Research-Teaching Linkages Case Study ‘Training in Research Methods’

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Context

Degree Structure

- BSc 4 years
- MChem 5 years
- Both include a research project in final year
- Years 1-3 are common and include conventional laboratory courses

A variety of course components provide preparation for the final year research project, and these are the topic of this presentation.

Training in "Transferable Skills"

In 3rd year the practical course includes exercises in Transferable Skills:

- Poster exercise
- Abstract exercise
- Oral presentation
- Long report
- Problem-based learning

- Following 3rd year, BSc students progress to their final year and the level 10 research project (20 credit points).
- MChem students may choose from a number of options in 4th year.

MChem Choices in 4th year

Students have a number of options in 4th year:

- Industrial Placement (UK, Europe or USA)
- Year In Europe
- Year in Singapore or Hong Kong
- Remain in Edinburgh

Years in Industry, Europe or Asia

Students choosing these courses:

- Carry out a research project
- Prepare a literature survey
- Write a project report
- Present a talk
- Undertake 3rd year revision exercises

The Year in Asia students undertake two projects:

- 6 months at Nanyang Technological University, Singapore
- 6 months industrial placement in Singapore

These 4MX students therefore gain the necessary training in preparation for their final year Level 11 research projects (20 points) during their year away from Edinburgh.

Edinburgh Based 4th year MChem Students

In the absence of a 4th year industrial/university research project, these students undertake a 40 point Level 10 course “Introduction to Research Methods” which is comprised of three components:

- A written exercise (literature review)
- Literature survey for the final rear research project
- Two “Research Methods Exercises”

4M Written Exercise

This exercise is a literature review on a given topic, generally of current research interest. The scope is defined by the exercise supervisor and initial guidance is provided along with some leading references.

- Feedback is provided on a draft of the review before final submission.
- The final assessment and feedback are available to students before they embark on their final year project literature survey.
- The exercise thus provides preparation for the project literature survey.

Final Year Project Literature Survey

- Students are assigned to their final year project supervisor early in semester 2 of the 4th year. A literature survey on the topic of the project is written and assessed during this year.
- Students build upon and apply the experience gained in the preceding Written Exercise.
- The writing of the literature survey provides preparation for the project (Level 11, 40 points) which starts at the beginning of semester 1 in 5th year, and enables students to make a rapid start on the practical work at this time.

Research Methods Exercises (RMEs)

In place of a conventional laboratory practical course, 4M students undertake two exercises in different areas of chemistry designed to provide training in:

- Research planning
- Techniques (synthetic, computational, analytical)
- Use of instrumentation
- Safety and risk assessment
- Teamwork
- Presentation formats.

RMEs – the concept

- During the first week groups explore the literature relevant to the exercise. They then meet with the supervisor(s) to define their aims and methods.
- Initial guidance is provided, but students are then free to design and structure the exercise to achieve aims set by the group, with advise from the supervisors.
- Groups are provided with a budget (£50/student) and control over its use.
- Groups are encouraged to divide the work between the members to most effectively achieve their defined aims.
- Student groups are changed for each exercise.
- Each exercise has a postgraduate demonstrator assigned who is available “on-call”.
- Exercises are generally run by pairs of academic staff.

Organisation of RMEs

- Each exercise lasts 9 weeks with students devoting 10 hours/week
- Students work in small groups of 4 or 5.
- Each of the exercises is reported in two formats:
  - Poster
  - Written (paper manuscript form) report

  The poster session is held several days before the report deadline to allow incorporation of feedback into the paper.

These presentation formats build upon those in the “Transferable Skills” course undertaken in 3rd year.

Research Methods Exercises – Example 1

Photoactivation of Metal Complexes

This exercise studies the transformations of metal complexes which can be achieved by photolytic processes.

- Students initially study the established UV photolysis of titanium(IV)citrate providing titanium(III) species.
- They then go on to explore the design of water soluble cyclopentadienyl Ti(IV) complexes with chromophores to provide photolytic access to cyclopentadienyl Ti(III) complexes using visible light.

This exercise teaches synthetic transition metal chemistry, spectroscopy, and photolysis techniques. Also introduces the use of such processes in designing functional molecules for application in biological systems.

The results from the 2004/05 group were in included in a published paper:
J. Paradies, J. Crudass, F. MacKay, L. J. Yellowlees, J. Montgomery, S. Parsons, I. Oswald, N. Robertson , P. J. Sadler,
J. Inorg. Biochem., 2006, **100**, 1260.

Research Methods Exercises – Example 2

Protein Engineering and Molecular Modelling

In this exercise students investigate the use of molecular modelling techniques to investigate the effect of variation of the amino acid sequence in an enzyme.

- Explore the Protein Data Bank and obtain structural data for Flavocytochrome b_2 and related enzymes.
- Examine the 3D structure and identify the sites involved in substrate binding and catalysis.
- Model the enzyme-substrate interactions and identify possible amino acid sequence changes which could optimise these for alternative substrates.
- Re-engineer the enzymes *in-silico* to investigate the effects of these changes on substrate specificity.

This exercise teaches the use of structure visualisation software in enzyme chemistry and the application of molecular modelling in predicting, understanding and manipulating enzyme function.

Research Methods Exercises – Example 3

Catalytic Synthesis of Chiral Alcohols

In this exercise students explore two alternative methods of synthesising chiral alcohols using catalysis:

- Synthesis of chiral amino alcohol ligands from amino acids and use as ligands in the asymmetric alkylation of aldehydes by $ZnEt_2$.
- Synthesis of a ketone substrate and investigation of its biocatalytic reduction using the enzyme *Mucor miehei* lipase
- Compare the two alternative methods in terms of reaction rate and selectivity for the desired chiral product.

This exercise introduces the concepts of asymmetric catalysis and biocatalysis.

Provides training in organic synthesis, analytical and spectroscopic characterisation of products, and the use of chiral hplc in determining the stereochemical composition of compounds.

Summary

The *Training in Research Methods* course builds upon the 3rd year lab courses and transferable skills training by providing:

- Training in literature searching and writing of literature reviews
- Experience of three different areas of chemical research and their techniques, methodologies and instrumentation.
- Guided practice in defining research aims and planning projects.
- Practice in different presentation methods.
- Practice in team working.
- Introduction to risk assessment.

In this way the course achieves the aim bridging the gap between the 3rd year (level 9) practical laboratory/trans skills work and the final year level 11 research project.