Introduction to Computing and Quantitative Research

Peter Vamplew
based on material by Ray Williams and Mike Cameron-Jones
Introduction to research

Universities deal in knowledge

2 aspects to this:

- teaching: established knowledge becomes known by more people
- research: new knowledge is discovered

Knowledge is about true, justified beliefs

Research is about finding new things and proving them to be true
Types of research

- **Pure Basic**: experimental or theoretical work to acquire new knowledge without looking for long-term benefits
- **Strategic Basic**: experimental or theoretical work to acquire new knowledge in specific areas in the expectation of making useful discoveries
- **Applied Research**: original work to acquire new knowledge with a specific application in view
- **Experimental Development**: systematic work using existing knowledge to produce new products, devices or services or to substantially improve new ones
The research process

- to explain a phenomenon
- to carry out a task
- to solve a problem

Think of a new idea

Implement the idea in some way
- mathematical model
- computer program
- experiment
- physical device

Modify the idea in light of the evaluation

Evaluate the idea using the implementation

statistical analysis
qualitative assessment
field testing
Publication

- Publication is the visible part of research.
- Research is like a rambling walk.

- The published version follows a straightened path - ignores the irrelevancies and dead-ends.
- This is not to say that it is a lie or distortion - all relevant discoveries should be reported.
Literature review

Publication is both the start and endpoint of research.

Research starts by reviewing the existing knowledge in the area:
  - before you can create a new idea, you must know what is already known.

Research ends by publishing your discoveries:
  - adds what you have found to the accumulated body of public knowledge.
Types of literature

- textbooks
- edited collections of papers
- journal papers
- conference papers
- workshop papers
- web information
Searching the literature

- electronic sources (library session on Wednesday will review this)
- paper sources
  - skim proceedings/table of contents
  - look at section headings
  - read title
  - read abstracts
  - read introduction .. then skim to conclusion
  - read paper in full
  - follow up on references at the end
- can also use citeseer.com to find papers which have referenced this one
- maintain a database of references as you go (can use EndNote)
Reading a Research Paper

3 questions to ask of a paper

– What does the author claim to have discovered? (abstract)
– Should you believe this claim? (look at the evidence)
– Is the new knowledge interesting?
  • originality: how different is it from previous knowledge?
  • significance: how important is it?
  • relevancy: how relevant is it to the research you are conducting?

we will examine this in more detail on Wednesday
Evaluating evidence

- types of evidence:
  - theoretical
    - mathematical or logical proofs
  - empirical results
    - simulation
    - real system

- how relevant is the evidence?
- how strong is the reported effect?
- how sound is the methodology?
- what assumptions are made, and are they valid?
- how credible are the benchmarks or test cases which were used?
Writing a research paper

- all the points made for reading should also be considered when writing a paper
- ensure your paper answers the question which the reader will be asking
- any claims made in your paper should be justified:
  - deduced by logical argument
  - based on authoritative sources
  - based on valid analysis of experimental results
Quantitative research

- much computing research produces evidence in the form of measurable results
- the experimental design needs to consider the nature of these measurements, and how they will be analysed
- factors such as the accuracy and resolution of measurements need to be accounted for
Experimental process

- design the hypothesis (what idea is being tested)
- design experiments to test this (need to consider what measurements will be required in order to prove or disprove the hypothesis)
- carry out experiments and gather results
- analyse results to evaluate the hypothesis
- review hypothesis on the basis of the analysis
Presenting data

- All the measurements made during the experiments should be retained.
- Probably won’t all be included in the final publication (too much detail).
- May be included in an appendix.
- The main body of the publication is more likely to report summaries of the original measurements.
Presenting data (2)

Data can be presented in various ways:

- tables
- graphically
  - line graphs
  - scatter-plots
  - pie-charts
- summaries
  - histograms
  - averages (mean, median)
  - standard deviation (measures the spread of data)
most common form of hypothesis is in the form of a comparison
- A is better than B in terms of attribute C
gather two sets of data measuring C (one under condition A, one using B) and compare them
need to establish whether any observed differences are valid or merely the result of random variation
various statistical tests: the most common is the t-test
P = 0.05 or lower, implies a 95% probability the effect is real - usually regarded as acceptable proof
more sophisticated tests also exist - get advice from your supervisor and/or a statistician early in designing your experiments and analysis
you need to measure what matters
you need to decide how you are going to measure it (sometimes this is not obvious)
you need to decide how to ensure that any conclusions you draw will be justified as valid
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