Genes and Society: 
A Life Science Module for Non-Life Science Students

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Introduction

Teaching is a process of continuous learning. Almost all leading universities have teaching development centres like the Centre for the Development of Teaching and Learning (CDTL) at NUS. This underscores the importance of effective learning through teaching.

To be a good teacher, one of the prime requirements is to have passion and be committed towards nurturing students to become effective learners. Besides disseminating subject knowledge, a good teacher should also consistently review his/her course material and teaching methodology in order to enhance their students’ learning experience. In addition to these soft skills, there are several technically advanced teaching tools available to help educators. In NUS, such teaching tools can be found at the Centre for Instructional Technology (CIT) (http://www.cit.nus.edu.sg).

Nonetheless, a class or academic meeting will not fulfill its learning outcomes if the teacher and students do not have the correct mindset and do not communicate with each other in unison.

As a typical university lecturer, one of the biggest challenges I face is having to teach a wide range of students, from first year undergraduate students fresh out of high school, to final year graduate students who are almost at the end of their Ph.D. programme. Teaching such a diverse range of students requires the teacher to be able to handle classroom situations very carefully and strike a fine balance in terms of the quality and quantity of teaching. In addition to having to manage diversity among students, some lecturers face two more challenges: having to teach a large class (300 students and above) and teaching a subject to a group of students who have little or no exposure to that subject. While both are highly demanding situations, they can mould a fledgling lecturer into an excellent and successful one once the mission is accomplished. As Einstein aptly puts it, “you do not really know a subject unless you can explain it to your grandmother”.

In this article, I share my teaching experience, approach and the tools I use when I undertake an even larger challenge—teaching 600 non-life science students a module which combines biotechnology and life science concepts. In the following paragraphs, I will present the teaching strategies I employ to motivate these students, including the use of unconventional but informative correlations such as making the connection between “how babies are made” and DNA super-coiling. I will also talk about how I psychologically prepare and support my students in their learning journeys, as well as the technically advanced and basic teaching aids I use to engage students.
Teaching First-year Students

Module content

Several curriculum planning guides (Pan, 2008) and pedagogical literature (Successful Learning, 2006) cite effective content and workload as factors for a successfully run module. For example, the two first year undergraduate life science modules which I teach, LSM1101 “Biochemistry of Biomolecules”, a compulsory life science module for first-year students and GEK1527/LSM1302 “Genes and Society”, which is taught to non-life science students, both contain the essential curricular components—lecture, laboratory practical and tutorial—with a workload distribution of 26, 16 and 8 hours respectively. While each session lasts 2 hours, the actual teaching for both modules is around 1 hour and 30 minutes. The teaching duties for such modules may be shared by up to three lecturers and they aim to prepare first year students for life science, with chapters on buffers, proteins, nucleic acids, lipids and carbohydrates. They are offered in both semesters at NUS; LSM1101 has a typical class size of 250 to 350 students, while GEK1527/LSM1302 has up to 550 students. The cohorts can be a mix both students who have GCE ‘A’ levels and from the local polytechnics, and international students who have experienced a different high school education system. The mode of assessment for both modules consist of two continuous assessment (CA) exams (20% each) and the final exam (60%) with multiple choice questions and essay type answers. On top of the academic load, a lecturer may have to be the module coordinator and oversee all related administrative duties, including smooth running of the practical sessions, exam grading and declaration of results.

Teaching strategy

In terms of my teaching philosophy, I believe that every student deserves to be motivated. The main demand made to teachers is that when they teach, they should have their students’ complete attention. The classroom is like a music hall where teaching is akin to a concert or performance. Even the slightest disturbance in one corner of the classroom can be distracting or potentially lead to a commotion. Such situations may occur more frequently in a big class.

In addition, students tend to have very short attention spans, which can be directly proportional to the module level and inversely proportional to the class size. As such, one has to bear this information in mind when adopting a particular teaching strategy. Also, no teacher has ever been successful in making all students in his/her class succeed without some additional help. There will always be a subset of students among the cohort that need that extra help and others who may not be interested to learn new things. Teachers must also remember that if a student fails a module, it can be an upsetting and memorable experience (i.e. the student will remember you forever). Furthermore, it will affect his performance in other modules. As the teacher, teaching your subject with passion and showing students you care that they fulfill their learning outcomes will go a long way in motivating them to not only learn your subject well, but also spur them on to strive to get the best possible grade.

The following are some examples from my teaching experiences on how students, even those with minimal or no exposure to a particular subject, can be motivated to follow even the most difficult topic.
**Getting their attention by showing a video/graphic related to the topic—How babies are made**

In the application of nucleic acids covered in GEK1527/LSM1302, students have to be introduced to the concepts of cloning and stem cells (Lanza, 2009). I prepare the class by showing students a video on a baby’s development after a sperm cell and ovum cell fuse. This video draws their full attention. Concurrently, I introduce them to the concepts of developmental biology, which slowly leads to the parallels drawn between natural fertilisation and cloning (see Figures 1a and 1b).

Students gain a better understanding of the concept of cloning when the introductory video first draws their attention. Thus one can see that being able to firmly secure our students’ attention is a major teaching strategy. Once a lecturer establishes a good approach in simplifying these concepts and proves his teaching techniques are effective in getting his students’ attention from the first class, it is likely that he will continue to be well received throughout his teaching tenure.

**Providing learning guidance through storytelling—Cancer and drunkards**

In this example, I show my students how a particular cancer pathway is activated by telling them a short story. There were two bad persons, A and B. One day they met and went to the pub, where B got drunk. When they left the pub, they saw a good person, C, who was holding a bad person D (eventually a friend of A and B). A and B attacked C and forced him to drink. Now C could not hold on to D anymore and released him. D, when released, started doing a lot of bad things.

This story is very easy for anyone to follow. It draws identical parallels with the activation of retinoblastoma (Venkataramani, Swaminathan & Marmorstein, 1998; Xiao et al., 2003; Flowers, Beck & Moran, 2010), a cancer of the retina which occurs mainly in children. Figures 2a and 2b on page 16 depict the parallels. The proteins Cyclin D1 and CDK 4/6 are the bad persons A and B. Phosphorylation (shown in Figure 2b as the circled ‘P’) is the drinking. The tumour suppressor protein Rb is the good person C, and the E2F transcription factor is the bad person D. Normal children do not get retinoblastoma,
mainly because the INK family of proteins in their system prevent Cyclin D1 and CDK 4/6 from combining. In addition, the p21 protein prevents the Cyclin/CDK from phosphorylating Rb, which is tightly bound to the E2F protein.

This story was well received in the class and students gained a better understanding of how cancer cells develop.

Providing learning guidance through anecdotes—Why was the police inspector dumber than a thief?

It is an undeniable fact that biology students do not expect much mathematics in their class. However, there will be situations where the application of some mathematics, physics or chemistry is required even in a life science class. Apart from serving as a ‘refresher’, anecdotes can come in handy if the teacher has to introduce physics concepts to the class.

For an example of such an anecdote, consider a scene commonly shown in the movies—that of a villain carrying a box full of gold bars (or coins). A police inspector would chase him and there would invariably be a fight, after which the inspector would confiscate that box of gold.

Following a simple physics calculation, the mass of the box would be

Mass = Volume x Density
= \((l \times b \times h) \times d\)
= 45 x 30 x 10 x 19.3
= 260550 gm
= 260.55 kg

where l, b, h are the length, breadth and height of the box in centimetres respectively, and d is the density of gold in g/cm\(^3\). By looking at the above calculation, it is apparent that it is humanly impossible to carry such a load in one hand. As a comparison, I showed some videos of world records for weightlifting. For instance, the record for the heaviest snatch of all time in weightlifting, at 216 kg, is held by Antonio Krastev of Bulgaria (Krastev, n.d.; Hedle, 2007). In addition, the record for the heaviest clean and jerk of all time, at 266 kg, is held by Leonid Taranenko (Taranenko, n.d.; ChildsPlay2008, 2006).

In using this example, I teach students to ask the right questions when they observe that something is ‘too good to be true’. Cultivating the ability to make scientific inquiry is an important aspect of learning and knowledge generation.
Managing common psychological learning barriers

Each student is different, and their levels of prior knowledge, motivation, understanding and commitment will vary. Some international students would initially find it difficult to blend into the university’s academic system due to language barriers and having to make cultural adjustments. On top of these, they also have to cope with adapting to changes in the academic system and learning new teaching styles. Dealing with all these can become a burden for them. However, there are certain common questions that will have almost the same impact on each student. For example, one can start a class by asking students what job they plan to apply for upon graduation. Even though this question is not directly related to the subject matter, the discussion is very relevant to students’ lives and would immediately get their attention. They become more alert and would listen intently to how you address these questions, as they know that they are dealing with something which is very important for their future.

Scaffolding students’ learning

Providing such psychological preparation has been beneficial for students in helping them navigate the challenges of the module, and I have also been rewarded very well through excellent student feedback scores. Similarly, I psychologically prepare and support my students when it comes to learning the subject itself. For instance, scaffolding helps students to learn new knowledge by building on prior knowledge (Vygosky, 1978). Imagine that they must write an essay about glycolysis. To help students tackle such a big question, I break the problem down to three levels of difficulty, beginning with the simplest. This first level only requires a one-line answer that would fetch students say, 2 marks out of 10. I would then encourage them to proceed to the next level after ensuring that they completely understand the concept behind the one-line answer. Some students are able to complete all three levels at once and can even move on to additional exercises in the textbook, while some stop at the second level. Of course, in every cohort there will be some very bright and sharp students who grasp these concepts quickly and are adept at self-directed learning. Be that as it may, this strategy of breaking a big problem into manageable levels has motivated almost all students to learn at least the minimum to get some marks. More importantly, this approach ensures that no student feels left out.

Presenting stimulus in an effective manner

As mentioned earlier in the article, there are several advanced tools available for teaching. For example, Microsoft Powerpoint is useful for preparing handouts and slide presentations. I also make full use of the university’s Integrated Virtual Learning Environment (IVLE), where I post my slides at least one week before a class. Students can download the slides and get a printout for the class. I usually have almost the same set with some additional slides containing movies or cartoons.

The typical classroom in NUS is equipped with a writing tablet and a stylus pen. While teaching, a lecturer can write directly on the tablet so that the students can learn and discuss on the fly. In addition, these classrooms are equipped with a digital projector. These tools are indispensable for teaching, especially to a class of 350 students.

Yet, while technically advanced teaching tools are helpful, very basic stationery items like a strip of paper or a pack of index cards can also be cleverly used to explain complex biochemistry concepts. For example, I use a pack of index cards to create a DNA double helix in order to explain why DNA has a major groove and a minor groove (see Figures 3a and 3b). I also use a strip of paper to demonstrate how proteins fold and to explain the concept of torsion angles as well as the formation of secondary structural elements, α-helices and β-strands.

I also believe that interacting with students is an essential component of effective teaching.

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During the practical sessions, I make it a point of walking around the laboratory to observe how my students handle an experiment. I ask them a few simple questions as a lead-in to a discussion about the concept behind the experiment. I am also mindful that technology constantly brings changes and new developments. As such, I spare no effort in upgrading and enhancing my knowledge in the use of novel teaching tools and other aids. Whenever I attend conferences or go on scientific visits, I constantly keep my eyes and mind open to tested and accepted new devices, techniques and concepts in teaching.

Conclusion

As emphasised earlier, teaching forms one of the most important components of a faculty member’s academic duties. A good teacher would produce good students and enabling this transformation is vital for academic, educational, industrial and all other forms of development. When a person joins an academic institution, he must undertake an oath to be committed to teaching. An educator’s knowledge will become rusty when it is not shared with others in a proper way. For most cultures and civilisations, this noble profession is truly one of the highest callings a person can aspire to.

About the Author

A/P K. Swaminathan currently teaches Level 1000 biology (LSM1101 “Biochemistry of Biomolecules” and LSM1302/GEK1527 “Genes and Society”) and Level 5000 structural Biology (BL5215 “Macromolecular X-ray Crystallography”). He firmly believes that “every student deserves to be motivated” and the right way to engage them is by “telling [students about] a subject at the elementary level and making them expand it with their own imagination, talent and knowledge”.

Motivating Learners
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Endnotes

1. Phosphorylation is the process which causes an organic compound to take up or combine with a phosphoric acid or a phosphorus-containing group.

2. Glycolysis refers to the enzymatic breakdown of a carbohydrate (as glucose) by way of phosphate derivatives with the production of pyruvic or lactic acid and energy stored in high-energy phosphate bonds of ATP (adenosine triphosphate).

References


