Transforming traditional large lectures into active learning environments

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UBC is committed to improving student learning in undergraduate physics by transforming their traditional large lectures (> 200 students) into interactive classrooms. Instructors engage the students with challenging questions and tasks, which allow students to practice problem solving and reasoning skills. Also interrupting lecture with a task allows students to refocus and receive frequent targeted feedback from the instructor. Here we report on two components introduced into several first-year physics courses: (i) pre-class assignments that are completed at home by the students online, and (ii) worksheets that are worked on in small groups in class.

PRE-CLASS ASSIGNMENTS

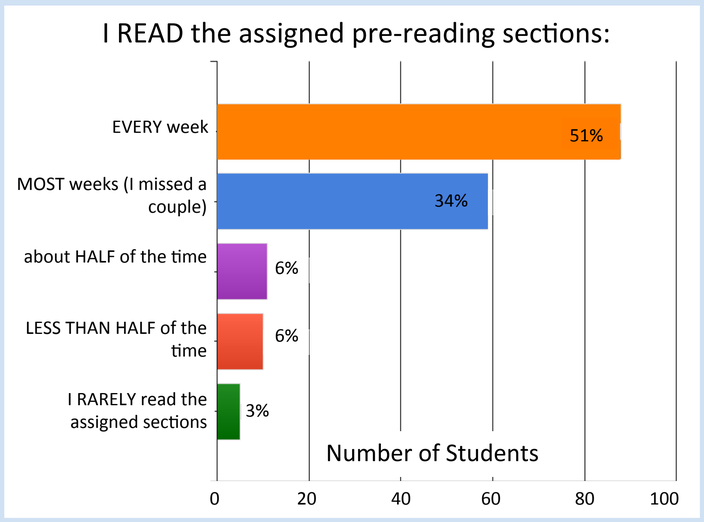
The main purpose of a pre-class assignment is to prepare students for learning in the next class. Similar to *Just-In-Time-Teaching*, students are first introduced to the material by reading the textbook, so that lecture becomes their second exposure. By assigning guided readings (example below) coupled with targeted quiz questions, students begin to recognize the textbook as being helpful to their learning.

refer to specific figures, equations, and examples; give questions to focus reading

21.4 Standing Sound Waves and Musical Acoustics. Compare Fig. 21.16 to 21.11: Only certain wavelengths fit on a string or inside a tube. Make sure you understand what the boundaries (open or closed tube) impose on the wavelengths and where equations 21.17 and 21.18 come from. Look carefully at example 21.5 and 21.6 . Compare the equation for a traveling wave to that of a standing wave. Why is the amplitude 2a? Is a standing wave moving?

- → Students must complete an online quiz due before lectures on Mondays.
- → Quiz questions will often refer to specific figures as well, e.g., In Fig. 21.4, what does the red line represent?
- → Clear tie to textbook & connection to lecture
- → Expectations: students should read text, but it's OK if they are confused

Are the students *actually* reading the text?



Phys 101 introductory physics course

85% of the students report reading the textbook on a regular basis
→ matches student comments

97% of the students report taking the quiz on a regular basis
→ confirmed by electronic records

Benefits

student
- first exposure at their own pace
- explicitly guided reading helps students focus
- come prepared for lecture – critical for peer instruction

instructor
- better use of class time
- reveal possible trouble-spots
- higher level questions in class

What MOTIVATED you to do the pre-readings?

109: helps understand material/ know what to expect in lectures/ found routine helpful
56: only for the 2% marks
3: did not find the pre-reading helpful

STUDENT COMMENTS

"I think it is very valuable to have the pre-readings to understand the lecture material and the pre-reading quizzes because if there are questions on the quiz that look unfamiliar or I'm not completely comfortable with it motivates me to go back to the text."

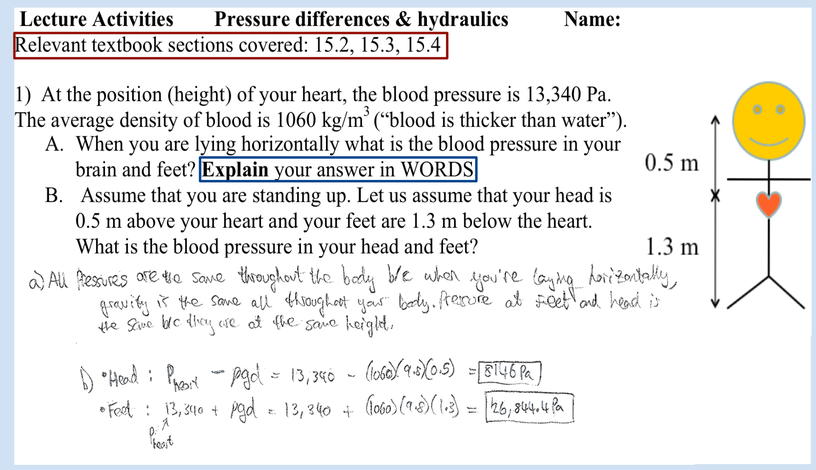
"It's for marks and it gives me a heads up on what we will be learning in class. it helps me to distinguish what I know and what I have troubles with so I can be all ears in the parts where I am struggling with in class."

The pre-readings were more useful than I thought. It was evident during the week where there was no pre-reading and I wasn't sure what the lecture was going to cover. I had much more difficulty understanding the concepts that week. "

IN-CLASS WORKSHEETS

The purpose of in-class worksheets (example right) is to engage the students with the new material. This forces the students to recognize which parts of the lecture they have understood and where they are still struggling.

- → Students asked to do calculations AND explain their answers
- → Connect to information in textbook
- → Encouraged to work together
- → More problems than can be finished in class
- → Similar questions appear on exams
- → FEEDBACK: mix of clicker questions, class discussion, work through problem at front



Lecture Activities Pressure differences & hydraulics Name:

Relevant textbook sections covered: 15.2, 15.3, 15.4

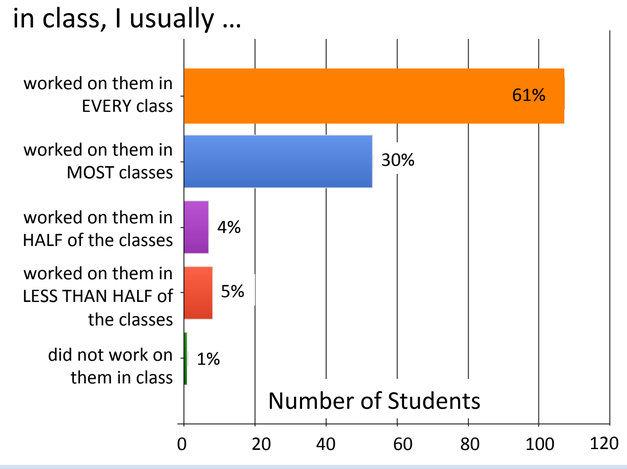
1) At the position (height) of your heart, the blood pressure is 13,340 Pa. The average density of blood is 1060 kg/m^3 ("blood is thicker than water").
   A. When you are lying horizontally what is the blood pressure in your brain and feet? **Explain** your answer in WORDS
   B. Assume that you are standing up. Let us assume that your head is 0.5 m above your heart and your feet are 1.3 m below the heart. What is the blood pressure in your head and feet?

0.5 m
1.3 m

a) All pressures are the same throughout the body b/c when you're laying horizontally, gravity is the same all throughout your body. Pressure at feet and head is the same b/c they are at the same height.

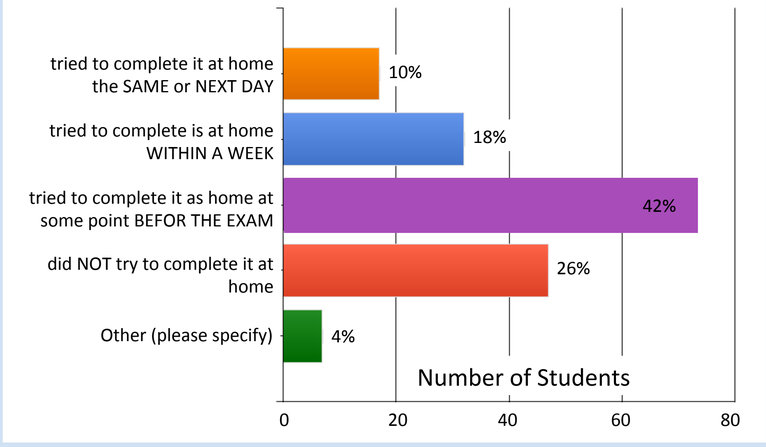
b) •Head : $P_{heart} - \rho g d = 13,340 - (1060)(9.8)(0.5) = 8146\ Pa$
•Feet : $13,340 + \rho g d = 13,340 + (1060)(9.8)(1.3) = 26,844.4\ Pa$
(P_{heart})

When given time to work on the worksheets in class, I usually …



91% of the students report regularly working on the worksheets
→ even though worth NO marks
→ confirmed by classroom observations

If we did NOT FINISH a worksheet in class, I usually …



70% of the students report trying to complete the worksheets
→ even though answers were NOT regularly posted

What MOTIVATED you to do the worksheets?

170: to know how well I am understanding the material /apply pre-reading/ work with others/ good practice/ everyone is doing them/ to solve it/ possibility of a follow-up clicker question/the challenge/ do well on the exam/ immediate feedback
0: not finding the worksheets helpful or worth their time

STUDENT COMMENTS

"Trying the problems after just being introduced to concepts is such a great way to understand the material. It allows you to clarify the concepts and realize what you are unsure of."

"I wanted to see if I actually understood what I had done in the pre-reading and to see if I could apply it."

"I found that the worksheets were really helpful to "cement" the concepts in my mind. It was also a good break from the lecture ... Plus it was helpful to have other people around me to help me if I didn't understand the questions."

"At first I wasnt really motivated to work on them at all, but once I realized that they helped my learning and would likely improve my mark I started working on them."

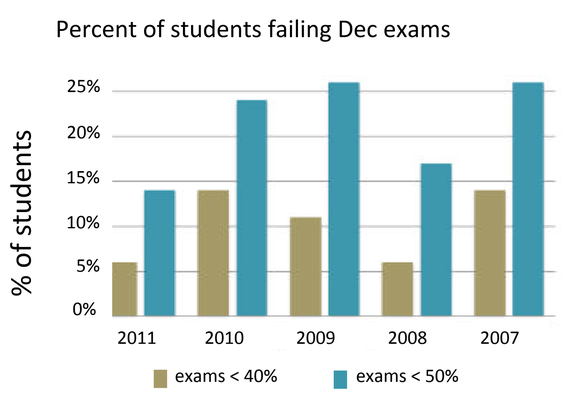
"I was not particularly fond of physics to begin with, but I actually started to enjoy it somewhat as the course unfolded. Although this course hasn't made me want to major in physics or pursue a career in physics, my appreciation and understanding of its relevance in our lives and in the world were certainly made clear in this course, I am glad that I had to take this course because I learned a lot. The reading assignments were very helpful, because they introduced to certain concepts that I might otherwise have overlooked or disregarded. I found the Mastering Physics problem sets, worksheets and tutorials to be particularly helpful because they helped to reinforce the important concepts from our readings that I usually did not understand too well, and the tutorials really helped to show me how to apply certain concepts with certain formulas in order to solve a problem."

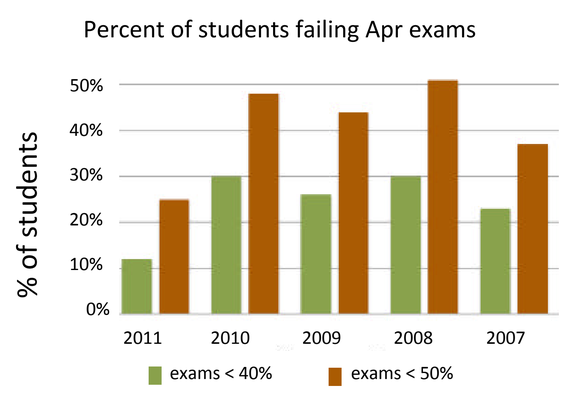
IMPROVED EXAM PERFORMANCE

Compare final exam raw scores over the years for PHYS 153: physics for engineers
→ 2011 course fully transformed

CONTENT
Dec exam: thermodynamics, simple harmonic oscillators, waves

Apr exam: electricity and magnetism, circuits, EM waves





CONCLUSIONS

- ✓technology allows for individual feedback in large lectures
- ✓students recognize the benefits of active learning components
- ✓positive student feedback may increase motivation
- ✓fewer students failing exams

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