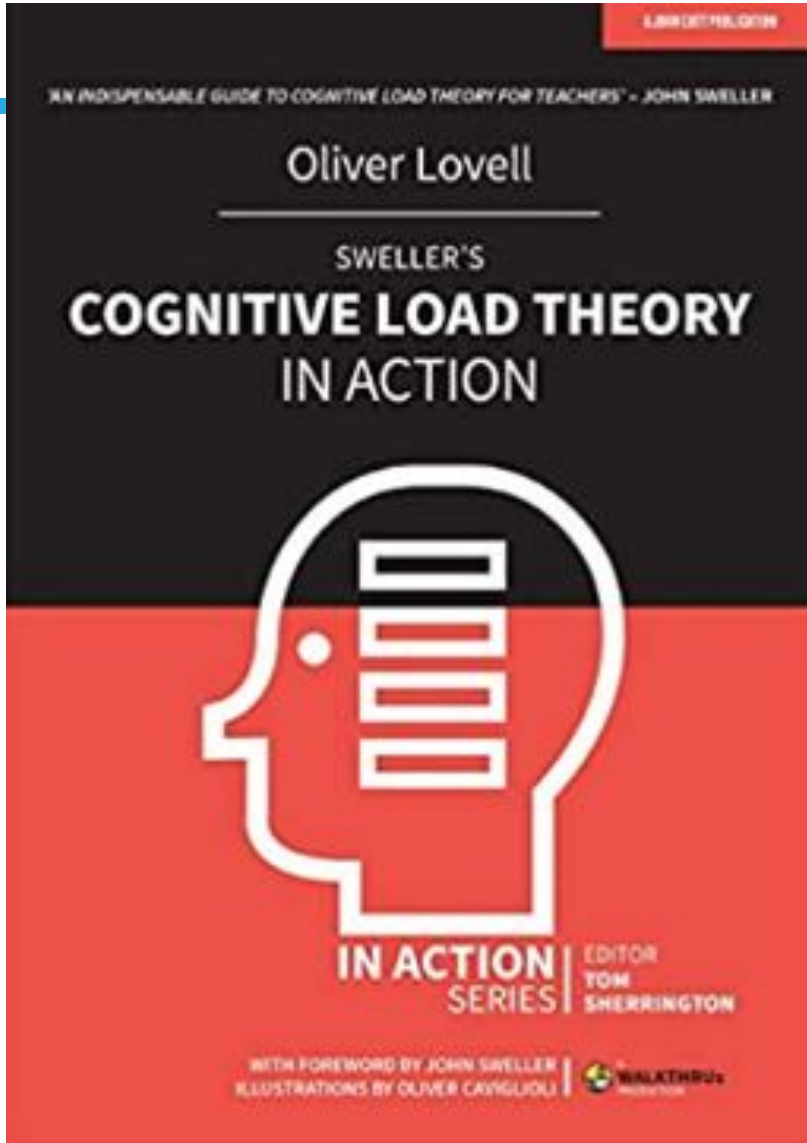
<https://medium.com/feedzaitech/cognitive-load-101-f89468e0a4d8>



Sweller's Cognitive Load Theory

In order to increase learning:

1. Reduce extraneous load, and
2. Optimize intrinsic load



Sweller's Cognitive Load Theory

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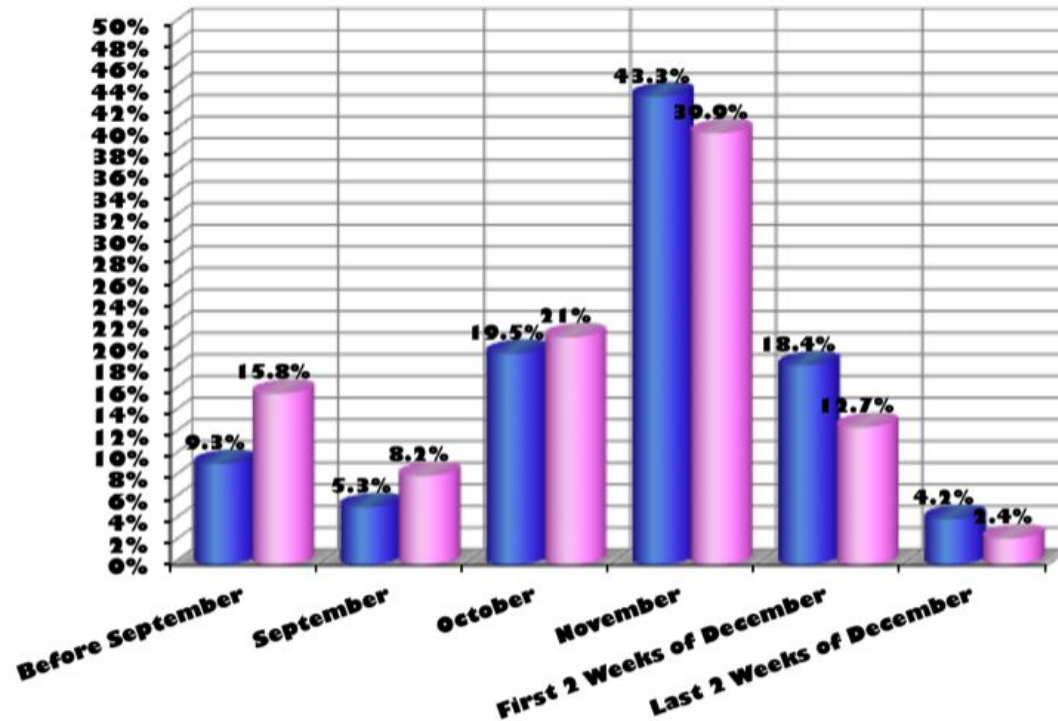
**Manage extraneous cognitive
load by eliminating
non-relevant details**

Example: eliminate non-relevant details

Before & after

Shoppers Begins Shopping for Holidays

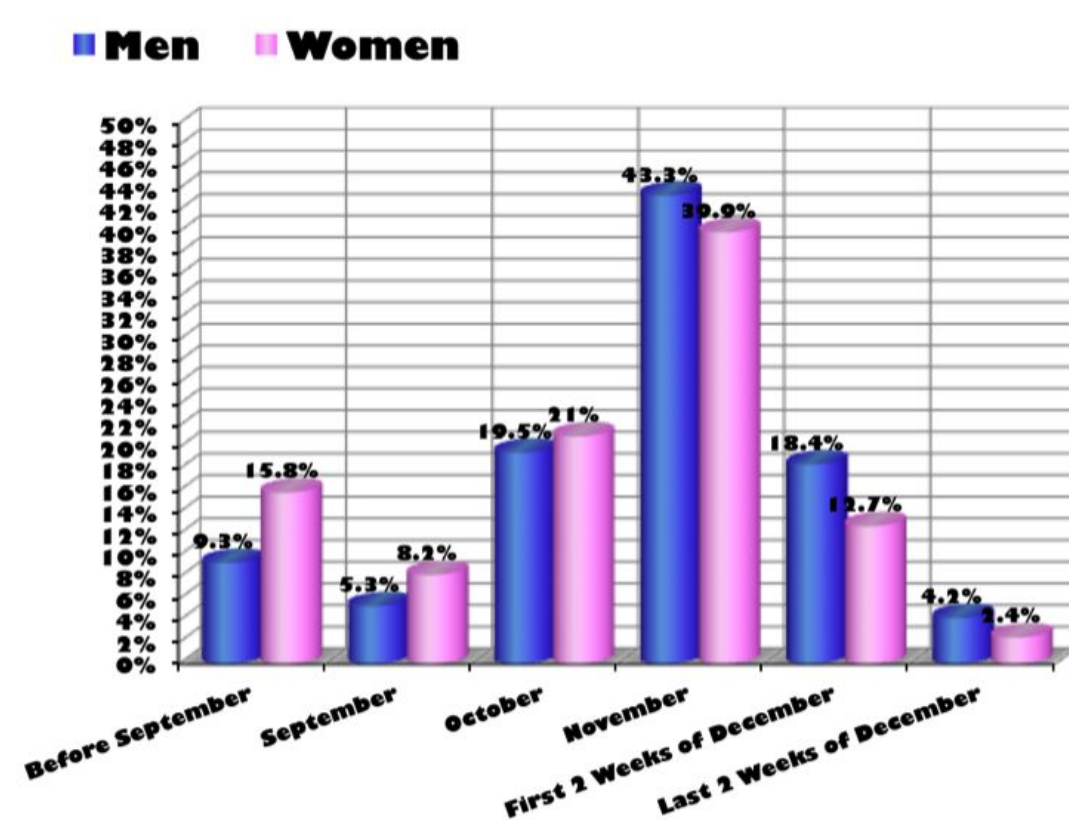
■ Men ■ Women



Example: eliminate non-relevant details

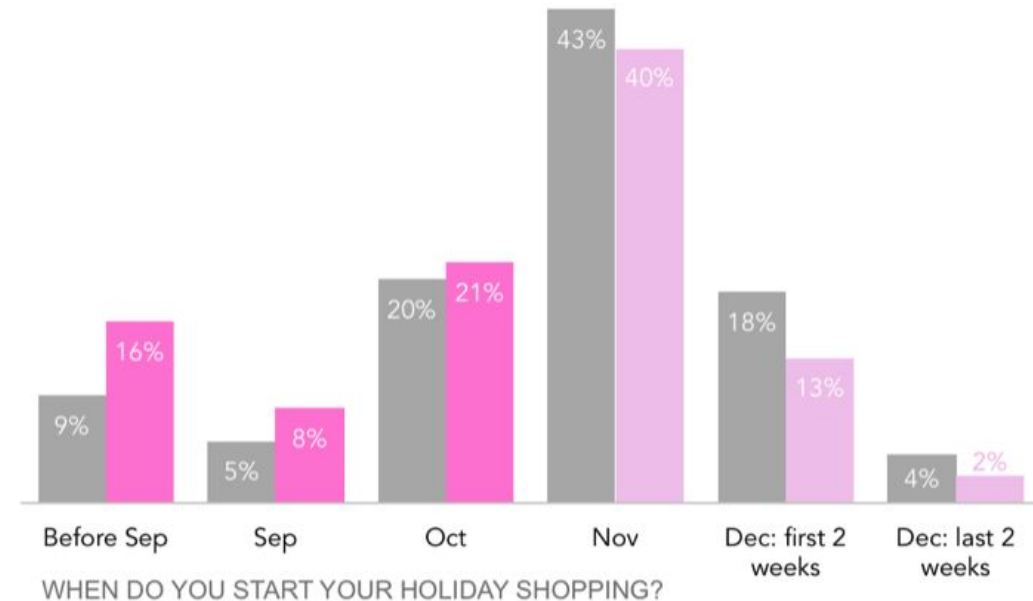
Before & after

Shoppers Begins Shopping for Holidays



More women start their holiday shopping early

■ Men ■ Women
% OF TOTAL



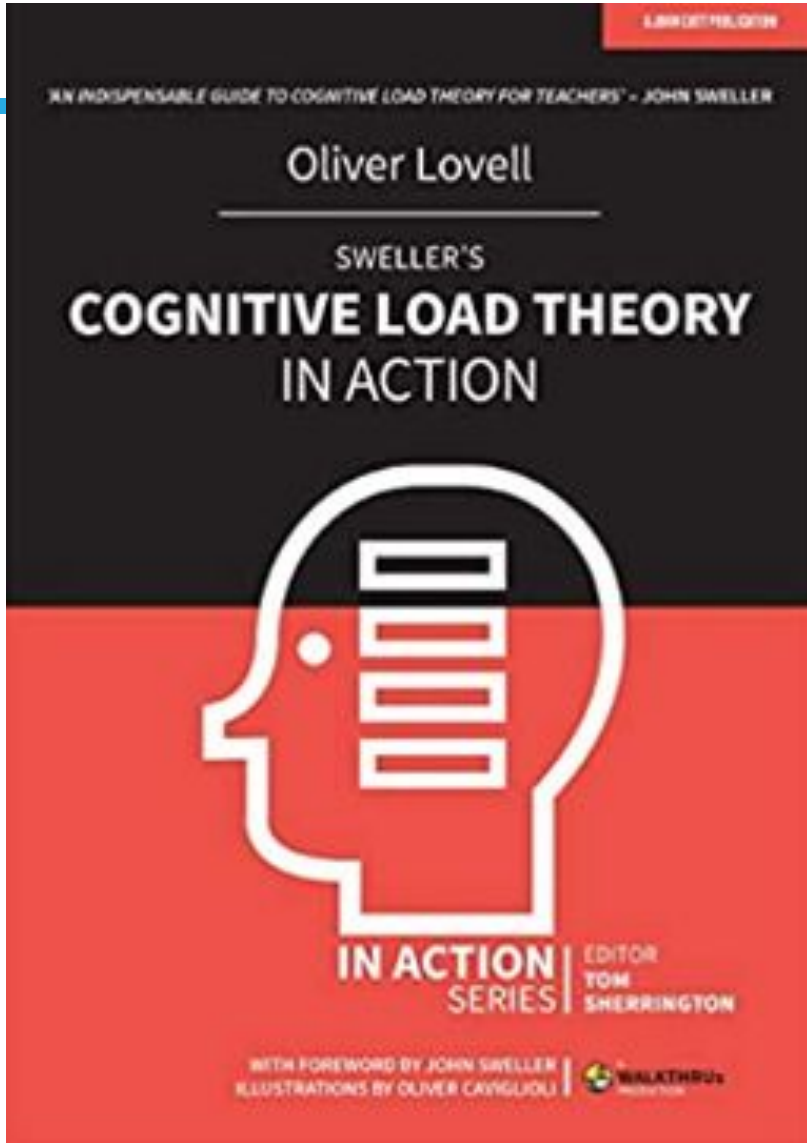
Educational Materials / Figures are pared down

Remove irrelevant details

Use figures rather than photos

Walkthrus

Explain relationships



- In order to increase learning:
1. Reduce extraneous load, and
 2. **Optimize intrinsic load**

What is intrinsic load?

Inherent complexity of a topic

How many elements?

How many relationships?

**Manage intrinsic cognitive load
by managing working memory
and using careful sequencing of
concepts using instructional
design principles**

Manage intrinsic cognitive load
by managing working memory
and using careful sequencing of
concepts **using instructional**
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Chunking Knowledge

- ▶ Reduce cognitive load by showing how information is grouped
- ▶ Helps learners know what to focus on and what to ignore
- ▶ Define "mental models" and show students how to shift them



<https://www.parentcorticalmass.com/2013/09/what-is-chunking.html>

Instructional Design (very simplified)

1. Write a learning objective
2. Decompose into smaller concepts
3. Establish relationships between concepts
4. Order/sequence concepts in lesson plan

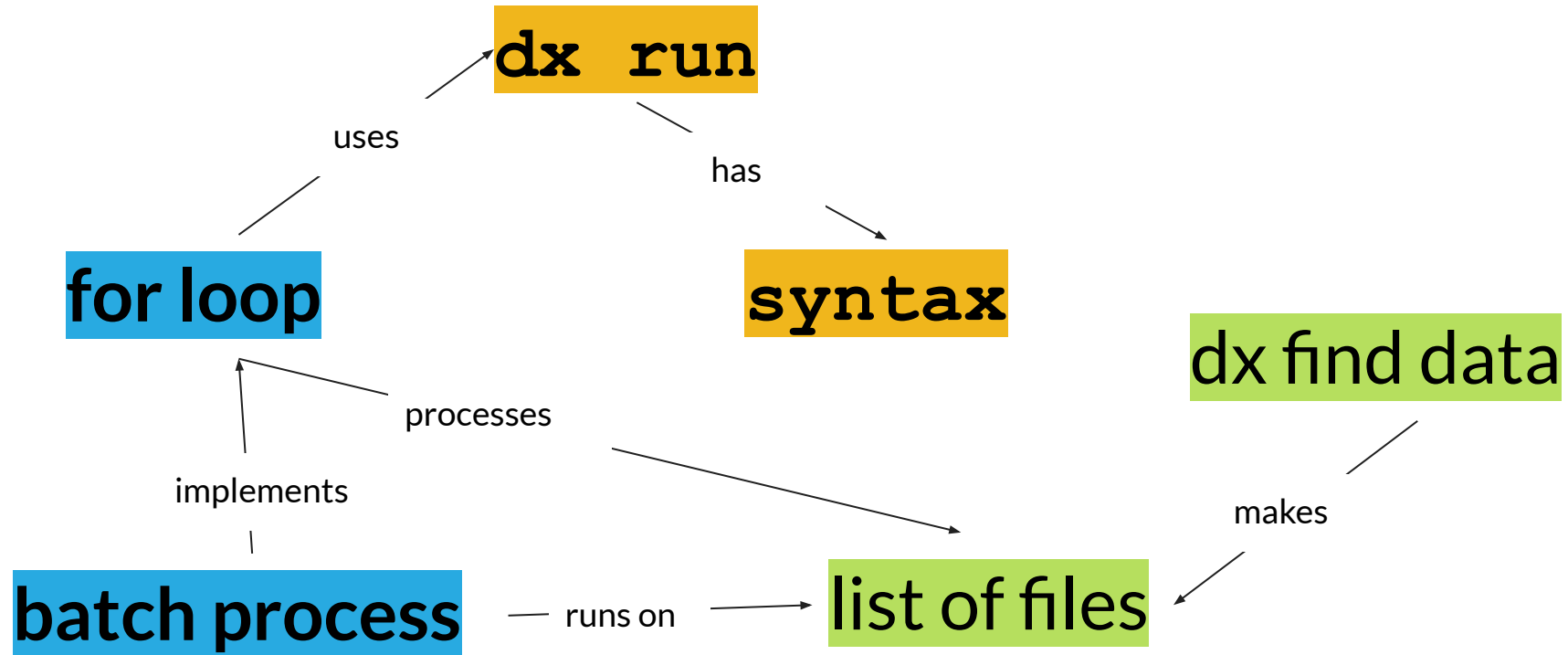
1. Learning Objective

Use `dx run` to batch process a list of files

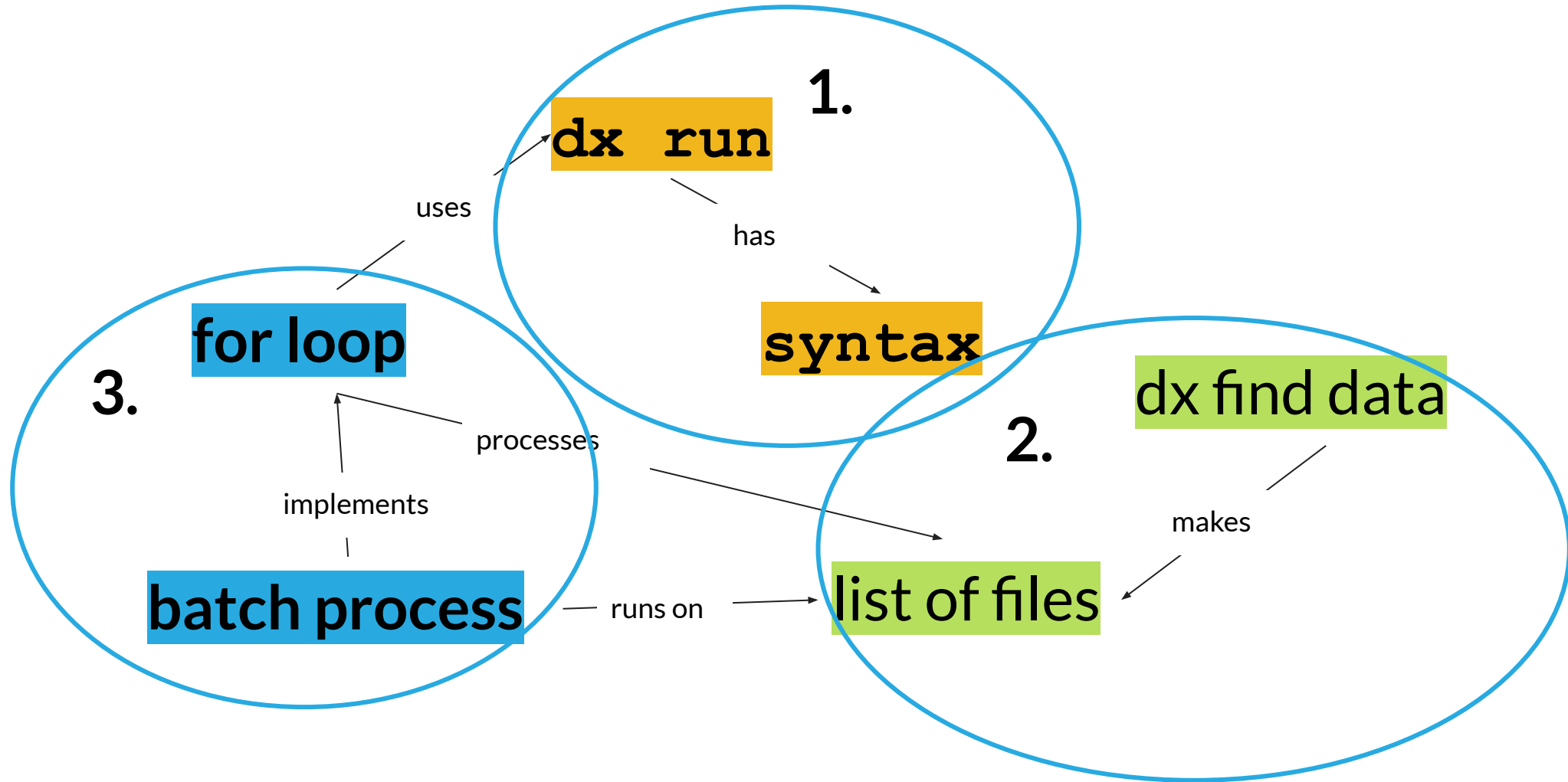
2. Decompose into Smaller Concepts

Use `dx run` to `batch process` a `list of files`

3. Establish Relationships (Concept Map)



4. Chunk and order



Active Learning using Challenges

How does coffee consumption affect medication usage in women?

Hypothesis:

Females who consume coffee have higher ibuprofen use than those who don't.

Do female coffee drinkers show a difference in ibuprofen usage compared to controls?

Treatment/medication code ...				
Participants 15,646 34,332 !				
Item	female_coff...		female_cont...	
paracetamol	3,203	18.82%	6,917	18.59%
aspirin	2,230	13.10%	4,948	13.30%
ibuprofen	2,086	12.26%	4,634	12.45%
simvastatin	1,939	11.39%	4,231	11.37%
glucosamine product	1,164	6.84%	2,433	6.54%

Designing Active Learning is Hard

- ▶ Testing and iteration important
- ▶ "Edge of Challenging"
 - ▶ (not too simple, not too hard)
- ▶ Use goal-focused questions with concrete answers
- ▶ Make sure the directions follow rules of cognitive load
- ▶ Review and reflect on answers to make sure students understand

Take Home Lessons for DNAnexus

- ▶ Effective communication
- ▶ Goal and task oriented documentation
- ▶ Establish and sequence core concepts that are necessary to be successful in running cloud jobs on the platform

Sequencing the flow of knowledge

Don't show a complex diagram all at once

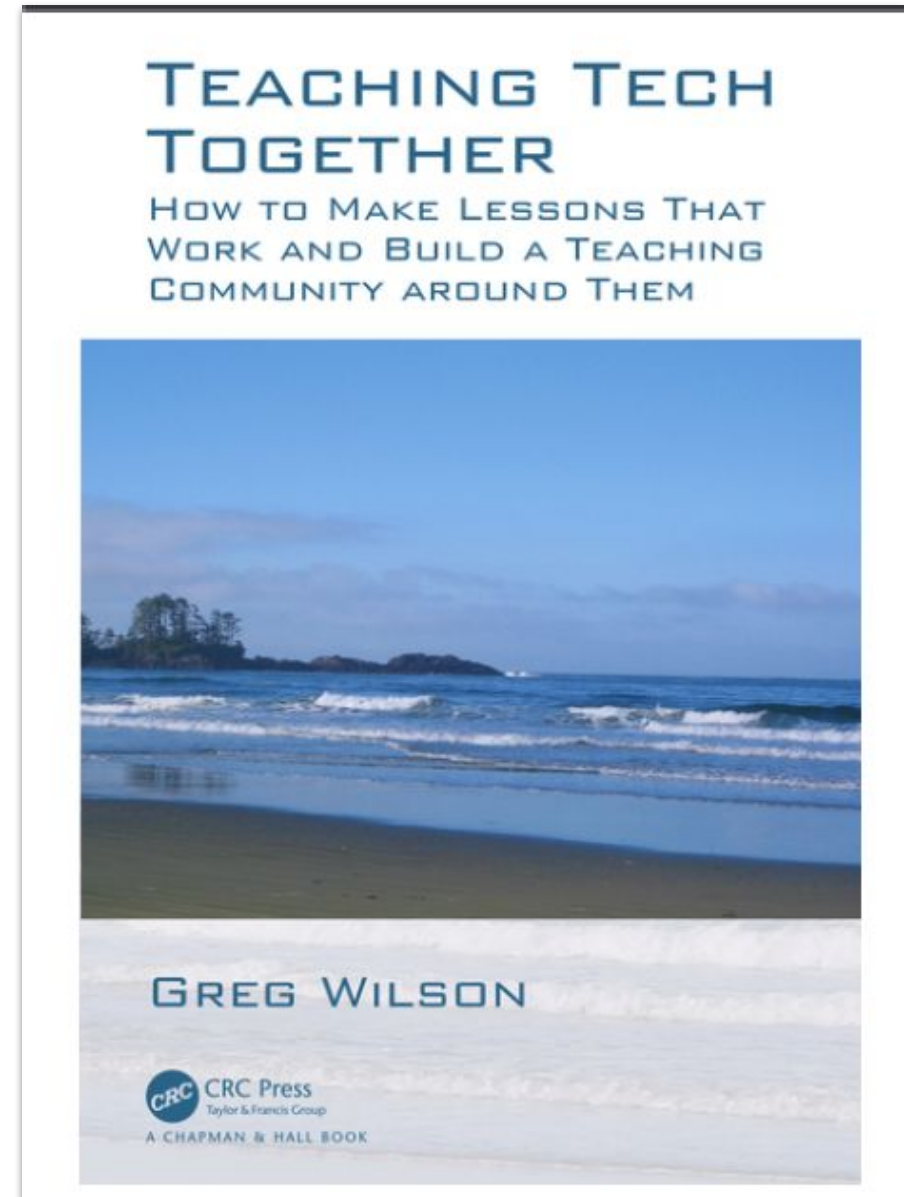
Talk about parts of the diagram

Explain relationships

Further Reading

(non affiliate links!)

- ▶ [Why Don't Students like School?](#)
- ▶ [Sweller's Cognitive Load Theory in Action](#)
- ▶ [Storytelling With Data](#)
- ▶ [Teaching Tech Together](#)



Thank You
