Thursday 6 June, UQ
12-1pm Seminar: How Students Learn (Are we giving students bad advice?)
John Falconer

Abstract
In order to help our students succeed, we should know how students learn and what the most effective ways to learn are. Should we tell students to reread their textbook as a way to better learn the material in our courses? Should we suggest they review their class notes and/or look over the solutions to homework problems before an exam? What is our basis for providing suggestions to students who do poorly on the first exam in a course? This session incorporates current research findings on learning, and provides practical information on how academics can help undergraduates improve their abilities to study and learn.

Reviewing?
Semester-long study (Brown et al. (2014) p 34-35)
All material covered in classroom, homework, etc.
Material divided into three groups, interspersed

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<tr>
<td>in addition to normal instruction</td>
<td>quiz: start of class</td>
<td>review statements in class</td>
<td>nothing additional</td>
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<td></td>
<td>quiz: end of class</td>
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<td></td>
<td>review quiz 1 day before exam</td>
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<td>quizzes not graded</td>
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<td>end of semester exam</td>
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<td>79%</td>
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**How Students Learn** (Are we giving students bad advice?)
(Are we teaching so students best learn?)

John L. Falconer
University of Colorado Boulder

You just gave your first exam:

Class average = 72
6 students < 30

What advice do you give those 6 students to prepare for the next exam?

Work together

- Identify important topics
- Exams under time
- Rewo exam
Which are the most effective study approaches

- Reread textbook 1
- Underline and highlight textbook 0
- Review notes before exam 9
- Reread solutions to HW problems before exam
- Concentrated study on one topic 4
- Study in the same location 5
- Study several hours non-stop 2
- Being persistent: continue trying to solve problem when stuck i.e., trying longer than 30 minutes 7
Answers for 25 students

- Re-read textbook [11]
- Underline and highlight textbook [10]
- Review notes before exam [23]
- Concentrated study on one topic [16]
- Study in the same location [14]
- Study several hours non-stop [20]
- Being persistent: continue trying to solve problem when stuck [17]

Conclusions?
Students not a good judge of what results in the best retention
They have not received much information on how to study

We need to tell them

> 80% of college students use rereading (#1 strategy)

**Highlighting, underlining, poring over notes: most used strategies.**

**Why not reread?**

Time consuming

Does not test recall *(recall is different from recognizing)*

Does not spend time on things you forgot

Does not result in durable memory

Self-deception- growing familiarity starts to feel like mastery

**Used because of a faulty model of how we learn and remember**

Experiments show repetition does not build memory
Going over a highlighted text: passive, can cause *fluency illusion*.

List of paired items to test learning (chair-nine, horse-mouse, forest-seven)

<table>
<thead>
<tr>
<th>Group</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>read list</td>
<td>6 times</td>
<td>6 times</td>
</tr>
<tr>
<td>told to memorize</td>
<td>the first word in paired items</td>
<td>a different list of words</td>
</tr>
</tbody>
</table>

Which group learned more?
Learning same for both groups even though the first group saw the nouns 6 more times.

Mere repetition did not enhance learning.

**Reviewing?**

Semester-long study (Brown et al. (2014) p 34-35)

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</tr>
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<td>nothing</td>
</tr>
<tr>
<td>normal instruction</td>
<td>class</td>
<td>in class</td>
<td>additional</td>
</tr>
<tr>
<td>on material</td>
<td>quiz: end of</td>
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<td></td>
<td>class</td>
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<td>review quiz 1</td>
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<td>day before exam</td>
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<tr>
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<td>79%</td>
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<td>79%</td>
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<td></td>
<td>review</td>
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<tr>
<td></td>
<td>quiz 1 day</td>
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<td></td>
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<tr>
<td></td>
<td>before exam</td>
<td></td>
<td></td>
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<tr>
<td>end of semester exam</td>
<td>92%</td>
<td>79%</td>
<td>79%</td>
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</table>

**Testing increases retention** (Brown et al. (2014) p 34-35)
Which results in better learning? Trying to solve a problem
A. before being taught the solution
B. after reading the textbook
C. after watching the instructor solve a problem
D. by looking at an example problem in the textbook

People remember things better, longer, if they are given very challenging tests on the material, tests at which they are bound to fail.

What should students do?
Practice testing (active retrieval) had the most evidence supporting its benefits for learning across context and over time.
Practice retrieving improves learning for facts, complex concepts, problem-solving techniques, and motor skills.

Recall doubled one week later

![Graph showing recall improvement over study methods](image)
Retrieving a memory makes it stronger.

The harder your brain works to dig out the memory, the greater the increase in learning

Active retrieval tells what you know and don’t know
Which study approach is more effective for learning a particular subject?

<table>
<thead>
<tr>
<th></th>
<th>Mon</th>
<th>Wed</th>
<th>Fri</th>
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<tbody>
<tr>
<td>A.</td>
<td>30 min</td>
<td>30 min</td>
<td>30 min</td>
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<tr>
<td>B.</td>
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<td>90 min</td>
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<tr>
<td>C.</td>
<td>45 min</td>
<td>45 min</td>
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</tbody>
</table>

24 students selected A but when asked what they do, however

A. 0
B. 11
C. 13

Learn pairs of syllables and adjective (lum-happy)

**test: 1 day later**
Pairs recalled

1-day delay
massed learning
8 times: same day

distributed learning
2 times per day: 4 days

1-week delay

Pairs recalled

1-day delay
massed learning
8 times: same day

distributed learning
2 times per day: 4 days

Test: 1 week later
Less total study time if space out study

Repeated *practice testing* works best when spaced.

**Desirable difficulties**

Conditions of learning that make performance improve rapidly often fail to support long-term retention and transfer.

Conditions that create challenges and slow the rate of apparent learning often optimize long-term retention and transfer.

How can students improve learning that does not involve studying?
Exercise

Get enough sleep

**Exercise**
- improves memory and learning ability
- enhances growth of hippocampus cells
- reduces stress
- improves ability to focus
Sleep
- has an important role in memory formation
- if you don’t sleep, you’ll remember a lot less
- sleep deprivation can worsen performance in a declarative memory test by as much as 20-50%

Students given a series of math problems with a method to solve them. 12 hours later, given more problems

<table>
<thead>
<tr>
<th>12-hour delay</th>
<th>Percent who discovered shortcut</th>
</tr>
</thead>
<tbody>
<tr>
<td>awake</td>
<td>20%</td>
</tr>
<tr>
<td>sleep 8 hours</td>
<td>60%</td>
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</tbody>
</table>
Interleaved practice
Percentage correct answers on sets of problems

Test: 1 week later
Find volumes of different geometric solids

<table>
<thead>
<tr>
<th></th>
<th>Group 1</th>
<th>Group 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>practice problems</td>
<td>![Images](Group 1)</td>
<td>![Images](Group 2)</td>
</tr>
<tr>
<td>% correct during practice</td>
<td>89%</td>
<td>60%</td>
</tr>
<tr>
<td>% correct on test 1 week later</td>
<td>20%</td>
<td>63%</td>
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Learning from interleaved practice feels slower (can be confusing)
Much more effective in long term
Teaching slope and graph problems.
Homework either interleaved or blocked
Interleaved: both old and new problems of different types mixed together
Surprise final test: either 1 day or 1 month later
  1 day later: interleaving group 25% better
  1 month later: interleaving group 76% better.

Self-explanation
Explain how new info is related to known info; explain steps during problem solving.
Percent of logical reasoning problems answered correctly
Constantly ask yourself “why?” and “what if?” questions

Study in various locations: you need to recall in various locations. Simply alternating the room where you study improves retention. Vary conditions, background, type music, etc.
Memorizing 40 words (same study time):

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<tbody>
<tr>
<td>study twice</td>
<td>1 room</td>
<td>2 rooms</td>
</tr>
<tr>
<td>words remembered</td>
<td>16</td>
<td>24</td>
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The brain makes subtle associations between what it is studying and the background sensations it has at the time.
Learning strategy (interruption to initiate percolation)
Start work on large projects as soon as possible
Stop when stuck - this activates the project and initiates percolation
    sleep, exercise, work on something else

Two modes of thinking:
Focused: Concentrating on things that are usually familiar.
Diffused: A relaxed mode of thinking "your thoughts are free to wander".
What can you do?

Explain to students how learning works
Use frequent quizzing to help students consolidate learning
Design quizzes/exercises to reach back to concepts and learning covered earlier in semester
Suggest that students schedule exact times they will study for exam
Explain desirable difficulties
Meet with students who don’t perform well on first exam

Meeting with students improved student performance
Email intervention almost same as no intervention


Course A                                        Course B
Thermodynamics exam performance improvement

<table>
<thead>
<tr>
<th>Exam 1</th>
<th>Exam 2</th>
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<tbody>
<tr>
<td>26</td>
<td>73</td>
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<td>75</td>
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<tr>
<td>51</td>
<td>85</td>
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Atomic Habits book: Schedule specific times to study

When studying groups over two weeks:

1. Record where they will exercise (35% exercised)
2. Record where they will exercise and tell the benefits (38% exercised)
3. Record where exercise but **plan specific times and days to exercise** (91% exercised)
Pre-exam survey Final Exam

1. Successful high achievers use resources strategically when preparing for exams. Indicate which resources will facilitate your studying so as maximize the effectiveness of your learning. Briefly describe how you plan to use that resource.

☐ Solving practice exams
☐ Re-solving homework problems
☐ Re-doing in-class ConcepTests (clicker questions)
☐ Re-watching some screencasts
☐ Going to office hours to clarify unclear aspects
☐ Discussing with and explaining to classmates
☐ Using interactive simulations
☐ Reading over test taking tips
☐ Looking at the equation pages that you will bring to the exam
☐ Other (describe)

2. Having a **concrete schedule** for studying so that your studying is spread over multiple days will better prepare you for the exam. Describe a concrete plan for your studying (what you will study each day, at what time, and for how long) for the 9 days before the exam. You are more likely to follow the plan if you schedule the time each day that you will study. Each day might look something like this:

   Sunday 4:00-5:00 PM  Answer Chap 17 ConcepTests;  
   8:30-9:30 PM   Solve Chap 4 example problems
How to Study/How to Learn

**Screencasts**

- How to Study: Part 1 - discusses practice testing
- How to Study: Part 2 - discusses distributed practice and interleaved practice
- How to Study: Part 3 - discusses additional approaches to studying to improve retention, and what approaches to avoid
- How to Study using Screencasts
- Testing Effect - the testing effect is the finding that long-term retention and memory is improved when one tests themselves as opposed to simply reviewing the material.
- Spaced Repetition - spaced repetition is a learning technique where you review material and increasingly spaced intervals to improve long-term retention. This video covers the definition of spaced repetition and how to implement it.
- Interleaved Learning
- Memory Rehearsal: Factors in Learning Chapter
- Fixed Mindset vs. Growth Mindset
- 13 Study Tips - some tips that are based on widely accepted research by neuroscientists and learning experts.

**Handout**

- How to Study/How to Learn
Recommended reading

*How to Study* screencasts on [www.LearnChemE.com](http://www.LearnChemE.com) and YouTube