BIOL235

Experimental Design and Data Analysis for Biology

S2 Day 2014

Dept of Biological Sciences

Contents

General Information

Unit convenor and teaching staff
Unit Convenor
Belinda Medlyn
belinda.medlyn@mq.edu.au
Contact via belinda.medlyn@mq.edu.au

Other Staff
Katherine McClellan
katherine.mcclellan@mq.edu.au
Contact via katherine.mcclellan@mq.edu.au

Credit points
3

Prerequisites
(6cp(P) in BBE or BIOL or ENV or ENVE or ENVG or GEOS units) and (STAT170(P) or STAT171(P) or PSY122(P))

Corequisites

Co-badged status

Unit description
Biological organisms are inherently variable, which means that practicing biologists need a solid grasp of how to design experiments and how to interpret the resulting data. This unit provides a foundation in the principles of experimental design and data analysis for biology. The unit is taught by biology staff and draws on research carried out in the Department of Biological Sciences. Students also learn the overall process of asking and answering questions in biology. Students learn a range of common data analysis techniques, and how to interpret the outcomes of these analyses. There is a strong emphasis on critically evaluating biological studies and identifying sound conclusions and not-so-sound conclusions. This unit is strongly recommended for students planning a career in biology or environmental science.

Important Academic Dates

Information about important academic dates including deadlines for withdrawing from units are available at https://www.mq.edu.au/study/calendar-of-dates

Learning Outcomes

On successful completion of this unit, you will be able to:

Develop testable hypotheses from general scientific questions

Design an unconfounded experiment to test a given scientific hypothesis

Identify dependent and independent variables and recognize different types of variable

Choose an appropriate statistical test to analyse experimental data

Carry out a range of commonly-used statistical tests using the computer package MINITAB

Correctly interpret results from statistical tests

Clearly present outcomes from experiments, using figures, tables and text

Critically evaluate other studies

Identify possible confounding factors

Evaluate whether statistical tests have been correctly applied and interpreted

Assessment Tasks

Name	Weighting	Due
Weekly Quizzes	10%	Tues 10 am, weekly
Tutorial write-up	10%	Tutorials
Mid-semester test	10%	Week 8
Experiment report	20%	Mon 28 October 10 am
Final exam	50%	Exam Period

Weekly Quizzes

Due: **Tues 10 am, weekly**
Weighting: **10%**

Every week there will be an on-line quiz with example problems to complete. These problems will be based on that week's lectures and tutorial and provide a chance for you to practice applying the concepts you have learnt. It is strongly recommended that you make a serious effort to complete these quizzes.

On successful completion you will be able to:

- Develop testable hypotheses from general scientific questions
- Design an unconfounded experiment to test a given scientific hypothesis
- Identify dependent and independent variables and recognize different types of variable
- Choose an appropriate statistical test to analyse experimental data
- Carry out a range of commonly-used statistical tests using the computer package

MINITAB

- Correctly interpret results from statistical tests
- Clearly present outcomes from experiments, using figures, tables and text
- Critically evaluate other studies
- Identify possible confounding factors
- Evaluate whether statistical tests have been correctly applied and interpreted

Tutorial write-up

Due: **Tutorials**
Weighting: **10%**

After each tutorial you will write up your answers to that week's tutorial. You will hand them in in hard copy at the following week's tutorial. This exercise is to check that you understood the material covered in the tutorial.

On successful completion you will be able to:

- Design an unconfounded experiment to test a given scientific hypothesis

Mid-semester test

Due: **Week 8**
Weighting: **10%**

You will be tested on your knowledge of lecture material for weeks 1-6 in Week 8 (following semester break). This test will be delivered as an online assignment accessible through iLearn.

On successful completion you will be able to:

- Identify dependent and independent variables and recognize different types of variable
- Choose an appropriate statistical test to analyse experimental data
- Correctly interpret results from statistical tests
- Critically evaluate other studies
- Identify possible confounding factors
- Evaluate whether statistical tests have been correctly applied and interpreted

Experiment report

Due: **Mon 28 October 10 am**
Weighting: **20%**

You will be required to design, conduct and analyse an experiment of your own. We will give you a range of alternative experimental questions to choose from. You will need to pick a question, design and carry out an experiment addressing that question, then write up the results in the form of the methods and results sections of a scientific paper. Full details will be given at the

start of semester. **Important: The report is COMPULSORY - students who fail to submit their report will FAIL the unit irrespective of their marks in other assessment tasks.**

On successful completion you will be able to:

- Develop testable hypotheses from general scientific questions
- Design an unconfounded experiment to test a given scientific hypothesis
- Identify dependent and independent variables and recognize different types of variable
- Choose an appropriate statistical test to analyse experimental data
- Carry out a range of commonly-used statistical tests using the computer package MINITAB
- Correctly interpret results from statistical tests
- Clearly present outcomes from experiments, using figures, tables and text

Final exam

Due: **Exam Period**
Weighting: **50%**

The final exam will be held during the Semester 2 Exam Period and will be 3 hr (plus 10 min reading time). Please consult the University Handbook to determine the commencement and finishing dates of the compulsory exam period. More details on the structure of the final exam will be given closer to the time.

On successful completion you will be able to:

- Identify dependent and independent variables and recognize different types of variable
- Choose an appropriate statistical test to analyse experimental data
- Correctly interpret results from statistical tests
- Critically evaluate other studies
- Identify possible confounding factors
- Evaluate whether statistical tests have been correctly applied and interpreted

Delivery and Resources

CLASSES

Internal Students

Contact hours consist of 2 lectures and one 2-hour tutorial per week.

* Lecture and tutroial times will be available on ilearn

External Students

Lecture material will be placed online for access by external students.

Tutorials will take place online

REQUIRED AND RECOMMENDED TEXTS AND/OR MATERIALS

Recommended Reading

- **Statistics explained: an introductory guide for life scientists**. 2nd ed, Steve McKillup 2011 (MyiLibrary Online access)

Other suggested reading:

Online: The Handbook of Biological Statistics http://udel.edu/~mcdonald/statintro.html is an excellent resource which covers many of the same topics as BIOL235 in a very accessible way.

Library: The library holds a wide range of books covering stats for biologists at different levels. Some favourites from the biology staff are listed below in approximate order of difficulty. These books will be placed in reserve.

- **Practical statistics for field biology** Jim Fowler, Louis Cohen, Phil Jarvis 1998 (QH318.5 .F68 1998)
- **Statistics for terrified biologists** Helmut F. van Emden(QH323.5 .V33 2008)
- **The analysis of biological data**. Whitlock & Schluter (QH323.5 W48 2009) - in Reserve
- **Experiments in ecology : their logical design and interpretation using analysis of variance** A. J. Underwood 1997 (QH541.24 .U54/1997)
- **A primer of ecological statistics** Nicholas J. Gotelli, Aaron M. Ellison 2004 (QH541.15.S72 G68 2004)
- **Experimental design and data analysis for biologists** G. P. Quinn, Michael J. Keough; 2002 MyiLibrary Online access

UNIT WEBPAGE AND TECHNOLOGY USED AND REQUIRED

Website

Lecture graphics and iLectures will be available on iLearn (http://ilearn.mq.edu.au). iLearn is a web-based communication package and can be accessed by most web browsers from inside or outside the University. iLearn and email will be the primary methods of communication in this subject. You are expected to use iLearn for:

- Regularly checking subject announcements;
- Downloading lecture, tutorial and reference materials;
- Checking your grades.

How do you log in? The URL for the iLearn log in page is: http://ilearn.mq.edu.au/.

You must log in to iLearn each time you use it. Your user name is your student number, and your password is your myMQ student portal password, provided upon enrolment (unless you've changed it). If you are having trouble accessing your online unit due to a disability or health condition, please go to the Student Services Website at http://sss.mq.edu.au/equity/about for information on how to get assistance.

If you are having problems logging on, that is, if you cannot log in after ensuring you have entered your username and password correctly, you should contact Student IT Help, Phone: (02) 9850 4357 (in Sydney) or 1 800 063 191 (outside Sydney).

Software

Practical work will be carried out using the computer program MINITAB. Students are able to download copies of MINITAB for their personal use from the student portal.

Important: Students with Mac computers will need a Windows emulator to run MINITAB.

WHAT HAS CHANGED?

The assessment tasks have changed since last year. Last year there were fortnightly homework problems. This year you will do weekly online quizzes, and write up the tutorial material. The new assessment methods should provide for more supported learning.

Unit Schedule

LECTURE SCHEDULE

	TOPIC	LECTURER
	INTRODUCTION	
1	Introduction	Belinda Medlyn
2	Concepts of Experimental Design	Belinda Medlyn
3	Looking at Data	Belinda Medlyn
4	Hypothesis Testing and Effect Sizes	Belinda Medlyn
	TESTS FOR DIFFERENCES	
5	One-way ANOVA	Belinda Medlyn
6	Assumptions of ANOVA	Belinda Medlyn
7	Transformations	Belinda Medlyn
8	Comparisons after ANOVA	Grant Hose
9	Power analysis	Grant Hose
10	Two-factor ANOVA	Belinda Medlyn
11	Two-factor ANOVA	Belinda Medlyn
12	Non-parametric tests	Josh Madin

13	Randomisation tests	Josh Madin
14	Experimental design: testing for differences	Michelle Leishman
	Semester Break	
15	Analysing frequencies	Belinda Medlyn
16	Experimental design for frequencies	Andy Barron
	TESTS FOR RELATIONSHIPS	
17	Correlation and regression	Drew Allen
18	Correlation and regression	Drew Allen
19	Logistic regression	Darrell Kemp
20	Mutliple linear regression	Drew Allen
21	Analysis of covariance	Drew Allen
22	Experimental design: testing for relationships	Melanie Bishop
	MULTIVARIATE DATA	
23	Summarising and Visualising Multivariate Data	David Nipperess
24	Multivariate Classification and Hypothesis Testing	Dick Frankham
	SUMMARY	
25	Multivariate Classification and Hypothesis Testing	David Nipperess
26	Revision	Belinda Medlyn

PRACTICALS SCHEDULE

Internal Students

LAB#	ACTIVITY
1	Getting Started
2	Effect Sizes and Hypothesis Testing
3	ANOVA Basics
4	ANOVA: Super SAO Challenge
5	Power analysis
6	Factorial ANOVA
7	Non-parametric tests
	MID SEMESTER BREAK
8	Analysing frequencies

9	Regression
10	Logistic regression
11	What test when?
12	Multivariate data
13	Meta-analysis

Policies and Procedures

Macquarie University policies and procedures are accessible from Policy Central. Students should be aware of the following policies in particular with regard to Learning and Teaching:

Academic Honesty Policy http://mq.edu.au/policy/docs/academic_honesty/policy.html

Assessment Policy http://mq.edu.au/policy/docs/assessment/policy.html

Grading Policy http://mq.edu.au/policy/docs/grading/policy.html

Grade Appeal Policy http://mq.edu.au/policy/docs/gradeappeal/policy.html

Grievance Management Policy http://mq.edu.au/policy/docs/grievance_management/policy.html

Disruption to Studies Policy http://www.mq.edu.au/policy/docs/disruption_studies/policy.html *The Disruption to Studies Policy is effective from March 3 2014 and replaces the Special Consideration Policy.*

In addition, a number of other policies can be found in the Learning and Teaching Category of Policy Central.

Student Code of Conduct

Macquarie University students have a responsibility to be familiar with the Student Code of Conduct: https://students.mq.edu.au/support/student_conduct/

Student Support

Macquarie University provides a range of support services for students. For details, visit http://students.mq.edu.au/support/

Learning Skills

Learning Skills (mq.edu.au/learningskills) provides academic writing resources and study strategies to improve your marks and take control of your study.

- Workshops

- StudyWise
- Academic Integrity Module for Students
- Ask a Learning Adviser

Student Services and Support

Students with a disability are encouraged to contact the Disability Service who can provide appropriate help with any issues that arise during their studies.

Student Enquiries

For all student enquiries, visit Student Connect at ask.mq.edu.au

IT Help

For help with University computer systems and technology, visit http://informatics.mq.edu.au/help/.

When using the University's IT, you must adhere to the Acceptable Use Policy. The policy applies to all who connect to the MQ network including students.

Graduate Capabilities

Capable of Professional and Personal Judgement and Initiative

We want our graduates to have emotional intelligence and sound interpersonal skills and to demonstrate discernment and common sense in their professional and personal judgement. They will exercise initiative as needed. They will be capable of risk assessment, and be able to handle ambiguity and complexity, enabling them to be adaptable in diverse and changing environments.

This graduate capability is supported by:

Learning outcomes

- Correctly interpret results from statistical tests
- Critically evaluate other studies
- Identify possible confounding factors
- Evaluate whether statistical tests have been correctly applied and interpreted

Assessment task

- Experiment report

Commitment to Continuous Learning

Our graduates will have enquiring minds and a literate curiosity which will lead them to pursue knowledge for its own sake. They will continue to pursue learning in their careers and as they participate in the world. They will be capable of reflecting on their experiences and relationships with others and the environment, learning from them, and growing - personally, professionally

and socially.

This graduate capability is supported by:

Learning outcomes

- Critically evaluate other studies
- Identify possible confounding factors
- Evaluate whether statistical tests have been correctly applied and interpreted

Assessment task

- Experiment report

Discipline Specific Knowledge and Skills

Our graduates will take with them the intellectual development, depth and breadth of knowledge, scholarly understanding, and specific subject content in their chosen fields to make them competent and confident in their subject or profession. They will be able to demonstrate, where relevant, professional technical competence and meet professional standards. They will be able to articulate the structure of knowledge of their discipline, be able to adapt discipline-specific knowledge to novel situations, and be able to contribute from their discipline to inter-disciplinary solutions to problems.

This graduate capability is supported by:

Learning outcomes

- Choose an appropriate statistical test to analyse experimental data
- Carry out a range of commonly-used statistical tests using the computer package MINITAB

Assessment tasks

- Weekly Quizzes
- Tutorial write-up
- Mid-semester test
- Final exam

Critical, Analytical and Integrative Thinking

We want our graduates to be capable of reasoning, questioning and analysing, and to integrate and synthesise learning and knowledge from a range of sources and environments; to be able to critique constraints, assumptions and limitations; to be able to think independently and systemically in relation to scholarly activity, in the workplace, and in the world. We want them to have a level of scientific and information technology literacy.

This graduate capability is supported by:

Learning outcomes

- Develop testable hypotheses from general scientific questions
- Design an unconfounded experiment to test a given scientific hypothesis
- Identify dependent and independent variables and recognize different types of variable
- Choose an appropriate statistical test to analyse experimental data
- Carry out a range of commonly-used statistical tests using the computer package MINITAB
- Correctly interpret results from statistical tests
- Critically evaluate other studies
- Identify possible confounding factors
- Evaluate whether statistical tests have been correctly applied and interpreted

Assessment tasks

- Weekly Quizzes
- Experiment report

Problem Solving and Research Capability

Our graduates should be capable of researching; of analysing, and interpreting and assessing data and information in various forms; of drawing connections across fields of knowledge; and they should be able to relate their knowledge to complex situations at work or in the world, in order to diagnose and solve problems. We want them to have the confidence to take the initiative in doing so, within an awareness of their own limitations.

This graduate capability is supported by:

Learning outcomes

- Develop testable hypotheses from general scientific questions
- Design an unconfounded experiment to test a given scientific hypothesis
- Carry out a range of commonly-used statistical tests using the computer package MINITAB
- Correctly interpret results from statistical tests

Assessment tasks

- Weekly Quizzes
- Experiment report
- Final exam

Creative and Innovative

Our graduates will also be capable of creative thinking and of creating knowledge. They will be

imaginative and open to experience and capable of innovation at work and in the community. We want them to be engaged in applying their critical, creative thinking.

This graduate capability is supported by:

Learning outcomes

- Develop testable hypotheses from general scientific questions
- Design an unconfounded experiment to test a given scientific hypothesis

Assessment task

- Experiment report

Effective Communication

We want to develop in our students the ability to communicate and convey their views in forms effective with different audiences. We want our graduates to take with them the capability to read, listen, question, gather and evaluate information resources in a variety of formats, assess, write clearly, speak effectively, and to use visual communication and communication technologies as appropriate.

This graduate capability is supported by:

Learning outcome

- Clearly present outcomes from experiments, using figures, tables and text

Assessment tasks

- Tutorial write-up
- Mid-semester test
- Experiment report

Engaged and Ethical Local and Global citizens

As local citizens our graduates will be aware of indigenous perspectives and of the nation's historical context. They will be engaged with the challenges of contemporary society and with knowledge and ideas. We want our graduates to have respect for diversity, to be open-minded, sensitive to others and inclusive, and to be open to other cultures and perspectives: they should have a level of cultural literacy. Our graduates should be aware of disadvantage and social justice, and be willing to participate to help create a wiser and better society.

This graduate capability is supported by:

Learning outcomes

- Critically evaluate other studies
- Identify possible confounding factors
- Evaluate whether statistical tests have been correctly applied and interpreted

Assessment task

- Experiment report

Socially and Environmentally Active and Responsible

We want our graduates to be aware of and have respect for self and others; to be able to work with others as a leader and a team player; to have a sense of connectedness with others and country; and to have a sense of mutual obligation. Our graduates should be informed and active participants in moving society towards sustainability.

This graduate capability is supported by:

Learning outcomes

- Critically evaluate other studies
- Identify possible confounding factors
- Evaluate whether statistical tests have been correctly applied and interpreted

Assessment task

- Experiment report