

Statistics for Marine Studies: The issues in teaching statistics to students of mixed ages and backgrounds

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The Diploma in Marine Studies offered at the Bay of Plenty Polytechnic is a two year course unique in New Zealand. The course has considerable emphasis on the practical, students obtaining their dive instructor's certificate and optionally a boat skipper's licence as well as covering marine biology and aquaculture. Sampling and Surveying is one module in the second year which enables students to prepare scientific reports incorporating adequate statistical analysis. The statistics taught has been extensively adapted from a purely mathematical content. The statistical software used is MS Excel as this is the software available to our graduates in the workplace. The students start with a wide range of mathematical skills from virtually nil to year 13 statistics. The challenge is to get them to the same level by the end of the 150 hour module, when only 70 of the 150 are actual teaching. In this workshop I outlined the module I teach, covered the blends of statistics and science and discussed some of the difficulties encountered. Descriptions of some classroom activities were provided .

I live in Tauranga in the Bay of Plenty on the East coast of the North Island of New Zealand, about 3 hours drive from Auckland. We have about 30 kilometres of uninterrupted surf beach. The main beach where many surf life-saving competitions are held is Mt. Maunganui. With an extensive harbour and such a lot of surf beach, the water sports are very popular and the region is an ideal place in which to base a marine studies programme. I taught maths at secondary school level for 17 years but it was in my years outside the classroom that I learnt that people who had not achieved academically had merely not succeeded in that system. This is my 6th year teaching statistics and mathematics at Bay of Plenty Polytechnic.

The programme

Bay of Plenty Polytechnic is a small to medium institution, has over 6000 students and has approximately 28% Maori students. The Marine Studies programme has been offered for 10 years, undergoing several changes but maintaining a focus on practical plus academic excellence. It is a two-year full-time course that leads to a Bachelor of Applied Science (Auckland University of Technology) and also links directly into a Masters Degree in Aquaculture (Deakin University, Melbourne).

Students graduating can develop careers with the Department of Conservation as a scientific observer and researcher, as a technician, as a teacher, or in any of the occupations allied to diving and tourism.

Year 1

Students study Coastal botany, Marine invertebrates, Marine surveying, Marine mammals, birds and fish, Fisheries Aotearoa New Zealand, Marine Science and Ecology Conservation issues and perspective. They also complete their NZ Coastguard Boatmasters, Certificate Project Jonah Marine Mammal Medic Certificate, PADI diving training to Divemaster level, First Aid and Restricted Radio Telephone Operators Licence. Introductory Computing completes the course for the year.

Year 2

Students study: Marine ecology and monitoring; Freshwater ecology and monitoring; Marine reporting; my module of Surveying and Sampling (Statistics); and three options from the list below:

- PADI Open Water Instructor Course
- Aquaculture 1 — system design and maintenance
- Aquaculture 2 — production, growth and health

- Marine tourism
- Flexi option
- Environmental legislation

Entry Requirements

There are entry requirements which are waived if the student is 25 years or older, however relevant work or life experience is required. For younger students they must:

- be at least 17 years of age at the date of application
- have Year 13 (Australian year 12) passes in Mathematics, Biology and English
- supply a Curriculum Vitae
- supply a Doctor's certificate stating they are fit to dive.

Content

The Sampling and Surveying module is designed to equip students with skills in design of questionnaires, sampling and experiments and to introduce survey techniques, emphasising computer-assisted presentation and analysis of data. There are 70 hours class contact and 80 hours self directed study, giving a total of 150 hours for the module.

Within the module, the following are studied:

- The Survey Process
- Sampling issues
- Sampling design
- Types of data and responses
- Presenting data in tables
- Charts
- Measuring correlation
- t tests
- Non-parametric tests

Assessments

Assessment takes a variety of forms.

- **Assignment 1** – Rotary Park Sampling – is a group assignment where the students study the traditional mud snails in the mudflats of the harbour and the report is written up by the group with a division of labour.
- **Assignment 2** – a fish counting exercise – is completed in the Polytechnic dive pool with plastic fish in preparation for 10 day field trips to local islands to gather data for the Department of Conservation. Individual reports analyse the errors in the estimations of size and distance underwater as well as the identity of the fish.
- **Assignment 3** – report on a Research Article – asks the students to analyse the construction and statistical analysis contained within a published scientific report.
- **Assignment 4** – sampling at Slipper / Tuhua Islands – involves reporting on the data gathered on their field trips and comparing to the previous year's data.
- **A computer check** list ensures that students have actually completed the statistical exercises on the computer. Although no grade is given for this, it is required for course completion.

The **final assessment** is a two and a half hour examination based largely on the mathematics of the statistics but always set in context.



Teaching Issues

Balance

Every year the challenge has been to encourage the students who are lacking in confidence and support them gently until they have sufficient faith in themselves to confidently tackle new concepts yet still maintain the interest of the school leavers who may have just completed year 13 statistics. It is vital to make each student feel they are personally important to me.

Student type

The content of the Diploma programme is such that it tends to attract students who enjoy the physical experiences offered. Consequently in the first lesson I present them with an activity - measuring arm-spans - that allows them to succeed. The situation presented to them is not as mundane as “measuring arm-spans” implies. Rather they imagine that they are groups of kina (sea urchins) and they are measuring their diameters. This simple adaptation helps them relate the activity to their diving and swimming experiences. They quickly realise that as they are pooling results they have to have a consensus regarding the measurements: are they in cm or m; are they finger-tip to finger-tip; are they across the back or front of a person? These are issues that do not require any background in maths and there is no one “correct” answer. The tape measures supplied are too short to do the job of measuring in one step, so they have to devise an accurate method of reaching from finger-tip to finger-tip. It is surprising how many different methods they invent.

History

I try to avoid using maths in which they have possibly failed until later sections of the module. The word *Algebra* is rarely used – the mere mention of the word sends shudders through many students – and very often I use words instead of symbols. I explain to them that my aim is to give them sufficient skills to be able to process data that they might gather in a survey / project and to be able to understand the concepts to make correct inferences. I am not trying to make them into statisticians.

Jargon

When I began teaching statistics to the second year students on this course I was still in the “pure maths” mode from secondary school. There is a jargon used in the mathematics world that has no place in the science world. I was not familiar with this form of reporting in which the mathematics result is reduced to a very brief phrase. Instead of stating, “Because $p = 0.645$, there is insufficient evidence to reject the Null Hypothesis that the mean of the population is 55cm at a 5% level of significance”, the science world requires, “The change in the mean was not statistically significant ($p > 0.05$)”. I had to adapt very quickly to the differences.

Context

Attempts are made in schools to link to reality, but this is often contrived, as the “real” examples are outside the students’ experiences. The students in this applied course have real situations where they have real needs. The first assignment in the first few days of the course is a report on a field trip to assess different strategies of monitoring the numbers of mud snails. The students have data they have gathered and can see a purpose for. They have to style their report on the accepted standards for scientific publications and they have to produce appropriate graphs in the correct format. They can apply knowledge they have gained in other sections of their programme, such as environmental awareness, to their assignment.

The students often do not have the maths “hooks” in place to relate new concepts to but they almost always have practical experience. I often encourage students to nominate situations that mean something to them and we create

problems on the spot relating to the subject content. This helps give them ownership of the learning process and there is no “wrong” (although sometimes censored) answer. Some years it becomes an unspoken challenge to suggest the most original situation. By having to fill in the details of the problem with “real” numbers for the mean and standard deviation, the students develop an awareness of what is in balance, for example if they suggest a mean of 15 cm and a standard deviation of 10, they realise the problem will not “work” as they will not have a normal distribution.

Learning Styles

With such a range of ages and life experiences, there is a wide range of learning styles and learning paces. Teaching at the tertiary level allows the freedom to be more adaptable than is permissible at secondary. It is also essential for this course. I have ensured there is plenty of physical activity to appeal to the kinaesthetic learners. This year the students, as a class group, had to select an activity they could do using their dive pool which would produce bivariate activity. They chose to do “bombs” into the pool, with two students estimating the width and height of their splashes after each student had weighed in. The discussion that followed required them to agree on how to use the data (there were several options). They then input the data, processed scatter graphs and worked to produce the highest possible r-squared value. Not only did the students enjoy the activity immensely (the 25+ year olds were delighted to have an excuse to be kids again) but they learnt the concepts in a very easy manner. They also learnt how data could be distorted or misused to present a very different picture.

There was much repetition available for those who needed to write problems out over and over. “Jack” could sustain his attention for a short span of time only, so he negotiated to remove himself to the library where he would work on the first step of a process until he had mastered it. If he remained in class for the whole session the information would scramble and he would finish the day more muddled than when he started. “Susan” had identified earlier that she learnt best by teaching herself. She negotiated to come to class only when she was having difficulty and, once her issue was resolved, she would quietly leave.

Visual, auditory, kinaesthetic and linguistic styles of learning were all catered for at various times. When listening to students explain why they were struggling, I carefully noted their use of words and responded accordingly. “I don’t see it” required a visual response; “I don’t get it” required the student to do the writing; “It doesn’t make sense” required more explanation of the rationale; “I don’t know what to do next” required the steps in the process to be spelt out more clearly. Some needed to write the key points in their own words, so I encouraged them to tell me about the concept and I would repeat their words back to them.

Enjoyment and Empowerment

It is important that the students have some fun while they are learning. This does not mean I have to be an entertainer but rather the climate in the class is good-humoured and everyone experiences success to some degree. The students have more marine knowledge than I do, so we share information in a two-way process which helps us all to feel part of a learning team. The students see me as someone who knows more about maths than they do but they, in return, can stand tall in their own domain.

The students are encouraged to use their own judgement when reading statistics – not on a biased, emotional level, but on a reasoned and questioning level. They learn that they have the right, and often the duty, to question the statistics methods, the interpretation and the discussion. One assignment they find very difficult is to analyse and critique an existing report that has already been published. One year a student was very anxious about handing in her response as she had “demolished” a report, but her criticism was justified and backed up by solid comments. In comparison another student, who had assessed the same report, was very critical in colloquial language with no justification at all. Both students learnt that valid criticism is acceptable.

Many of the students feel confident enough to continue on and complete a degree the following year. Often these are students who have performed poorly at secondary school but as they confront the challenges of tertiary learning, they see pathways and possibilities opening up. Parents of these students are overwhelmed at graduation to see their hitherto non-achieving sons and daughters receiving their degrees. Most commonly the parents have not been to University themselves so they see the achievement as a break-through the educational barriers.

Student Issues 1

The range of the students’ ages for 2005 was from 19 to 36 years. In other years the range has been from 19 to 50 years. The distribution for 2005 is shown in Figure 1. This broad range brings many issues that need to be addressed.

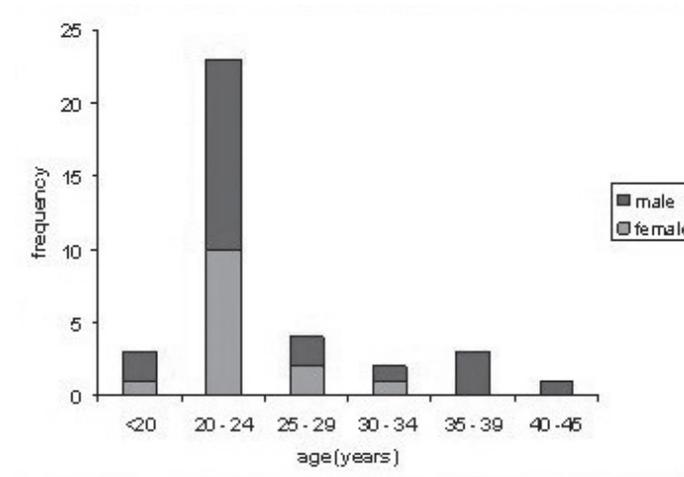


Fig. 1. Distribution of age and gender of students in 2005.

Attitudes

Confidence

Many students have a lack of confidence in their own mathematics ability and have a high level of anxiety when beginning the course. Some of them have never succeeded in maths; others have last been successful in primary school; still others might have been successful at year 11 but between 20 and 30 years previously. Often they recall their maths teachers with negativity and this has reflected on to their attitude towards maths in general. On the other end of the spectrum, some students have completed year 13 statistics relatively well in the previous year.

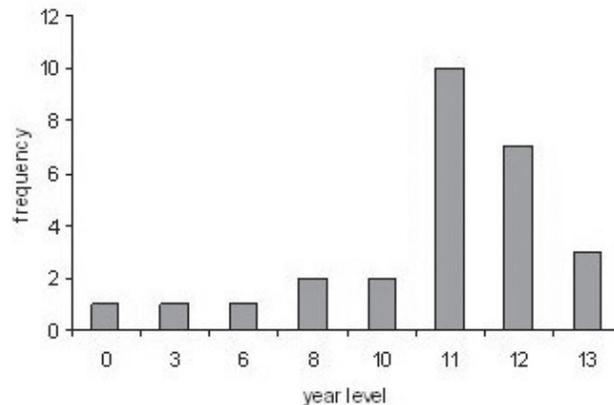


Fig. 2. Year level at which students felt they were last successful in mathematics before studying Sampling and Surveying.

I discuss in general that students in the past have all managed to pass the course despite having, in some cases, no maths background whatsoever, providing they do all the assignments and put the effort in. In other words, the course content is not beyond the reach of any of them. Once they absorb this concept and have some positive and non-threatening experiences they are willing to put in the effort required.

Over-confidence

I also warn the students about being over-confident. This usually relates to school leavers. They need to become aware that styles required in the scientific world are different from the school mathematics world and adapt accordingly. Because I have taught in the abstract world of secondary school statistics (where problems, although couched in “real” context, are usually far removed from the experience of the student’s world) I am able to link across and explain that the jargon they learnt is no longer required in their scientific reports. I place much emphasis on understanding the concepts and very little on the actual arithmetic calculations. This is often a very different focus from that of the students’ experience in secondary school statistics.

Students are invited to make reasoned decisions about their attendance for the whole of the class time. There is a 90% daily attendance requirement before they are allowed any resits, so if they decide against attending, they have to be very confident that they will be able to pass all elements. The last half-hour of a three hour lecture is often spent reinforcing the concepts and skills learnt and students who feel confident might choose to leave early.

Student Issues 2

Lack of Skills

Calculators

Some students, especially the older ones, have never used a calculator and are too nervous or embarrassed to ask. I have seen them actually shaking from fright and uncertainty as they punch the keys. I have an OHP of the calculator and go through the very basic steps starting at turning the calculator on. The numbers are not too large (40 maximum) for me to be able to check on each student as we work through examples in class.

Computers

Although students are expected to have completed a computer course the previous year, not all of them are skilled enough to be called "computer literate". During the first session on computers they are given computer data and required to process it with whatever skills they possess. I collect their printouts and check them overnight. There is no mark allocated to this activity so it is non-threatening and it enables both me and them to recognise their individual computer skills.

Data Processing

One of the most difficult areas for students seems to be taking field data and knowing how to process it. The initial exercise on the computers gives them some practice at this. They have three assignments which relate directly to this. The instructions are very specific, except in the last assignment which has one section with no direction. They do several activities during which they gather data and process it with some direction.

Relating to Context

Unless I relate the maths to a context that is familiar to the students they often cannot link into the concepts. I do not always understand why they cannot, but experience has taught me that some are unable to connect. Teaching the concept of the mean or average seemed very straightforward to me without a context but a mature student was very confused until I related it to an activity she was familiar with, in this case measuring the length of fish caught by recreational fishers.

Report Writing

Scientific report writing has pedantic rules which must be adhered to. Even the description of the hypothesis tests must be written in a certain manner. The penalty for ignoring these rules is reduced marks at degree level as well as diploma level. In this course I try to give the students sufficient knowledge so they are not penalised at the next level. Some students have a major issue with this, especially if they are of the more creative mould and do not like being directed in their "style".

Mathematics

The students quickly learn that failure in maths in the past does not affect their performance in statistics. If tables were a problem, this is now irrelevant. If algebra was a problem, this is now irrelevant. Manual methods of calculating statistics, like mean and median and including the standard deviation, are taught so they develop some understanding of the concepts. They then use Microsoft Excel to draw graphs and to calculate basic statistics. Normal distribution is taught manually to give them a good foundation on which to build understanding of the various tests they will use or encounter.

Time

Flexibility of programme is very important with these students. Many of them have child commitments which sometimes encroach on their lecture time. I am fortunate in that I work half of my time in the Education Development Centre. If a student misses class for a valid reason, they can book a one-to-one session with me and catch up.