Vocational Aqualabs - Vocational Generic Skills for Researchers

Experimental Design

Unit 1 – Basics of Experimental Design and Analysis

Trevor Telfer & James Bron
Senior Lecturers
University of Stirling

Education and Culture DG
Lifelong Learning Programme

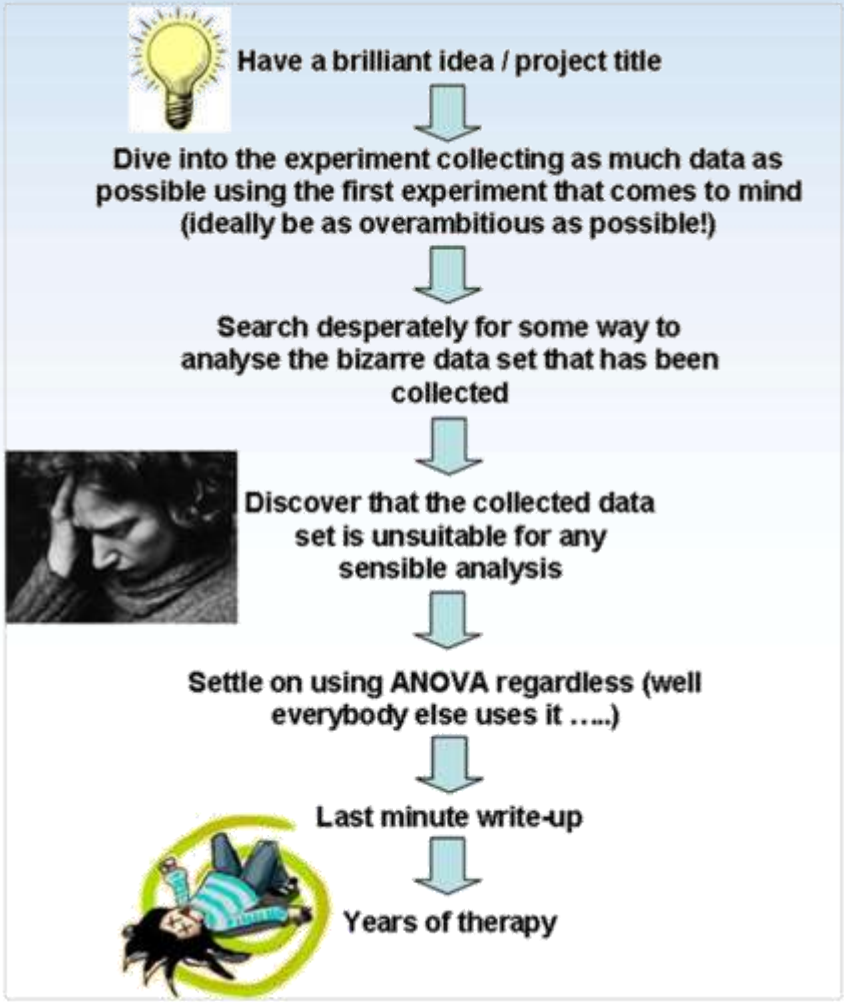
General Introduction

This unit will investigate the basics of experimental design and analysis. During the unit we will cover the basics of:

- Hypothesis generation
- Critical thinking and logical argument
- The power and rigour of experiments
- Testing the untestable?
- Need for communication and repeatability
- The experimental environment

General Introduction

- As scientists, both natural and social, at some time or another we will run experiments or carry out observations in order to test one or more hypotheses and then test them by analysing the data we collect.
- Unfortunately, for many scientists, a standard experimental protocol is often this

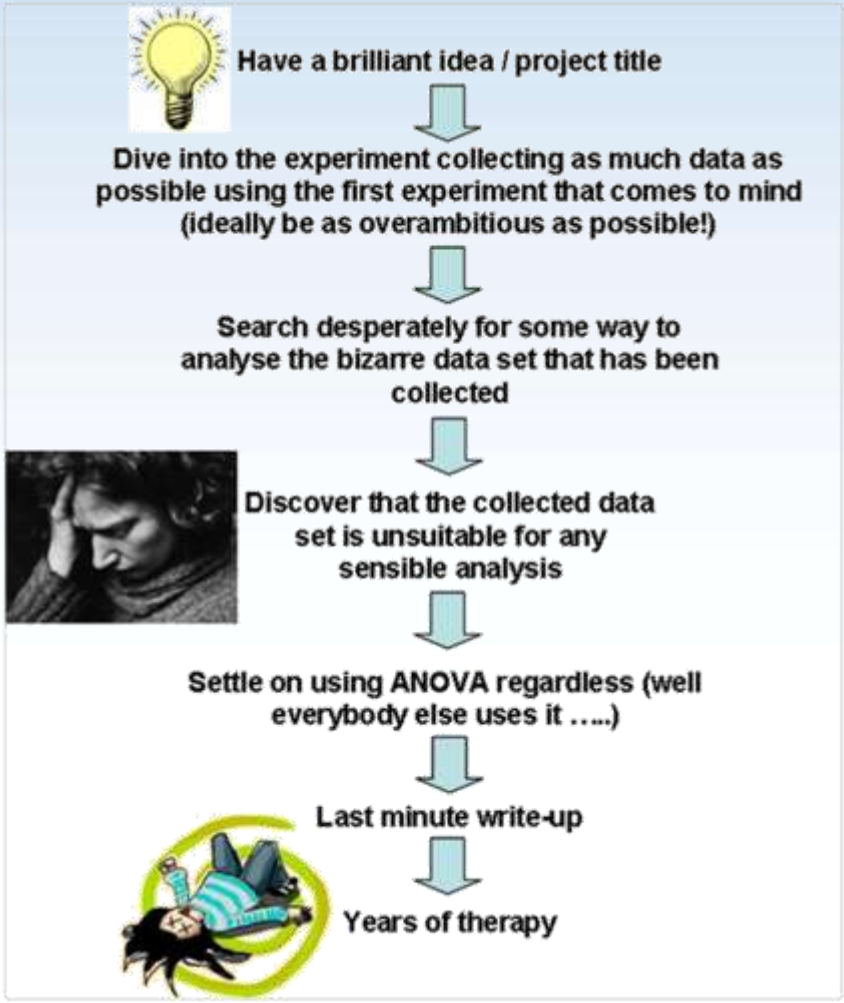


Vocational Aqualabs

General Introduction

Let's look again - some of the common mistakes made by the overambitious experimenter can include:

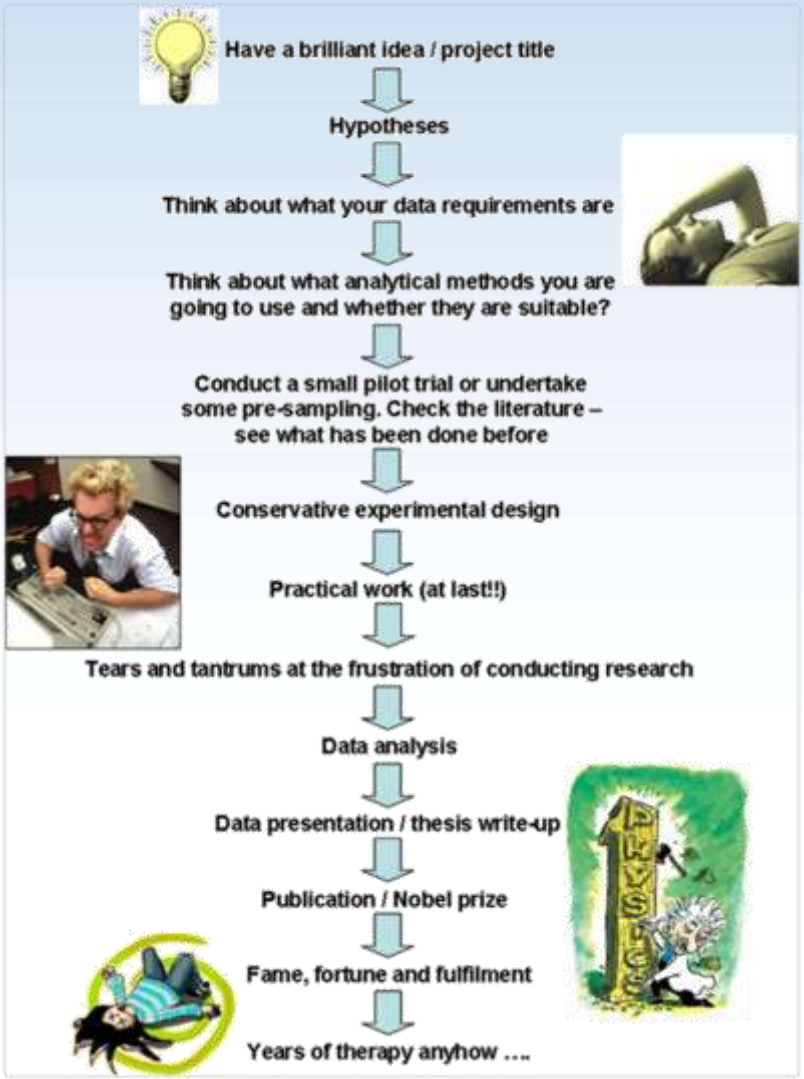
- the lack of replicates in their experimental design (i.e. commonly only one tank/pond per trial is used where ideally three or more per group is required),
- trying to measure too many variables
- too few observations or data points for each sampling point.



Vocational Aqualabs

General Introduction

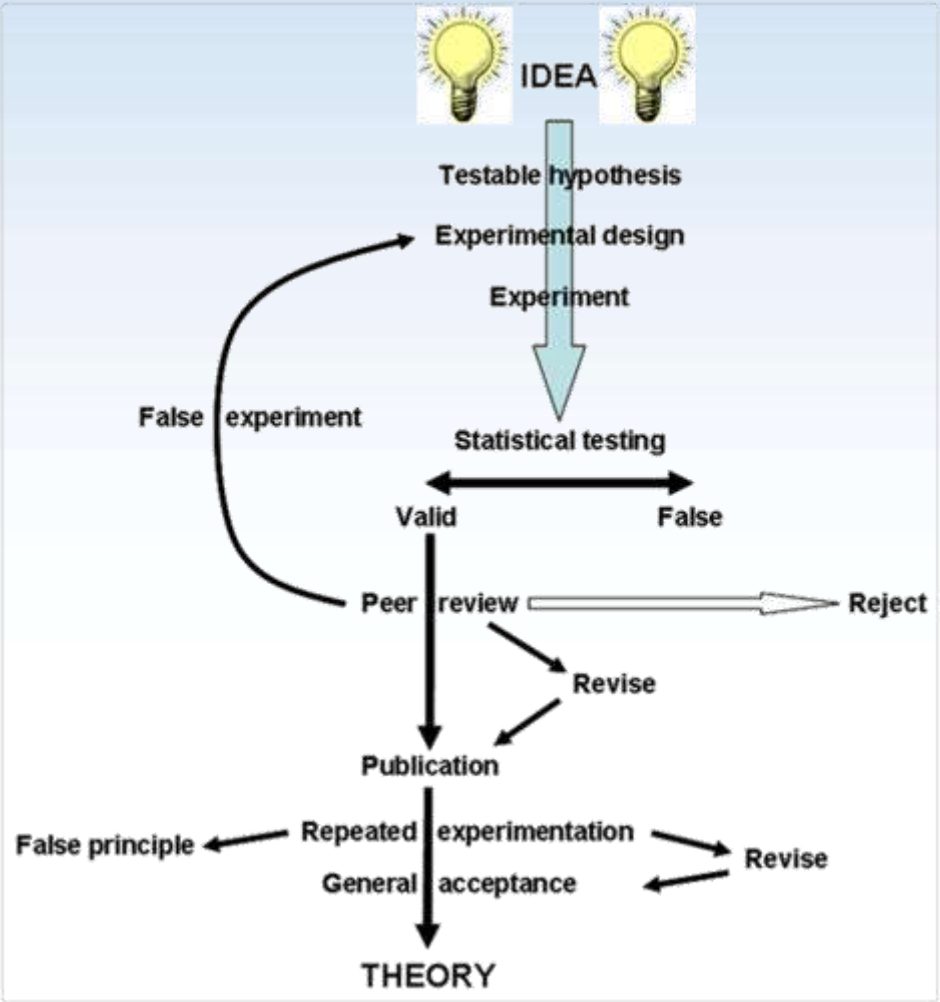
- So what should have been done?
- Here are the thought processes for a well designed experiment



Vocational Aqualabs

General Introduction

- A reason to perform experiments is to collect data needed to support a theory
- How do we turn an idea into a theory?



Vocational Aqualabs

Experimentation and hypothesis

- *"To call in the statistician after the experiment is done may be no more than asking him to perform a post-mortem examination: he may be able to say what the experiment died of."* R.A. Fisher, Indian Statistical Congress, Sankhya, ca. 1938.
- A hypothesis, is "*a tentative explanation for an observation, phenomenon, or scientific problem that can be tested by further investigation"* (a definition supplied by www.answers.com)

Experimentation and hypothesis

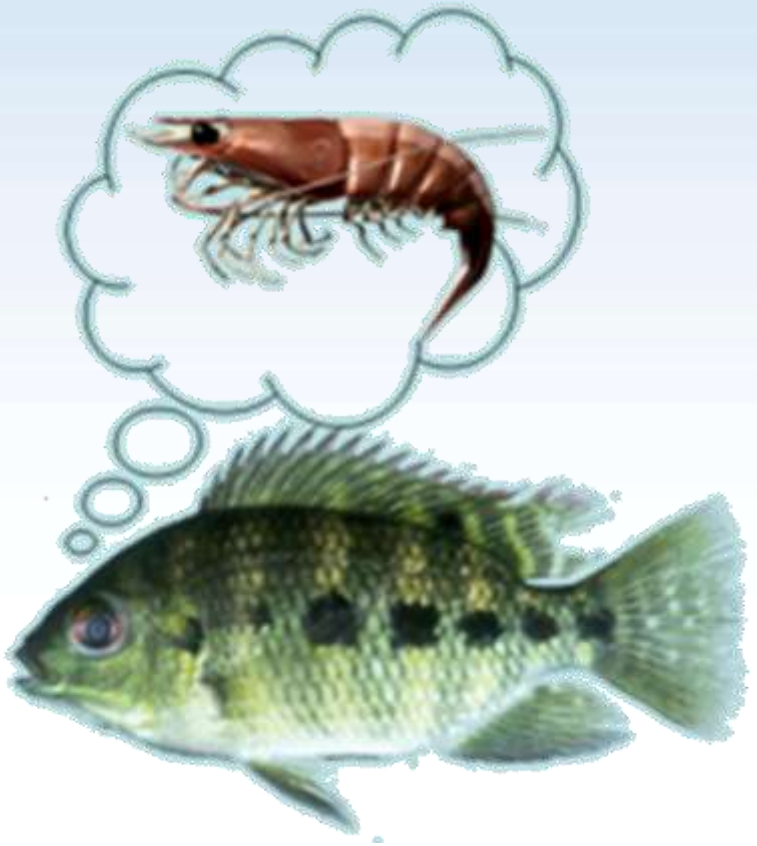
- Formulating a hypothesis is the first step in experimental design and it is used to express the aims of your project in terms of one or more simple **testable** hypotheses (H)

Vocational Aqualabs

Experimentation and hypothesis

Untestable H

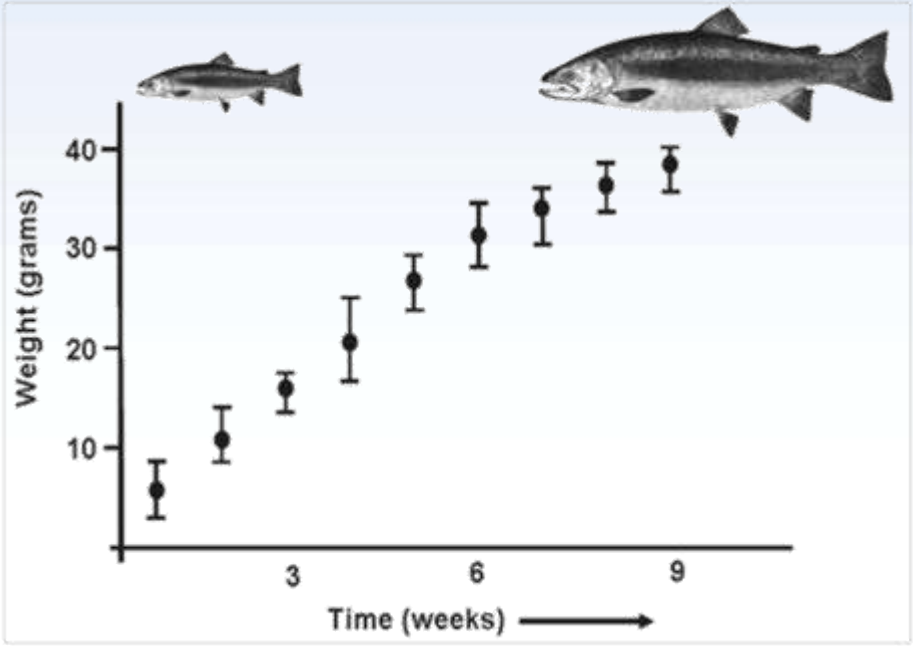
- **“Tilapia dream of prawns”**
- this hypothesis is untestable until we have a way of recording and visualising the thoughts and dreams of tilapia



Experimentation and hypothesis

Testable H

- **“Fish show improved growth if you feed them”**
- Set up an experiment to weight a known number of fish for a determined number of days
- Control – fish which are not fed



the average weight and range of 30 fish measured at each time point

Experimentation and hypothesis

- The measurements chosen determines the statistical tests used
- Remember that statistics are tools that you use and not an objective.
- Understand what you are trying to do, otherwise cannot ask the right questions of your work.
- Think of the process as:

Flow diagram taken from "An introduction to statistics" (www-micro.msb.le.ac.uk).

Types of data

Data consists of:

- Observations
- Values (variables)

Variables can include, e.g:

- **Number of live births** - coded 0, 1, 2, 3,.....
- **Geographical region** - Europe, Asia, UK, USA, etc.
- **Weekly earnings** - From $500 upwards
- **Size of fish** - From weight/length at start
- **Number of parasites** - 0 upwards per unit area
- **Dose of chemical** - 0 upwards
- **Behaviour** - 'Non smoker', Ex smoker' 'Occasional smoker'; ' Heavy smoker'
- **Gender** - Male or Female

Etc, etc.

Types of data

Independent variables

- Are experimentally manipulated by the experimenter (e.g. water flow rate, temperature in an aquarium, amount of food given, etc)

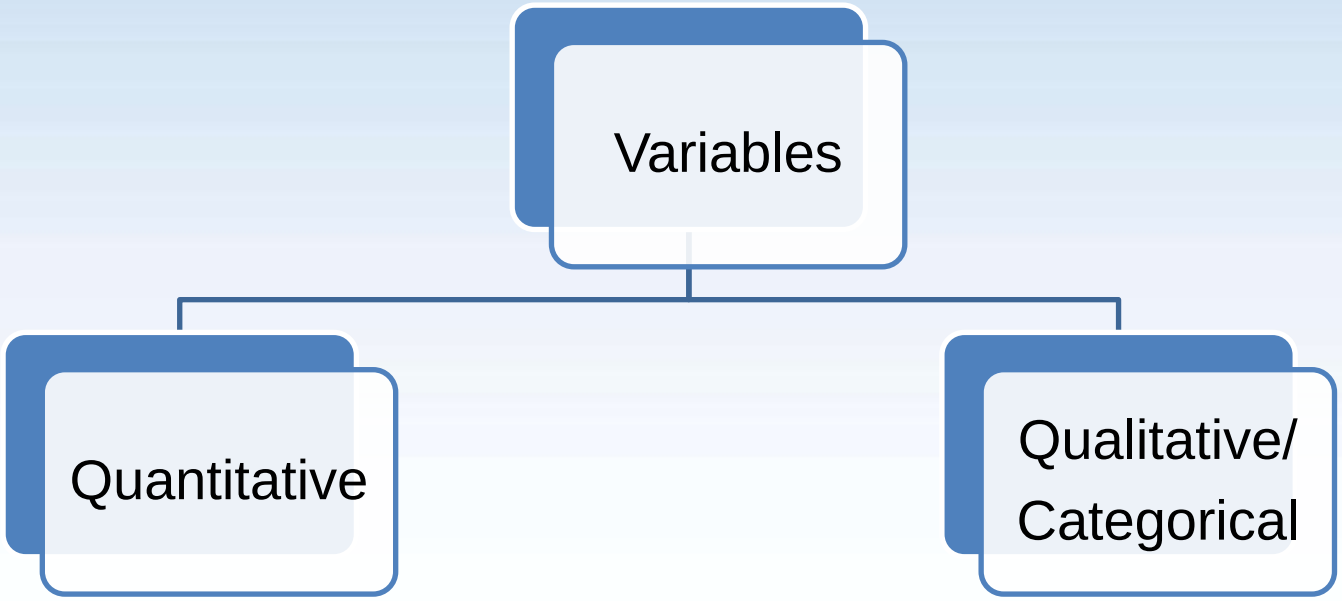
Dependent variables

- are measured by the experimenter during the experiment (e.g. growth rate in a feed trial etc)

Confounding/secondary

- Any other factor that may affect the dependent variables
- Unless the same for each group the test/comparison will be unreliable

Types of data



- Measurements of objects or events i.e. how much or how many of something
- Provides labels or names for categories of like items, i.e. a set of observations where any single observation is a word or code that represents a class or category.

Qualitative or categorical variables

For example:

- **Gender**: Can only be male or female
- **Smoking behaviour**: Can only be non-smoker, ex-smoker, occasional smoker or heavy smoker
- **Eye colour**: Could be black, brown, blue, green, hazel, grey etc
- **Hair colour**: Could be black, brown, blonde, auburn, red, grey, white etc
- **Geographic region**: Could be anywhere and have different sizes – continent, country, state, county, town, street, or designated described area, etc.

Qualitative or categorical variables

- **Ordinal variables** are variables with an ordered series which can be ranked. For example:

1) “greatly dislike fish”, 2) “are indifferent to fish” or 3) “greatly like fish”.

Qualitative or categorical variables

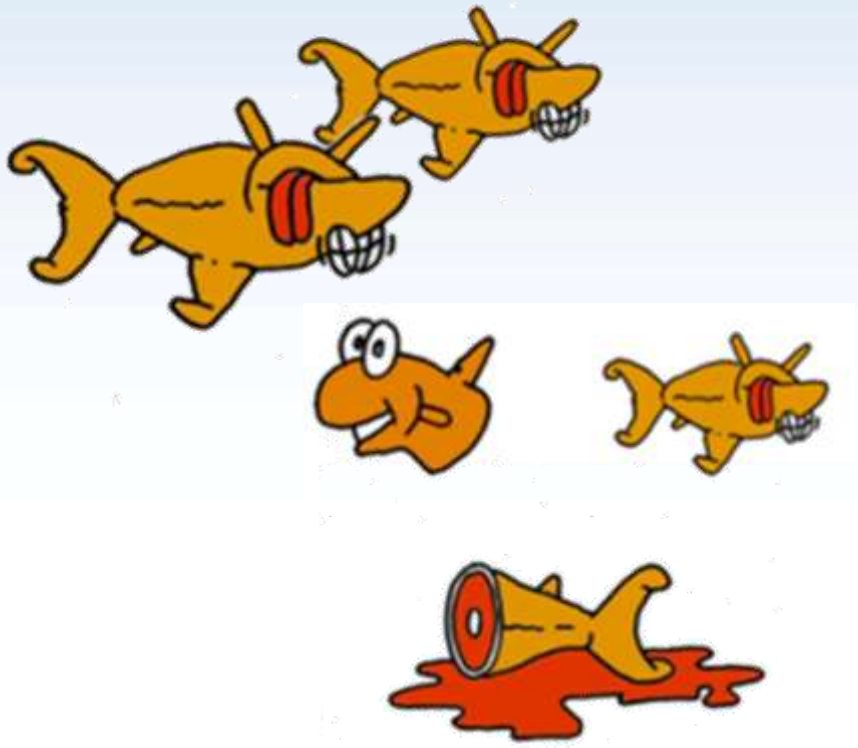
- **Nominal variables** do not have an inherent order or ranking sequence
- It is important to note that the categories are simply labels
- For example, we cannot say that “blue eyes” are greater than “brown eyes”.

Quantitative variables

- **Quantitative variables** are commonly the measurements of objects or events
- “how much” or “how many” of something
- For example:
  - The number of fish eggs hatching per batch
  - The length of fish
  - The weight of fish
  - The cost of rearing each batch of fish
  - Etc, etc

Quantitative variables - discrete

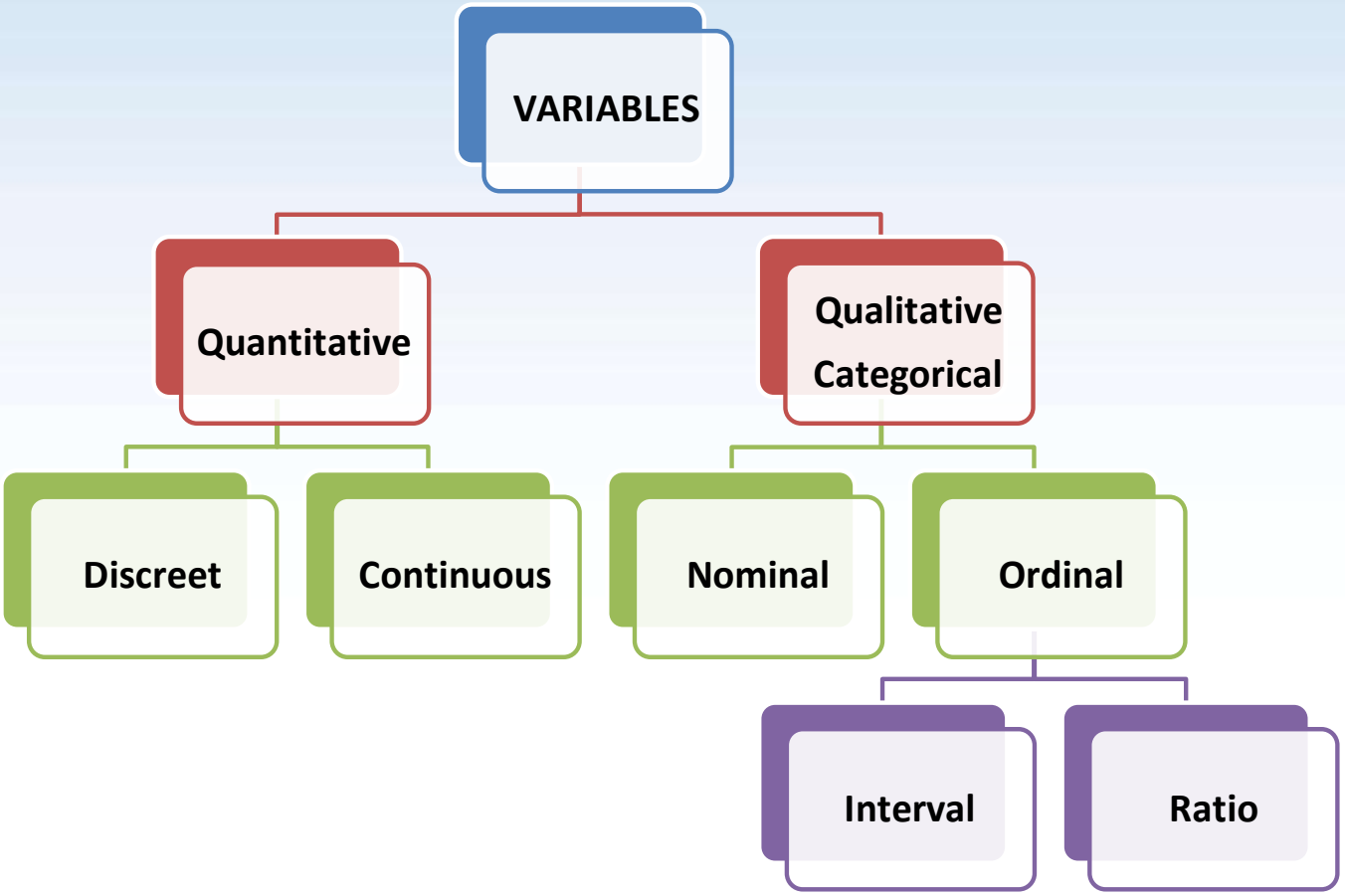
- **Discrete variables** are any kind of count;
- they take values in a restricted set such as integers {0, 1, 2... }.
- For example - “How many dead fish are there in a tank in response to a particular treatment?” You cannot have 1.5 dead fish, only have 1 or 2 etc



Quantitative variables - discrete

- **Continuous variables** are any kind of measurement, which can take any real number value.
- For example, height, weight, age, concentration etc....

Types of data - Summary



Vocational Aqualabs

Thank you

Trevor Telfer
Institute of Aquaculture
University of Stirling
Stirling, FK9 4LA, UK

AQUATT

UNIVERSITY OF ABERDEEN

UNIVERSITY OF STIRLING

INNOVAMAR

Aquark

Education and Culture DG
Lifelong Learning Programme

This project has been funded with support from the European Commission. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained herein.