Bioscience Learning & Teaching Case Study

Teaching Basic Maths to Bioscience Students at UEA

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School / Department: School of Biological Sciences

Institution: University of East Anglia

Activity: To teach basic maths to HE bioscience students.

Student Group:
For first year biological science students, studying a 'Maths for biologists' course. Approximately 150 students each year.

Aim:
To engage students' interest in maths as it relates to biology and build their confidence in tackling biological, mathematical problems.

Context /Background:
I was asked to take over maths teaching to our first year biological sciences students approximately five years ago. The course was a maths and statistics course and I took over teaching the maths part of it. Prior to taking over the course, I gave the students a brief formative maths test to try and gage the level I should be teaching at. It was clear that questions I thought would be simple for the students to answer, were pitched too high for many. Using the information gathered from this initial test I designed a customised maths test in three sections with questions of increasing difficulty. I then added a section at the front of the test with even easier questions, the idea being that the students could start with something incredibly easy to give them some confidence before tackling the progressively harder questions. Between 5 and 10% of the students got one or more questions wrong in this first section. (See www.bioscience.heacademy.ac.uk/events/norw130308.aspx for details of the test). Each academic year since, I have given students the same test when they arrive at UEA and each year the number getting questions wrong in this first section has been within this same range. When setting up the course I also discussed potential course texts with a book publisher and they suggested that I should put together a custom book, *Maths for Bioscientists,* to help the students. I did this and it now forms the basis for the maths course.

I was interested in how the maths ability of students coming into university related to their maths ability when in years 12 and 13 at school. So I went into some local schools and tested AS- and A2-level students on their maths ability. I also questioned school teachers about how they felt their pupils would cope at university and what sorts of things their pupils would find difficult. They generally felt that the over-dependence of pupils on their calculators would be one of the biggest problems. This was one of the incentives to write an article for the THE. (See www.timeshighereducation.co.uk/story.asp?storyCode=407190&sectioncode=26).

Example description:
When students arrive at UEA Biological Sciences they are given a diagnostic maths test. This was paper based, but is now electronic and run by Password, previously English Language testing but have altered their name to incorporate other subject areas (www.englishlanguagetesting.co.uk). It comprises four sections of increasing difficulty and ranges from asking students to calculate 50% of 40, to basic logs and calculus. It also questions them about their confidence and attitude to maths.

This electronic test gives immediate feedback to the students, as a grade from A to E, and also delivers their percentage mark to me within an hour of them completing the test. Using this for the first time this year I found that hours of marking disappeared from my work load and also the slick modern computer suite presented such a different impression for the students when they first arrived, relative to a paper copy in an old lecture theatre.

From this test I first group all students who score around 80% and above, in addition to those who have A2 maths. These students are taught separately and cover biologically-specific maths fairly quickly, subjects such as converting between units and moles and molarity, and then go on to look at applications of calculus in biology. This keeps them interested and provides them with extra tools which they could use in other modules. For example, there is a general essay paper at the end of the first year where there will be options of questions which would allow them to demonstrate their knowledge of the uses of calculus in biology, if they wish to. The actual purpose of the top set is to remove them from the students who struggle with maths, so they do not demoralise the slower students or disrupt the necessarily slow teaching. It also serves to reduce numbers in the main class.

The remaining students are all taught maths together; however there is still a huge ability range. Students are taught maths in a two-hour lecture, once a week. I pitch these lectures so that I feel about 70% of students will get the maths from this teaching method. To go any slower would disengage the more able students, but to go at their speed would disengage the slower students.

The topics covered in the lectures include:

- Conversions between units
- Areas and volumes
- Moles and molarity
- Rearranging and solving equations
- Graphs, triangles, logarithms and basic calculus

During my first year teaching this course a lecturer, who had experience teaching maths to students, advised me to stop using PowerPoint slides and to use the OHP or blackboard. This proved to be excellent advice. It slowed my pace down so I was writing with the students, allowed me to write at a pace they could follow, and pause, mid-calculation when necessary.

In addition to the lectures, students have approximately bi-weekly seminars which help check how they are progressing. These seminars give them a small-group situation to address any issues they have. Students are grouped according to their score in the diagnostic maths test and also on their answer to the question about their confidence in maths. This allows me to put students in groups with other students of a similar ability and confidence. Lower ability groups are small, between 6 and 8 students; higher ability groups are larger, with 12 to 15 per group. This grouping according to ability is particularly crucial to maths teaching where a confident student could undermine any confidence of a weaker student if they were in the same group. If students end up in a wrong group (sometimes they go to the wrong room by mistake at the beginning of the year) seminar leaders and students report back to me that the group hasn't worked, that weaker students don't get a chance to answer questions or stronger students get very bored. These groups are assigned to specific seminar leaders who wish to teach students of a specific ability. I have found that these seminars have brought out hidden qualities in lecturing staff, both in those able to teach top groups and stimulate their enthusiasm, and those who have the patience to help and encourage the lower ability groups.

I also run a weekly help session where I cover any part of the course students wish to go through. I approach these sessions with a very relaxed and informal style. Subjects I find they particularly struggle with are conversions between units, and rearranging equations. Our student-support service, which runs through the Dean of Students Office (DoS), also runs weekly help sessions with a maths tutor. These are confidential, so I don't know who turns up, but I am told if there are any

areas that come up repeatedly so I can make any necessary adjustments to my teaching. Students can also ask for one-to-one help from this student-support service. In addition to these teaching sessions there is the custom book, *Maths for Bioscientists*, to go with the course. Students are advised to purchase it and most do find it essential to the course.

For the custom book, I took material, mainly from Foundation Maths (Anthony Croft and Robert Davison), and added sections with biology-specific examples, sections about moles and molarity, and basic calculus in biology. Two other lecturers helped write the book content. I also put in a chapter from a book called 'Get Ready for Biology' (Benjamin Cummings). This included some extremely basic maths. I felt that some students would need that information and may feel embarrassed to ask about such simple calculations, but it gave them a source of information where they could remind themselves of some basic rules. I wrote the book in a way that takes students step by step through some mathematical problems. It acknowledges that students may panic at some questions, but the idea is that, having panicked a bit, they then have the confidence to tackle questions and succeed. There are also many questions in the book for the students to try. As part of the *Maths for Bioscientists* book, the publishers added a free-of-charge 'My Maths Lab' web help package with lots of extra questions. I do not use this as part of the course, but it is there for students to use as an extra resource. It was a huge job putting the *Maths for Bioscientists* book together and, unlike writing an ordinary text book, I had to format the pages I wrote myself, and I get no royalties from it. The benefit to me comes from being able to teach directly from it, so planning a lecture is merely a case of deciding which page numbers I want to cover.

There is no assessed coursework as part of this course. There are four course tests evenly spread through the year, which are cumulative; maths taught at the beginning of the course is still tested in the last course test. Feedback on the course tests is provided in the seminar groups. They do have formative coursework, set and marked in the seminars, but it is up to each student how much they do.

Throughout this whole process I have had a mentor from the student support service (DoS) who helped me understand maths which I hadn't done for some decades. I found that, to teach maths, I had to fully understand each subject without any 'fudge factors'. One area where I could not find a comprehensive account with unambiguous teaching was in the use of moles and molarity. With the help of my mentor I pieced it all together from basics, so I could teach it without any confusion for the students, using logic and units to explain the whole subject. I still have occasional maths lessons myself and I let the students know that I am also learning, to reinforce further the idea of university being a world of scholars which they enter, rather than a teacher-student one-way learning process.

Results / Feedback:
Students generally respond very well to this combination of teaching techniques. They acknowledge that all the help is there if they chose to use it. I have had students come up to me on campus to say how much they appreciate the style of the *Maths for Bioscientists* book. They find the course helpful without being patronising in any way.

Maths is a subject that can instil fear even in the most accomplished lecturing staff, and some lecturers feel they cannot take seminars. Others felt that, as biology lecturers, they should not be teaching basic maths. But I've not found it hard to find enough seminar leaders for the course each year and some of the lecturers feel a great sense of achievement in helping students gain confidence in maths and some have got great feedback from the students and found that extremely rewarding. Students have come to UEA to learn biology, it can come as a bit of a shock to some to find themselves in maths classes. The maths is fully integrated into the biology-subject modules so it is seen as a support to the degree course. Examples in the lessons are biologically-related, and students are constantly told where each bit of maths is useful in biology.

There is a core of students each year who attend the help sessions and gradually develop confidence. It is useful to follow the progress of these students and so gage how effective the course is. Lecturers who take seminar groups also provide regular feedback about how their students are progressing. Feedback on course tests is given to students in these seminars allowing seminar leaders to follow how their students are doing in the course assessments and build up more of a relationship with their students.

Through the course students learn maths specifically applicable to biology. There is therefore a built-in incentive to learn the material. There was one student, a mature student who came in through a foundation course, who didn't know the difference between a metre and a millimetre when he arrived. I regularly saw him sitting in our café area working through the *Maths for Bioscientists* book. He came to every help session, and by the end of the year he was near the top of the class. This is an extreme case, but the students who want to succeed can do so through all the different types of help that are on offer.

The course has developed to its current state over five years. The *Maths for Bioscientists* book is on its second edition, but is due for amendments to go into a third edition, with even greater degree of explanation for areas such as conversions between units and rearranging equations. The maths curriculum in schools is changing continually and so it has proved vital to keep up with these changes to ensure the course is still effective. I follow changes in the curriculum reported in the teaching press and have regular discussions with school teachers. I also have opportunities to work with AS and A2 pupils where I can question them about their understanding of maths and statistics in their biology classes. However, the diagnostic test can act as a buffer against changes at school and foundation level, providing information on students' abilities independent of their school grades.

Further comments or information:
The course itself is a maths and statistics course. Teaching statistics has required a different approach and I found that even students with A2 statistics did not understand the basic concepts, so all students are taught together for statistics, irrespective of maths ability. It has required the same slow, careful approach to teaching because students can be more terrified of stats than they are of maths, but the need for an integrated approach with other modules has proved even more vital than for maths. I have not found a statistics text which starts at a basic enough level, so the third edition of the maths book will include a chapter explaining the very basic concepts of statistics.

For anyone embarking on designing a maths course for their students I would suggest they:

1) Test their students beforehand with the Password test or equivalent self-written test where questions start at a very basic level,
2) Remove students who have A2 maths from the main class,
3) Avoid using PowerPoint slides in lectures,
4) Make sure students understand how all the maths they learn relates to biology, and
5) Don't underestimate the value of contact time with staff in favour of cheaper, easier, online methods.

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