The Experimental Design sessions were a series of 5 one-hour facilitated discussion sessions. Approximately 15 students attended each session. They were asked to read the appropriate section of the text book (detailed below) and prepare answers, in advance, to each of the questions/experimental outlines as shown on the following pages. Each session consisted of discussion, some elements of small group work and/or carrying out mini-projects as detailed.

Level 3 Zoology / Aquatic Bioscience Module

Review Questions for Experimental Design for the Life Sciences

Textbook: Ruxton GD, Colegrave N. *Experimental design for the life sciences* Oxford: Oxford University Press, 2003.

Session outline
To aid students in focusing their understanding, a member of academic staff will facilitate group discussions on specific sections each week from Weeks 3 to 7. The class will be split into four for this, and group will meet in the Graham Kerr Library each week. Attendance at these is compulsory, but is no substitute for reading the book. In no sense will the member of academic staff lecture to the group. Rather they will help direct discussion among the group of students, aimed at testing and developing depth of knowledge and understanding. Hence, reading the appropriate section of the book before attending a group discussion is mandatory.

There is one meeting for each section. As well as having read the appropriate section carefully at least once, you should make an attempt to answer all the questions for that section.

Session 1 - Pages 1-12: Chapter 1 & Section 2.1

1.1   Imagine that the research task you want to address is to estimate the fraction of the electorate who plan to vote in the next election for the Scottish Parliament. You plan to do this by surveying a sample of the appropriate statistical population. Carefully define this population in your own words.

1.2   In the example of question 1.1, how would you choose a representative sample for the survey?

1.3   In the example of question 1.1, what number of people would you aim to gather data on?

1.4   The book argues that if we were surveying the food preferences of different nationalities, then using five members of one family as five independent measurements of the food preferences of the nationality of that family would not be statistically valid. Explain the reasoning behind this in your own words.

1.5   Are there any variables you can think of where you might be able to justify using members of the same family as independent sampling units?

1.6   Are there ethical considerations associated with the surveys described above?

1.7   An early draft of the book contained the following real example, but the authors were persuaded that it was both a flawed way of collecting data and ethically objectionable.

> A social scientist wanted to find out what papers people in a given street read. The problem is that people can be expected to lie when you ask them, saying that they read a broadsheet when they actually read a tabloid or no newspaper at all. The social scientist got around this by saying that he was piloting a paper recycling scheme, providing people with sacks and asking them to deposit all their waste paper in a sack which he collected at the end of the week. This allowed him to evaluate which papers were read using the papers placed in the bags. Having obtained this information, he took the contents of all the bags to a paper bank.

Why is this unethical and scientifically flawed?

1.8(a)   Salmon parr eat less per day in winter than summer. Suggest at least three hypotheses that could explain this.

1.8(b)   How would you critically test between these hypotheses?

Session 2 - Pages 12-29: sections 2.2 -2.8

2.1   Imagine that a study did find that people who preferred butter were better drivers than those that preferred margarine. Can you think of any hypotheses that could explain this finding, and consider which of these you consider most plausible.

2.2   How would you the measure driving ability in a study like the one described in question 2.1?

2.3   Ecologists commonly use indirect measures such as clutch size, feeding rate and mass per unit length as indirect measures of fitness. What are the limitations of this, and why do ecologists persist in using these indirect measures in the face of these limitations?

2.4   Can you think of a scientific study where ethical considerations might drive you to use indirect measurements?

2.5   In the tail length experiment, we want to have a control group in which tail length is unaltered. Why do we bother to cut the tails off then glue them back on in exactly the same position?

2.6   Discuss how you would test the hypothesis "Female humans find blue eyes more attractive than brown" by correlational and manipulative means. Discuss the pros and cons of each and which you would adopt to address this question.

2.7   The book suggests that women who go to university are less likely to marry than those that do not. However, the book argues that we should not conclude from this that studying at university in itself causes a reduction in a woman's propensity to get married. Explain this reasoning in your own words.

2.8   A driver in their twenties is three times as likely to be involved in a road traffic accident as a driver in their sixties. One explanation for this could be that people become safer drivers as they get older. Can you think of any likely third-variable effects that could provide an alternative explanation for this observation?

2.9   Can you think of an alternative explanation for the observation of the last question, in terms of reverse causation?

2.10.   Which of the explanations above do you think is the most important factor explaining the three-fold difference in accident rates between these age groups?

Session 3 - Pages 30-57: Chapter 3

3.1   I want to describe the average height of third year undergraduates at the University of Glasgow. Would the L3 Zoology class be a reasonable sample to use?

3.2   Is there anything aspect of third year undergraduates at the University of Glasgow for which the L3 Zoologists might be a reasonable sample to use?

3.3   Imagine that I want to test the hypothesis, "Is the average height of male third year undergraduates in the engineering faculty different from the average height of equivalent students in the science faculty?" How many would you sample in each faculty?

3.4   If the populations were the same as the last question, but you wanted to test to see if there was a difference between these two populations in average number of CDs owned by a person, how would this influence the sample size that you would use?

3.5   In the elk habitat preference study on page 40, why does the book recommend taking daily measurements at random times? Why not collect the data at the same time every day?

3.6   Before you fly off on holiday, your plane is checked for metal fatigue. Which should you worry more about, Type I or Type 2 error in this metal fatigue check?

3.7   A major scientific journal reports that school pupils that play a musical instrument performed better in a general test of memory power than those that do not. From this they concluded that playing a musical instrument improves memory power. Do you consider their conclusion premature, and if so how would you go about collecting more data to test this hypothesis?

Mini Practical exercise

We assume that tossing a coin is likely to produce a Head or Tail each with 50% probability, but is this correct? In the discussion session, you will be assigned to a small group of 2-5 students. The group must design and perform an experiment to probe the validity of the hypothesis that coin tossing is a way of producing one outcome (a head) with 50% probability and another outcome (a tail) with 50% probability. The group should then present their results orally to the other groups.

Session 4 - Pages 58-81: Chapter 4

4.1   We wish to test for differences in fear reaction of mice to avian and mammalian predators. We intend to do this by monitoring the heart rates of wild-caught field mice following exposure to taxidermic mounts of a weasel and an owl. Consider the ethical and practical pros and cons of a cross-over design for this experiment (where the same individual is exposed to both stimuli) compared to a conventional fully randomised experiment. The mice would be returned to the wild after the experiment.

4.2   In the hen house experiment on page 76, if you could use only one of the controls (silence, conversation or Country & Western music), which would you use and why?

4.3   I want to compare sprint speeds between two groups of randomly selected 3rd year undergraduates. Members of one group have watched a motivational video for 20 minutes before taking the test and one group has listened to relaxing music for 20 minutes.
(a) Do you expect that a difference will be found?
(b) What covariates would you want to measure?
(c) Would a cross-over design (where we subject individuals to both manipulations sequentially) be effective for this study?

4.4   Exam books are designed so that the name of the student is unavailable to the marker; discuss the reasoning behind this in terms of blind procedures.

4.5   It is often suggested that chilli powder can be added to nuts and seeds put out for garden birds, as a way of making the food unattractive to squirrels without reducing its attractiveness to birds. Discuss how you might explore this using volunteer members of the public, with particular emphasis on including an appropriate control.

4.6   When two people approach a doorway from different sides at the same time, one must give way and allow the other person to go through first. What factors might influence how the two individuals decide who defers to whom?

Mini Practical exercise

You will be divided into groups. Choose one of the factors that you discussed in the last question and perform an experiment to explore its effect on deferring at doorways, either in this or a nearby building. Finish by presenting your results orally to the other groups.

Session 5 - Pages 82-109: Chapters 5&6

5.1   In the example on page 104, can you imagine any reason why giving a pile of questionnaires to a G.P. and asking them to give them to every tenth patient they see in their consulting room could lead to a biased sample?

Mini Practical exercise
Imagine that you are interested in interviewing final year students in schools in the Glasgow area to learn how they decide on whether to go to university or not. Bearing in mind the issues raised in section 6.2 on subsampling, decide how many schools to visit and how many pupils to interview in each school. It takes five hours to make the arrangements to visit a school. When you do visit, it takes an hour to organise things, after that you can process three students an hour. There are between 20 and 200 students in a school's final year.

In the discussion session, you'll be split into groups, and each group will be asked to present their chosen design orally. The best design will be chosen using the following criteria
1) scientific rigour
2) value for money (based on the cost of time invested in the study)

5.2   In question 5.1 how would you decide which schools to include in your sample?

5.3   In question 5.1, how would you decide what pupils from a given school to interview?

Mini Practical exercise
Working as a group can you design an experiment to test whether an animal can count. Each group will be assigned a different species to work on.

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