Physical Chemistry and Materials

Teaching Mathematics to First Year Undergraduate Chemists in the Context of their Discipline

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Abstract

New entrants to chemistry degree programmes are given a 24 hour course in mathematics if they do not have an A level qualification in the subject. This concentrates only on the skills necessary to successfully complete the first year physical chemistry course; these include simple statistics, functions, partial differentiation and integration. The course is taught using chemically relevant examples, in an order related to the chemistry course rather than traditional mathematics courses.

Level of Material: First Year

The Execution

Students arriving at university to study chemistry without an A level mathematics qualification are frequently surprised to learn that they will be required to take a course in mathematics for chemists. As they will have given up the subject two years earlier they are unlikely to be highly motivated on such a course, so retaining their interest and commitment is paramount. In order to do this, the course is based on the chemical topics to be taught which dictate both the order in which the mathematical material is covered and the examples which are used to illustrate the various mathematical topics. This has the advantages of both ensuring that the material being taught is highly relevant and of introducing students to material in the physical chemistry course which will be built upon later. This is a useful additional benefit that should aid learning at a later point in the course.

A potential disadvantage is that a lot of material is covered at an early stage of the undergraduate career and some of this is quite advanced. For example, partial differentiation has to be taught to students with only GCSE mathematics in their first semester. However, the requirements of the physical chemistry are such that the most important aspect is for students to be able to recognise appropriate symbols when they are met, rather than being necessarily able to perform certain skills. Thus exposure to a wide range of techniques can be considered appropriate even at this early stage.

Pre-requisite Knowledge

University matriculation requirements ensure that students will have at least GCSE mathematics at grade C. No specific prior knowledge is assumed, other than the ability to perform simple arithmetic and the simple use of a calculator. Instruction in more advanced calculator use is provided as appropriate during the course and at an individual level during problem classes.

Timetabling considerations result in the first contact session of the course being a problem class. In this session students work through context based problems that require only elementary mathematical skills. This is designed to get them to think about chemistry in numerical terms.

Basic computer use is assumed in order to run the computer assisted learning tutorials. Such introductory courses are provided centrally by the university at the start of each academic year. Students are made aware of these and are strongly advised to attend if appropriate. The presence of a member of lecturing staff during the formally timetabled computer tutorials ensures that minor difficulties in computer use are rapidly resolved.

How Are Students With Different Mathematical Backgrounds Supported?

The course is typically taken by students whose mathematical qualifications range from GCSE grade C to A level grade D. The latter group of students typically find the course much easier as it is largely reinforcing material they have previously studied. The presence of more than one member of staff in the problem sessions, and the fact that these staff walk around the classroom and are proactive in helping students, ensures that support is targeted at the weaker students.

Those students who have A level mathematics at grades A-C would not generally take this course, and would not generally receive any specific mathematical support. The one topic taught in this course which they would not have covered is partial differentiation, so this is actually covered at the appropriate point in the physical chemistry course. This also has the advantage of revising this conceptually difficult topic for the other students immediately prior to its use. The provision of weekly drop in sessions will also provide support for students who do have A level mathematics.

What Support Was Needed?

The course is taught by several members of the physical chemistry lecturing staff, depending on their availability and teaching loads in a given year. Problem sheets are prepared by the author and used by all the staff teaching on the course. Support for the problem classes has been provided by a postdoctoral fellow in physical chemistry, but in some years there have been delays in agreeing funding for such support. Also, when this member of staff left it was difficult to find a suitable replacement with a sufficiently high level of mathematical competence.

Development of the computer assisted learning software took place within the Chemistry Courseware Consortium, so the only input required was academic, involving the production of suitable scripts. All programming and implementation was performed by specialist staff at the CTI Centre for Chemistry at the University of Liverpool. Mounting of software on the departmental PCs was performed by the author. Maintaining this software was a time consuming task, although the department has now assigned a member of technical staff this responsibility.

Producing the textbook required the usual authoring process, but was hindered by frequent changes of personnel at the various publishers who were involved due to mergers and take-overs.

The Barriers

Many chemistry students are mathematically weak. However, a more significant barrier is that they may not appreciate the need to acquire certain mathematical skills. The approach taken here is designed to overcome this by demonstrating the relevance of mathematics to the physical chemistry course being studied.

The Enablers

The most important aspect of this course is the availability of sufficient staff to deal with student problems on an individual basis. Although this is largely done during the problem classes, provision of computer tutorials and drop in sessions also provide valuable opportunities for staff-student interaction.

Evidence of Success

For the motivational reasons noted, this would not be expected to be a particularly popular course. However, confidential student feedback has been consistently positive over a number of years. Failure rates are relatively low and most students go on to complete the first year physical chemistry course successfully. External subject reviews of the course have provided very favourable feedback.

How Can Other Academics Reproduce This?

The critical requirement in order to reproduce this form of course for other disciplines is a sufficient supply of discipline related problems. These can generally be generated by taking typical problems within a discipline and providing sufficient further information so that only mathematical skills and knowledge are being tested.

The provision of related software and textbooks is more difficult and will depend on individual circumstances, but may be possible once the problems are available.

Quality Assurance

The course has been subject to standard departmental quality assurance controls. These involve annual monitoring of student feedback on the overall module and a report by the module leader.

Other Recommendations

I would recommend using discipline specific mathematical problems to both illustrate and structure a support course in mathematics. In addition

- Provide sufficient staff support.
- Provide a variety of opportunities for staff-student interaction.
- Ensure that technical support is available.

References

Chemical Calculations, Blackie, Yates, P. C., (1997).

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