[O25] Enhancing the development of experimental design skills in life science undergraduates: the link between confidence and engagement

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BACKGROUND

Project work is seen as an essential component of most Bioscience degrees and this is perhaps most significantly demonstrated by the level of importance put on the final year project, which often contributes significantly to the student's final mark. Further, the subsequent success and direction of a student's research career does, to some extent, depend on the outcomes and subject area of the final year project. Currently, there is some debate within HE regarding final year projects as a key element of most bioscience degrees evidenced by the existence of a special interest group hosted by the HEA Centre for Bioscience. Concerns include the resourcing of projects, the impact on supervisors' time as well as the value placed upon these projects in terms of final degree mark.

It has been reported that the way students approach projects has a major impact on how supervisors perceive this academic 'chore.' As Ed Wood pointed out at the Making the Most of Final Year Projects event in 2004, 'Poor or poorly motivated students may just be throwing expensive chemicals down the sink' (Wood (2004)). We feel it is fair to conclude that not all students are wholly prepared, at this stage in their career, to engage with independent project work and therefore, there are currently gaps in supporting the acquisition of the skills necessary for successful experimental project work in many bioscience programmes. These skills include the ability to design, plan, conduct and critically analyse experimental investigations and projects. These skills are not only essential for the successful biology graduate but are also, central to the practice of research biologists and therefore should be developed in our degree programmes (Lederberg (1995)).

Most bioscience degree programmes do contain elements designed to develop students' experimental design and data analysis skills. Often these consist of lecture courses introducing elements of experimental design (e.g. the use of controls and appropriate sampling) and data analysis (with an emphasis on statistical analysis). However, most bioscience programmes offer students little opportunity to design and criticise experiments in a low risk setting, i.e. the vast majority of their practical work experience will be participating in controlled exercises and highly structured investigations (Hazel and Baillie (1998)) with little opportunity to truly 'experiment' prior to the final year project itself. In an attempt to address this gap, the Zoology/Aquatic Biology degree programmes at the University of Glasgow piloted a new course component in the 2003/04 session designed to aid the development of the skills necessary for effective project work in its students.

PILOTING OF THE EXPERIMENTAL DESIGN SESSIONS

3rd year students (of a 4 year Honours programme) participated in a series of facilitated discussions. The sessions were supported by a recently published book on experimental design for biologists (Ruxton and Colegrave (2003)) and a specially designed series of supporting questions and experimental design problems. The sessions took place early in the first semester and were delivered to groups of ~ 15 students; within these sessions the students worked in smaller groups to design experiments to answer a number of 'real-life' research questions. An example of these mini-projects is shown in Box 1.

Box 1. Sample mini-project in the Experimental Design Sessions

Devise a scheme for categorising a person's hair colour. Your scheme must give fine-detailed information but have very low levels of inter-observer variability. Demonstrate the effectiveness of your scheme by presenting data collected independently by several group members on a sample of people passing this building.

Throughout the academic year these same students had a number of opportunities to test and be assessed on their experimental design skills. The last of these is a short-term lab or field-based group project, the 'Insect Project.' As part of the Invertebrate Biology component of the course, the students choose from a range of topics on aspects of invertebrate biology. The projects are supported by a series of lectures on invertebrate taxonomy, anatomy and physiology. Students work intensively for 3 weeks in groups of 2 or 3 to design and carry out experiments to address a research question or questions. The projects are assessed by means of a group presentation and have been running with few alterations for over a decade. In the past, the success of the Insect Projects has been highly variable with some student groups engaging successfully and running the projects in a fairly independent manner; other groups have been less successful, requiring a great deal of input and guidance from the supervisor.

EVALUATION OF THE EXPERIMENTAL DESIGN SESSIONS

The effectiveness of the use of small group discussions to teach experimental design skills was (and is being) evaluated using a number of methods. First, a detailed questionnaire was used to obtain feedback from students at the end of the series of discussions. Analysis of this questionnaire, completed by participating students (52 students), indicated that over 90% of them believed they would be better at designing their own experiments after the sessions than before and 88% believed they were more able to criticise the design of others' experiments. In addition 80% of the respondents believed that this method of learning was effective and preferable to a lecture format.

Later, four of the six Insect Project supervisors were interviewed, using semi-structured interviews, after completion of the projects and presentations. These supervisors were chosen because of their long-term involvement with the projects, a minimum of 5 years. The interviews were designed to gauge their overall perceptions of their students' performance. The interviews were recorded, transcribed and analysed. The main findings from this analysis were that the supervisors were unanimous in believing that the majority of students engaged more successfully with the projects, required less direct guidance and supervision and that the outcomes of the projects were more successful than in previous years. These comments were reflected in considerably higher marks for this part of assessment than in previous years. Some of the comments from these interviews are shown in Box 2.

Box 2. Insect Project supervisors' comments in interview

Students engaged more effectively with the projects

'they were very focused and "let's get proper samples" so that we can really answer the question'
'I mean they were all motivated'
'they were . . . showing evidence of thinking about what they were doing quite deeply, which I don't think I'd seen before'
'there was evidence of a greater understanding of what an experiment is'

Students required less direct supervision

'*They were pretty well self-sustaining and they were critical of the data'*
'I was incredibly impressed at how they just went away and did the thing, and did a very good job'
'significantly less [supervision] than in the past, and they did significantly better'

Students conducted the projects more successfully than any previous cohort.

'I'm more encouraged about the way that things went this year than I've ever been'
'I thought this is the best year we've had for the quality of the science'

We will complete our evaluation of the outcomes of the pilot experimental design sessions by gathering data of student performance in their final year. For those students continuing to 4th year, a major part of their assessment, the honours research project along with the experimental design and data analysis paper of the final degree exam, will also draw on the skills learned in the discussion sessions. We will gather this data and correlate it with their level of attendance at the sessions. We will then compare this with the students' relative performance in components of their assessments not directly supported by the experimental design sessions.

REFINEMENTS OF THE EXPERIMENTAL DESIGN SESSIONS

A number of the Experimental Design sessions were observed by one of the authors (JM) and based on her observation and the reflection of one of the facilitators (GR) a number of refinements to the design of these sessions have been made for the current session.

These are:

- Room layout – the use of small group tables as opposed to a boardroom format
- Formal assignment of student to sub-groups for the duration of the discussion sessions
- Reduction of the number of sessions from 6 to 5, with sessions lasting 90 minutes instead of 60
- Inclusion in each session of at least one practical task where students work in small groups of 3-4 to design and perform an experiment, feeding back their experiences to the larger group. This is to allow the students to experience putting an experiment they've designed into practice. It will involve the students leaving the building in which the sessions take place to gather some data through on-the-spot interviews or observations/ classifications.

We are currently repeating the session evaluations performed in the pilot year in light of the alterations made to the format.

DISCUSSION AND FUTURE WORK

For us, the most surprising outcome of this pilot was the increased levels of student engagement and confidence as evidenced by the supervisors' comments. It is well known that for students to be successfully motivated they need 'to find challenge, stimulation, satisfaction and meaning in the work they do' (Seifert (2004)) and it has long been recognised that experimental project work where students have a level of autonomy is highly motivational and that there is an additional level of engagement if the student attains a sense of ownership of their work (Bliss and Ogborn (1977)). Students report that project work is one of the most enjoyable elements of their degree programme (Boud et al. (1986)). This does not explain why, in the pilot session, the Insect Project supervisors reported a greater degree of enthusiasm and engagement in their students than in previous years.

It has been suggested that 'students cannot conduct meaningful enquiries in areas in which they have no background'; courses should offer opportunities for students to learn the necessary skills (both conceptual and practical) to undertake project work effectively (Boud et al. (1986)) Many courses, especially at honours level, do teach experimental design including essential concepts like hypothesis generation, the use of appropriate sample sizes and controls. These rarely offer students the opportunity to practice these skills and concepts prior to an exam or piece of assessed project work.

Learning in small groups develops students' confidence and communication skills (Griffiths et al. (1996)) and we believe that the structured discussions piloted last year are an effective way, possibly the first the students have experienced, of allowing the students to practice their design skills, in a 'low risk' (i.e.unassessed) setting with immediate feedback whilst simultaneously allowing them to practice the 'group' skills which will be utilised later in the year. So we propose that one contributing factor to the reported improvement in performance in this project work was the additional support the students received through participating in the experimental design sessions. It is well known that confidence or self-belief (self-worth) is highly linked with performance (Covington (1984)) and we feel that the opportunity to practice designing experiments in the discussion sessions will have allowed most students to engage with their projects with a higher than previous level of confidence

We do not believe this was the only factor which influenced the outcome of last year's Insect Projects. Successful, independent project work cannot be achieved by students adopting a surface approach to learning. We believe that there are elements of the Insect Projects as they operated last year that encouraged a deep or at least strategic approach to learning (Biggs (1987); Entwistle (1997)) and that the perceived improvement in student performance last year was not wholly due to the fact that students were better equipped to design experiments.

We are therefore extending our study to examine the factors that motivated students to become more actively engaged with these projects than previous cohorts of students. In addition to the impact of the experimental design discussion classes, factors we will examine will include the timing of the projects, the impact of the implicit value placed on project work/experimental design by placing a formal teaching element into the 3rd year curriculum and the levels of student confidence. By identifying the elements of the projects which contribute to the students adopting such approaches it is hoped that such factors will be maximised in the presentation of the projects in future years and

may be used and applied to other elements of the curriculum. These factors will be examined by conducting semi-structured interviews with a panel of this current 3rd year students (15-20), shortly after the conclusion of their Insect Projects and presentations.

CONCLUSIONS

We have developed and evaluated a novel teaching resource in the form of a series of structured questions and 'real-life' mini-projects supported by interactive discussion sessions. We have shown that these resources have apparently equipped 3rd year students to engage more successfully with small group projects and would envisage that this will also be reflected in their performance in their final year projects. We believe these teaching resources could be applied and adapted to other Bioscience degree programmes. However, more crucially, the identification of factors that influence student engagement, and thus success, in project-based learning tasks within the biosciences might have serious ramifications for the way that project work and perhaps in particular, the Final Year project is presented and supported at present in most universities.

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