Bridging the gap to final year laboratory projects: a Level 2 Research Skills module

Kay H Yeoman, School of Biological Sciences, University of East Anglia, Norwich NR4 7TJ
E-mail: k.yeoman@uea.ac.uk

Background and rationale

Research is active, exciting and dynamic, but it does not need to be at the forefront of the field to be of value to teaching. Research capabilities include innovation, independence, setting and solving problems, analysing critically and being able to handle information in a variety of ways. These are crucial transferable skills which we need to teach our students. The primary objective of establishing a scientific research skills module in the School of Biological sciences was to act as a bridge between taught, prescriptive practical sessions in the first two years of the undergraduate degree programme and the final year research project. The module began in the 2005/6 academic year and has now had three cohorts of students.

The research project in the final year takes the form of an eight week placement in the research laboratory of a member of faculty. However students are often ill prepared for such an intensive experience, and although reports are produced which are of a high standard, it is usually due to close supervision by senior PhD students and postdoctoral scientists, who mentor students through the process. By providing a module in the second year, which enables second year students to undergo an open ended, heavily supported mini research project, it was hoped that the basic technical, analytical and writing skills would be acquired prior to the final year project. In this way, the students would be better equipped for this period of their degree programme and be able to contribute to the research group in which they do their project in a more effective way.

How to do it

The module runs in the Spring semester over a twelve week period. The module is worth 20 credits and is capped at 30 students per year, although the maximum number I have had enrolled has been 24. There are three members of staff who are involved in supporting the students, either in the laboratory or in the lecture series. The learning outcomes for the module are the development of:

- Research skills;
- Experimental techniques;
- Critical thinking and judgement;
- Analysis of Data and how to apply statistics;
- Scientific writing skills;
- Time management;
- Team working and leadership skills;
- Independent thinking;
- Assessment skills; and
- Oral presentation skills.

The research skills module involves a three-stranded pedagogy consisting of seminars, laboratory work and then dissemination of the research findings by students. Further details are provided in the table below.

Seminars	Laboratory	Dissemination
The research environment	General lab skills	Research paper
Safety	Laboratory safety	Oral presentation
Ethics	Cell culture	Scientific poster
Data analysis	Molecular techniques	
Scientific writing	Microbiology techniques	
Learning how to assess		

There are two or three seminars per week throughout the course of the module, covering topics such as the research environment, initial experimental planning, critical analysis of scientific literature and scientific writing (see accompanying website for a full list of seminar titles and the order in which they run).

Students also participate in two workshops, one on statistics and a second on bioinformatics. In the School of Biological Sciences we use the SPSS statistics package. To support the students in learning how to use this package we use the book 'Statistical and Data Handling Skills in Biology' by Ennos, (2007 2nd Edition); an excellent book which goes through statistics and shows screen shots of SPSS in action. For teaching students how to analyse DNA in silico we use the software package BioEdit, which

is freely available from www.mbio.ncsu.edu/BioEdit/bioedit.html

Mini laboratory research projects

Central to the module are the supported mini research projects. Students undertake the projects in groups of 2 or 3. Within their projects all the students learn basic laboratory skills, which include making media and solutions. They also have to think about and plan their experiments; methods are obtained through the research literature. In order to support the latter, we do a literature search in the computer suite, where they decide on suitable search terms and then use these to locate primary literature. I also provide a methods file on the Blackboard site, which lists the recipes and methods for commonly used microbial media and molecular techniques. Eight weeks is spent in the laboratory with an average of seven hours per week.

Examples of research project:

Investigating the content of probiotic products sold to the general public. Students choosing this project do a search of the current literature on probiotic supplements. They choose a probiotic on which to work and attempt to isolate and enumerate the bacteria. They can perform 16S rDNA analysis on purified cultures and test the survival rate of bacteria in artificial gastric juice.

The creation of living paints. In this project students attempt the site directed mutagenesis of green fluorescent protein, using the BioRad plasmid pGLO, to create mutants of different fluorescence. They use the current literature to find out which amino acids need to be altered to obtain different colours. They design their own mutagenic primers and optimise the mutagenic PCR reaction.

The isolation of nematode trapping fungi. Predacious fungi are fascinating and this project allows the students to work out ways of getting *Arthrobotrys oligospora* to induce traps. Methods for the isolation of soil nematodes are obtained from the literature as are methods for isolating other nematode trapping fungi. The students also have the opportunity to video the traps in action. They can also identify their own fungal isolates by analysing the 18S, ITS1, 5.8S and ITS2 region.

The microbial community living on and in lichens. Lichens are a mutualistic symbiosis between a fungus and a photosynthetic partner (usually algae). The lichen thallus is slow growing but very persistent and provides a unique ecological niche in which other microorganisms can proliferate. This project allows the students to think of ways to isolate microbes that live on and inside lichens. The isolated microorganisms are identified using ribosomal RNA analysis. Students have also used FISH probes for eubacteria on thin lichen sections and used electron microscopy to view the lichen surface.

The effect of caffeine on human/mouse cells. In this project students have the opportunity to learn animal cell culture. They investigate the effect of caffeine on cells and look for signs of apoptosis by measuring lactate dehydrogenase activity. They also look at the cells for signs of blebbing using DAPI staining.

The relationship between marine bacteria and marine algae under conditions of low iron. This project looks at the effect on low iron on the survival of the marine algae *Dunaniella salina*. It also investigates whether adding the bacterium *Halomonas* has any effect on survival of *D. salina* in low iron. This project involves a clear experimental design strategy with some thought on statistical analysis.

Isolation of thermostable protease enzymes. Students have the opportunity in this project to isolate thermophilic bacteria from compost sites. They test the bacteria for protease production using a combination of milk agar and an azocaseinase assay. The thermostability and pH range of the proteases can be determined. Students who enjoy biochemistry can also do some enzyme kinetics. The bacteria can also be identified using 16S rDNA analysis.

Assessment

The assessment scheme for the scientific research skills module is shown in the table below.

Assessment task	Weighting	Assessed individually / by group	Learning outcome assessed
Keeping a laboratory book	10%	Individual	Accuracy; Writing skills; Organisation
Writing the work as a research paper	65%	Individual	Scientific writing skills; Data analysis skills; Discussion, argument and personal interpretation
Oral presentation	10%	Group	Oral presenting skills; Team work; Organisations skills
Poster presentation (peer assessed)	15%	Group	Team working, judgement and constructive criticism; Honesty

Advice on using this approach

- Have a very clear idea of the type of research projects you can offer. Broad topics, where small groups (3 people) work together, but individuals take on different aspects of the research work really well.
- Give the students an opportunity to adjust to their research environment, show them the facilities they will need to use (e.g. where the ice machine is) and also show them the areas they can use in the rest of the department.
- Give 'group' sessions on general techniques such as media making and plate pouring.
- Ensure the practical programme is well supported with writing and data analysis workshops. Get them analysing their own data and thinking about the structure of their own reports in these sessions.
- Give the students a flavour of your research environment; they are fascinated by the structure and politics of a research group. This is generally a hidden world, but one which they are intrigued by.
- Make sure you have support in the laboratory from experienced postgraduate demonstrators, especially in the first few weeks of laboratory work.
- You will need the support of your technical staff; this is a very different way of running a practical. Get the students to think about equipment and chemicals they might need for their research. We use a system of 'order slips' which the students fill out, saying what they require and when.
- I use Blackboard to:

  Provide general laboratory recipes for growth media and buffer solutions;

  To post relevant scientific literature;

  Give links to journals and primary literature searching sites (eg PubMed);

  Provide sequences and data needed to complete the bioinformatics and statistics workshops; and

  Provide PDF documents of all seminars.

Troubleshooting

- In some instances there can be problems with the students working in groups, where one member is seen not to be working as hard, perhaps due to poor attendance. In this instance the students need to report their concerns to the module organiser, who can then talk to the student(s) concerned to see if there are other issues as to why they are having difficulty. It is up to the module organiser to make sure that all the students are aware of the assessment and learning outcomes of the module.
- Research/techniques can fail; in which case the students need to learn to troubleshoot to find different ways to approach a problem. This is a valuable learning outcome from this module, but the students need to be told that this is alright and failure often happens in research.

Does it work?

Student feedback

Students enjoy this module; they feel they learn many key practical and transferable skills, "It feels more like the skills needed outside university". The skills the students seemed to value the most are team working and communication, classic transferable skills. They comment on the value of having patience, how science can take you in unforeseen directions and the importance of planning. They also find the subject specific practical skills interesting, these include cell culturing techniques and the polymerase chain reaction, media preparation, bacterial culturing and running enzyme assays. These are all key technical skills which can be applied to a wide variety of research areas. Confidence and independence is also gained as a result of having designed and run an experiment, as well as knowing "what to do when things go wrong!"

In addition they feel more confident about undertaking their final year research project, which is one of the key aims of the module design.

- "Very informative about research projects, has taught me a lot about how to go about doing them and some of the things not to do."

Feeding forward into the research project

One of the reasons for developing this scientific research skills course was to act as a bridge between prescriptive practicals in the first and second years and the final-year honours degree research project. A cohort of students who took part in the research skills module were followed into their final year research project and a comparison of their component marks in their research project were compared against the course average. Interestingly, the marks for the report, the oral presentation and the overall mark were very similar. The conduct mark however was 3% higher for those students who had previously done the research skills course. This may reflect the added experience that these students brought to their final year research projects.

Caveats

- The first four weeks are very intense, but the students very rapidly adjust to reading papers and getting ideas from the literature. They actually become independent very quickly when they build up confidence.
- If you link the projects on offer with your own research interests, you can also benefit in a very real way with the generation of new data.

Further developments

I am planning to revise the module, so that it runs year long. The lecture series will be delivered in the Autumn semester along with the experimental planning. The actual laboratory work will still take place in the Spring semester. This will match other year long modules which are currently offered and will reduce the intensity of the experience for both myself and the students.

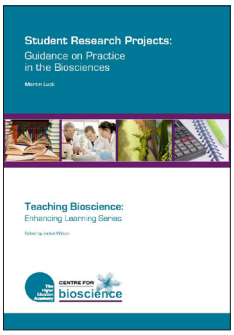
Reference

Ennos, R. (2007) Statistical and Data Handling Skills in Biology, 2nd edition. Pearson/Prentice Hall.

Further information

Yeoman, K.H. and Zamorski, B. (2008) Investigating the impact on skill development of an undergraduate scientific research skills course. Bioscience Education, **11**-5, available at www.bioscience.heacademy.ac.uk/journal/vol11/beej-11-5.aspx (last accessed 16th October 2008)

Accompanying materials



This case study was written to accompany the Teaching Bioscience: Enhancing Learning guide entitled *Student Research Projects: Guidance on Practice in the Biosciences*, written by Martin Luck and published by the Centre for Bioscience. The associated website (www.bioscience.heacademy.ac.uk/resources/TeachingGuides/) contains a downloadable version of this and other case studies and supporting materials.

Case Study published October 2008

The Higher Education Academy
CENTRE FOR bioscience

Centre for Bioscience
Room 9.15 Worsley Building
University of Leeds, Leeds, LS2 9JT
Tel / Fax: 0113 343 3001 / 5894
Email: heabioscience@leeds.ac.uk
Web: www.bioscience.heacademy.ac.uk