Moving away from dogmatic teaching: Experiences and Perspectives

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Lower-level life science undergraduate modules

- Large-classes at lower undergraduate levels are quite common
- Students are younger and need more guidance than higher level undergraduates
  - Important issues with large-classes include:
    - Diverse range of abilities
    - Student Engagement

Large-class settings for a Cell Biology module

- Time, Efficiency and Content
  - Didactic teaching?
    - Disseminate lots of information to make efficient use of time?
    - Didactic teaching has its advantages but it is **not** necessary and useful to make this the **only** mode of teaching for **all** lessons

Concerns about student engagement in large-class settings

- For classes 100 to 300 students in size, the concern has been engaging students in the topics taught.
- Didactic teaching is not always consistent with engaging students in class.
  - There is now a greater push towards active-learning
  - For us, we had wanted to promote active-learning during lectures/lessons

Active-learning in large-class settings

- Share your thoughts about active-learning
  - What you do think "active-learning" means?
    - Go to:
    - https://www.socrative.com/
      - Any mobile device with internet browser is fine
    - login as a Student
    - My classroom: 151525
    - Please provide input for **Question 1, 2 and 3**

Active-learning in large-class settings

- Engage students during lessons as opposed to getting students to listen passively to the instructor (Dewey, 1916; Wood, 2009)
  - Low engagement correlated with low retention of students in STEM (e.g. United States President's Council of Advisors on Science and Technology (PCAST) 2012)
- Active-learning during classes has been promoted in recent years as an alternative to didactic teaching
- How to conceptualise Active-learning and put it in action?

Conceptualising Active-learning: Using the idea of **Generative-learning**

- "the brain is not a passive consumer of information"
- "to learn with understanding a learner must actively construct meaning."
  - Linking external sensory stimulation to prior knowledge/experience, i.e. relating to existing understanding and/or re-building understanding

(based on Wittrock, discussed in Osborne & Wittrock, 1983)

Conceptualising Active-learning: Using the idea of **Generative-learning**

- "When we give information to pupils or answer a pupil question, our statement or explanation may help a pupil, but it can only help or lead to a **new** perception when the pupil does something with the information."
- "In generative learning, the pupil's knowledge, inference, and learning strategies are critically important because, as strange as it may seem, answers given to the pupil must still be generated or discovered by the pupil before they are comprehended."

(based on Wittrock, discussed in Osborne & Wittrock, 1983)

Conceptualising Active-learning: Using the idea of **Generative-learning**

- Generative learning – "those activities involving the actual creation of relationships and meaning are classified as generative learning strategies"

(Grabowski, 1996 in Richie and Volkl, 2000)

Conceptualising Active-learning: Using the idea of Generative-learning

- One approach in generative-learning is to uncover organisational relationships between different components of the environment:
- creating titles, headings, questions, objectives, summaries, graphs, tables, and concept maps.
- manipulation of objects, such as in a laboratory experiment.

(Grabowski, 1996 in Richie and Volkl, 2000)

Conceptualising Active-learning: Using the idea of Generative-learning

- A second type of generative activity integrates relationships between external stimuli and memory
- construct demonstrations, metaphors, analogies, examples, pictures, applications, paraphrases, or inferences.
- "…these activities not only require deeper processing of the instructional content, but they also result in a higher level of understanding."

(Grabowski, 1996 in Richie and Volkl, 2000)

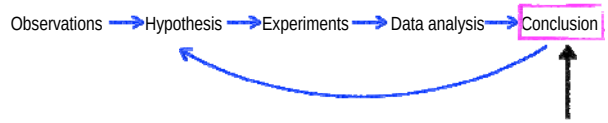
Using the idea of Generative-learning to reduce teaching in a dogmatic manner

- We as teachers have to:
- "… more clearly link instruction which develops sound understanding in science to the solution of problems,"
- and
- "to overtly explore … problems which can be solved by particular scientific models, and to overtly encourage strategies which enable pupils to construct meaning from problems …"

(based on Wittrock, discussed in Osborne & Wittrock, 1983)

Using the idea of Generative-learning to reduce teaching in a dogmatic manner

Simple overview of how we arrive at scientific knowledge:



We teach this mostly in a dogmatic manner

Perhaps this is why students show passive learning behaviour and not think critically??

Using the idea of Generative-learning to reduce teaching in a dogmatic manner

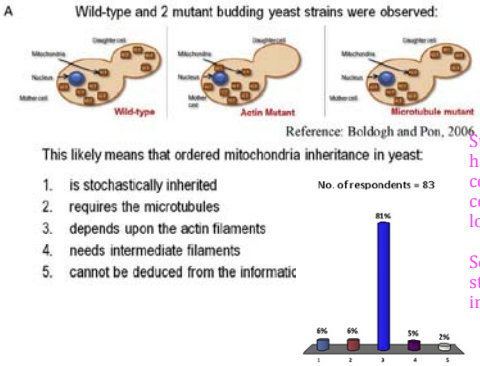
- One way to help reduce the problem of a dogmatic approach in the dissemination of knowledge in Cell Biology is to avoid always explicitly stating facts and concepts.
- Instead, during lectures, students could be tasked to reason through data to arrive at some understanding/knowledge – generative-learning model

How I tried to reduce teaching in a dogmatic manner

- I used to **state** in class that:
- *"mitochondria are inherited in certain organisms such as the budding yeast using actin filaments"*
- This was meant as **a piece of information** students needed to "know"
  - Students memorised this piece of information for the exams
    - since this was the way we teach and assess the information (multiple-choice questions)

Getting students to think about organelle inheritance

I tried using simple representations to **get students to deduce** how mitochondria are inherited in yeast:



Students appeared to have no problems coming to the right conclusions just by logical deductions.

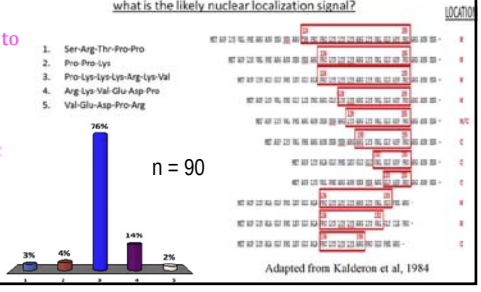
So this implies that students can make inferences from data

Getting students to deduce the nuclear-localisation signal (NLS) as another example

- I used to **state** for students in class the following statements:
  - *The data showing how a typical nuclear-localisation signal was derived from experiments conducted using the SV40 T antigen.*
  - *From the data, the typical NLS was found to be "PKKKRRV"*
    - So not surprisingly, students memorised the information for the exams

Getting students to deduce the nuclear-localisation signal (NLS)

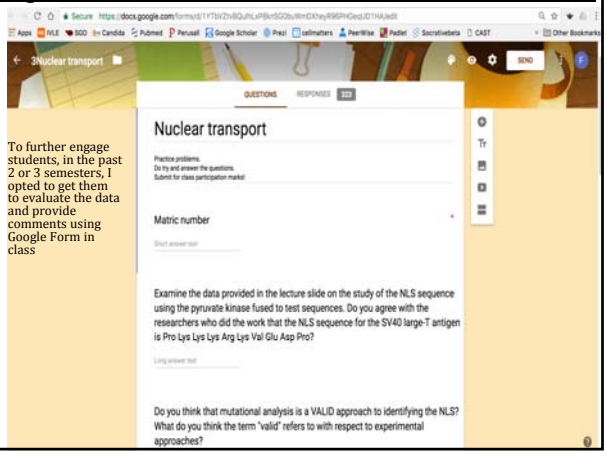
- I tested the possibility of using the **original** experimental data in class to get students to **derive** for themselves the likely NLS
- Clicker-type question incorporated into Powerpoint slides



Students appeared to have no problems coming to the right conclusions

No need to state for students every concept or fact?

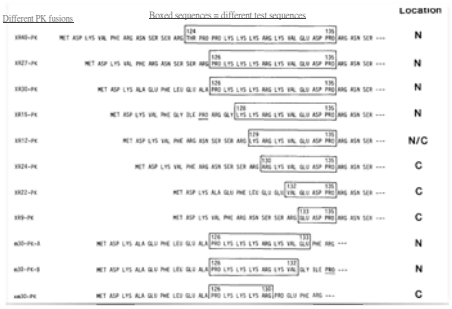
Getting students to discuss data on how the NLS was deduced



To further engage students, in the past 2 or 3 semesters, I opted to get them to evaluate the data and provide comments using Google Form in class

Getting students to discuss data on how the NLS was deduced

Examine the data provided in the lecture slide on the study of the NLS sequence using the pyruvate kinase fused to test sequences. Do you agree with the researchers who did the work that the NLS sequence for the SV40 large-T antigen is Pro Lys Lys Lys Arg Lys Val Glu Asp Pro?



Samples of students' written answers in class

- I got a number of answers like this:

No. I believe it is PRO-LYS-LYS-LYS-ARG.

- But also quite a number like these:

No. It should be instead, starting from position 128: Lys Lys Arg Lys Val. This is because this sequence is the most conserved amongst the mutants that still imported the protein successfully into the nucleus.

The data shows the fusions of different pyruvate kinase with different mutant test sequences (boxed) and their expressed locations. It is to show which sequence region affect the large-T localization. I don't agree with the result on the above sequence, because for 130-135 localizes at C (the minimal sequence region is 134-135) and 126-130 localizes at C. Thus, sequence Pro Lys Lys Lys Arg Lys Val Glu Asp Pro should be found in C

I think Lys Lys Arg Lys Val is sufficient for NLS sequence because in XR15-PK, without the Pro Lys, pyruvate kinase is still translocated to the nucleus. Also, because in m30-PK-B, without Glu Asp Pro, pyruvate kinase is still translocated to the nucleus.

No. The NLS sequence does not need both ends of the above mentioned protein sequence. From the results, either the first half or the second half can confer localisation. So it may possibly be 2 different types of NLS that may just be a random variation. Hence, the sequence may just be Pro Lys Lys Lys

Is the first Pro part of the NLS for qn 1 and why?

Samples of students' written answers in class

- From content analysis of students' written answers, it is fair to suggest that:
  - students seemed engaged
  - they had an opportunity to articulate their thoughts

Samples of students' written answers in class

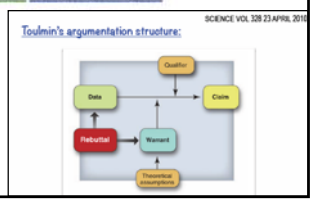
- From content analysis of students' written answers, it is fair to suggest that:
  - a number of students appeared also able to use **scientific argument**, although this was not taught specifically in the class:

claim — something like a warrant — data

No. To reduce the minimum sequence for the NLS, we can look at the shortest possible sequence whereby the PK is still able to be shuttled to the nucleus from the cytoplasm. If we look at m30-PK-B, the sequence is Pro Lys Lys Lys Arg Lys Val. The other text sequences which allowed the transport of the PK protein into the nucleus are longer than this particular sequence. Hence, the researchers are probably wrong.

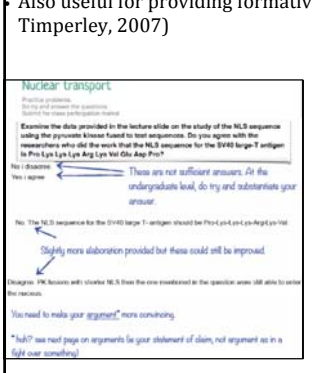
rebuttal of alternative claims

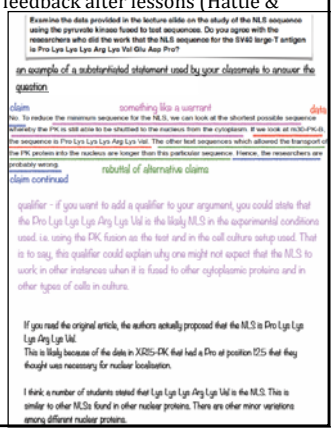
claim continued



Feedback to students' answers at Google Forms

- Also useful for providing formative feedback after lessons (Hattie & Timperley, 2007)





Can you think of an activity to run **in class** by simply converting your didactic statement of information into a multiple-choice question?
Or use data to get students to arrive at concept?
Take a few minutes to discuss with your neighbours and then write down 1 example you can think of.

- Go to:
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Out-of-class readings and assignments

- What about supporting students after lessons?
- Is it also possible to take a less dogmatic approach?

Out-of-class readings and assignments

- For the topic on Cell division, there are **too many** components to discuss during lecture time.
- Designed a **reading** for **graded take-home quiz** on CDK inhibitor instead of listing all the CDK inhibitors and their specific functions during lectures :


Contents lists available at ScienceDirect

Cancer Letters

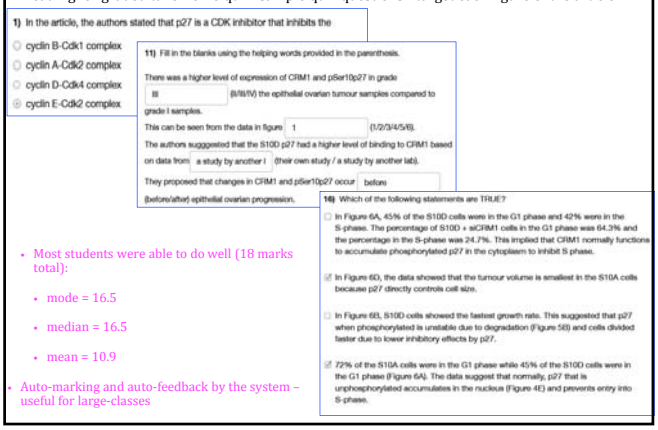
journal homepage: www.elsevier.com/locate/canlet

Knockdown of CRM1 inhibits the nuclear export of p27^{Kip1} phosphorylated at serine 10 and plays a role in the pathogenesis of epithelial ovarian cancer

You Wang, Yingying Wang, Jingying Xiang, Fang Ji, Yan Deng, Chunhui Tang, Shuyun Yang, Qinghua Xi, Rong Liu, Wen Di

Out-of-class readings and assignments

- Reading for graded take-home quiz: sample quiz questions - target each figure of the article:


1) In the article, the authors stated that p27 is a CDK inhibitor that inhibits the
- cyclin B-Cdk1 complex
- cyclin A-Cdk2 complex
- cyclin D-Cdk4 complex
- cyclin E-Cdk2 complex

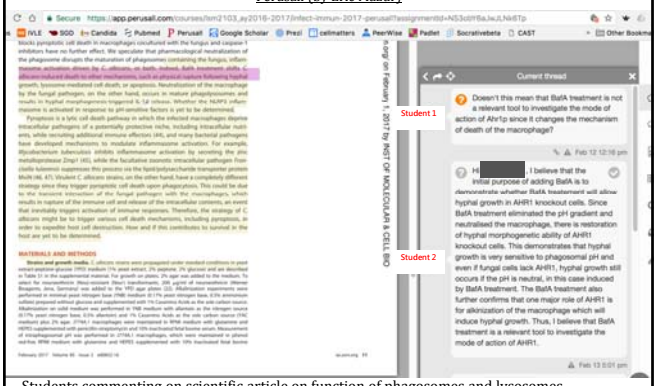
11) Fill in the blanks using the helping words provided in the parenthesis.
There was a higher level of expression of CRM1 and pSer10p27 in grade III (II/III/IV) the epithelial ovarian tumour samples compared to grade I samples.
This can be seen from the data in figure 1 (1/2/3/4/5/6).
The authors suggested that the S10D p27 had a higher level of binding to CRM1 based on data from a study by another l (their own study / a study by another lab).
They proposed that changes in CRM1 and pSer10p27 occur before (before/after) epithelial ovarian progression.

16) Which of the following statements are TRUE?
- In Figure 6A, 45% of the S10D cells were in the G1 phase and 42% were in the S-phase. The percentage of S10D + siCRM1 cells in the G1 phase was 64.3% and the percentage in the S-phase was 24.7%. This implied that CRM1 normally functions to accumulate phosphorylated p27 in the cytoplasm to inhibit S phase.
- In Figure 6D, the data showed that the tumour volume is smallest in the S10A cells because p27 directly controls cell size.
- In Figure 6B, S10D cells showed the fastest growth rate. This suggested that p27 when phosphorylated is unstable due to degradation (Figure 5B) and cells divided faster due to lower inhibitory effects by p27.
- 72% of the S10A cells were in the G1 phase while 45% of the S10D cells were in the G1 phase (Figure 6A). The data suggest that normally, p27 that is unphosphorylated accumulates in the nucleus (Figure 4E) and prevents entry into S-phase.

- Most students were able to do well (18 marks total):
  - mode = 16.5
  - median = 16.5
  - mean = 10.9
- Auto-marking and auto-feedback by the system – useful for large-classes

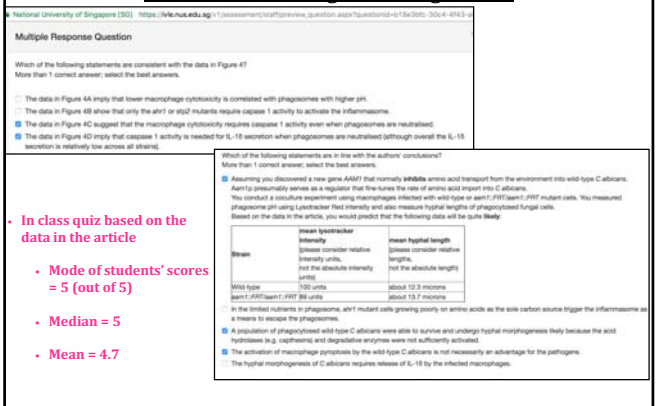
Out-of-class readings and assignments

Perusall (by Eric Mazur)



- Students commenting on scientific article on function of phagosomes and lysosomes
  - Auto-marking possible on quality of comments

Out-of-class readings and assignments


Multiple Response Question

Which of the following statements are consistent with the data in Figure 4?
More than 1 correct answer; select the best answers.
- The data in Figure 4A imply that lower macrophage cytotoxicity is correlated with phagosomes with higher pH.
- The data in Figure 4B show that only the ahr1 or stp2 mutants require caspase 1 activity to activate the inflammasome.
- The data in Figure 4C suggest that the macrophage cytotoxicity requires caspase 1 activity even when phagosomes are neutralised.
- The data in Figure 4D imply that caspase 1 activity is needed for IL-18 secretion when phagosomes are neutralised (although overall the IL-18 secretion is relatively low across all strains).

Which of the following statements are in line with the authors' conclusions?
More than 1 correct answer; select the best answers.
- Assuming you discovered a new gene AAA1 that normally inhibits amino acid transport from the environment into wild-type C.albicans. Aah1p presumably serves as a regulator that fine-tunes the rate of amino acid import into C.albicans. You conduct a coculture experiment using macrophages infected with wild-type or aah1::FRT/aah1::FRT mutant cells. You measured phagosome pH using Lysotracker Red intensity and also measure hyphal lengths of phagocytosed fungal cells. Based on the data in the article, you would predict that the following data will be quite likely:

Strain	mean lysotracker intensity (please consider relative intensity units, not the absolute intensity units)	mean hyphal length (please consider relative lengths, not the absolute length)
Wild-type	100 units	about 12.3 microns
aah1::FRT/aah1::FRT	89 units	about 13.7 microns

- In the limited nutrients in phagosome, ahr1 mutant cells growing poorly on amino acids as the sole carbon source trigger the inflammasome as a means to escape the phagosomes.
- A population of phagocytosed wild-type C.albicans were able to survive and undergo hyphal morphogenesis likely because the acid hydrolases (e.g. cepthesins) and degradative enzymes were not sufficiently activated.
- The activation of macrophage pyroptosis by the wild-type C.albicans is not necessarily an advantage for the pathogens.
- The hyphal morphogenesis of C.albicans requires release of IL-18 by the infected macrophages.

- In class quiz based on the data in the article
  - Mode of students' scores = 5 (out of 5)
  - Median = 5
  - Mean = 4.7

Perspectives

- How we teach science is different from they way we do science
- We tend to teach concepts (conclusions of experiments) rather than provide opportunities for students to engage with data and make sense of them
- Based on students' responses, it seems that they are able to work with data to derive certain knowledge/concepts

Perspectives

- Cognitive engagement was observed, even though only participation marks were awarded regardless of whether answers were correct or incorrect
- i.e. low participation marks were awarded for each class quiz – as long as students submitted, the quiz, they get about 1 mark that contributes to their final grade
- From the written answers, students elaborated more than the minimal answers – implying:
- That they perhaps felt challenged and wanted to work on the questions? Quizzes provided opportunities for students to use their skills in class?

Perspectives

- One important point issue is the need to scaffold students when using data in our activities
  - prepare students on the various techniques for experiments and their application
  - provide guidelines to students on the analysis of data

Question needing further study: What is the impact on student learning?

- It was possible to examine student engagement through their analysis of students answers such as their written short-answers
- However, it is **not easy to measure retention and long-term effects** - i.e. how to attribute the approach directly to student performance later on
  - This is a long-standing issue of trying to tie interventions to student learning, since students are exposed to other modules, become more mature and so on. Needs more thoughts.
  - Nonetheless, the level of class engagement and quality of students' written answers are encouraging in terms of using data to move away from dogmatic teaching

Acknowledgement

American Society for Microbiology, Biology Scholars Programme - for sharing active-learning and alignment strategies

Students from my undergraduate courses - for participating in my quizzes

Department of Biochemistry, Yong Loo Lin School of Medicine, National University of Singapore - for support in various ways

Thank you for the opportunity to share my experiences

Comments or questions?

References

Dewey, J. (2004). *Democracy and education: An Introduction to the Philosophy of Education*. Norwood, Mass.: Macmillian.

Hattie, J., & Timperley, H. (2007). The Power of Feedback. *Review of Educational Research*, *77*(1), 81–112. doi:10.3102/003465430298487

Osborne, R. J., & Wittrock, M. C. (1983). Learning science: A generative process. *Science Education*, *67*(4), 489–508. doi:10.1002/sce.3730670406

Ritchie, D., & Volkl, C. (2000). Effectiveness of Two Generative Learning Strategies in the Science Classroom. *School Science and Mathematics*, *100*(2), 83–89. doi:10.1111/j.1949-8594.2000.tb17240.x

Wood, W. (2009). Innovations in Teaching Undergraduate Biology and Why We Need Them. *Annual Review of Cell and Developmental Biology*, *25*, 93–112.