Types of Research

Exploratory, Descriptive and Explanatory

- Exploratory: *Explore ideas for which you don't know the answer for yet. Observation and documentation is key. Inductive method. Important to know where you are going to get information and how to collect it.*
- Descriptive: *Once a phenomenon has been isolated or relationships established you describe the phenomenon or relationships (writing a history for example).*

Exploratory, Descriptive and Explanatory…

- Explanatory: *Find reasons for the phenomenon. Trying to define causes (as opposed to describing effects).*

Basic and Applied

- Basic: *Discover new knowledge*
- Applied: *Make known knowledge useful*

(Definitions borrowed from Prof Kobus Vorster)

Quantitative and Qualitative

- **Quantitative:** *Data in number form or converted to number form (allocate numbers to particular values).*
- **Qualitative:** *Gather information that is not quantifiable (interviews, observation, etc.). What emerges are themes that might be representative of a community. Work in-depth on issues and real-life situations and results are not always hugely generalisable.*

Starting points for research
(Olivier pp 2)

- Solve a problem for which no apparent or known solution exists.
- Find a better solution for a known problem.
- Integrate bits and pieces of already discovered pieces of information into a coherent body of knowledge.

Research Strategy…..

(Olivier pp 2)

To accomplishing your research objective, you will need a research strategy = combination of research methods.

Tour of Research Methods
Summary of Olivier Chapters 7 - 15

Popular (Engineering ?) Research Methods (Olivier pp 11)

- **Literature Surveys** *(always part of engineering research)*
- **Models**
- *Languages (not popular in engineering as a primary method)*
- *Arguments (not popular in engineering as a primary method)*
- **Mathematical Proofs**
- **Prototypes**
- **Algorithms**
- *Surveys (not popular in engineering as a primary method)*
- *Case Studies (not popular in engineering as a primary method)*
- **Experiments** *(field-experiments are popular in some branches of engineering)*
- **Simulations**

Literature Surveys

- Refer to *Step 2* in the research process
- You need to establish what has been published by other researchers.
- **The literature survey must be thorough**.
- *Not citing a relevant reference can have embarrassing consequences and can result in a failure, not just a red face.*

Models

- Constructed since it is easier to manipulate or to comprehend than the real thing.
- A model contain aspects of the *real thing* that are relevant to your problem but excludes other aspects.
- Mathematical models and process diagrams are popular in engineering.

Models…

- To argue about a idea or to prove statements about existing ideas are sometimes expressed as models.
- Often used to propose a new idea since it is easier than constructing a physical system or implementing a complete process.

Languages

- Often used in computing and IT *(programming and database languages, Unified Modelling Language -UML, languages to express highly complex properties of systems, etc.)*
- Languages are almost always used in engineering design but are seldom the primary method of engineering research.

Arguments

- Always form part any research.
- If alternative solutions are compared it is normally necessary to present some arguments as to why one is better.
- Seldom the primary research method in engineering. *(In philosophical research it is often the primary method).*

Mathematical Proofs

- Scientific version of an argument - if correct it cannot be argued about or disputed.
- All proofs are based on assumptions.
- The proven truth is only as good as the assumptions.
- *(Refer to the insert on Fermat's last theorem for perhaps one of the most famous examples)*

Prototypes

- Prototypes per se are not research.
- So what are they good for ?
  - Demonstrate that a new model can indeed be implemented (proof of concept prototype)
  - Vehicle for experimentation
  - Demonstrate a new idea

Algorithms

- Often the solution to a problem is expressed as an algorithm.
- Just producing an algorithm is not research – aspects of the algorithm should be better than those previously proposed.
- The researcher should clearly show which aspects of the algorithm makes it more desirable *(faster execution, less memory, less complex,…)*

Surveys

- Questionnaires distributed to a sample or the entire population.
- Sometimes take on the form of interviews.
- Do not always require human participation.
- They do not merely count the number of times a phenomenon occurs, but also test theories put forward about the surveyed population.

Case Studies

- Similar to surveys, but only looks at a **few** cases that presently occur.
- Useful for studying some phenomenon in the situation where it occurs.
- Often qualitative rather than quantitative (descriptive statements versus expressed numerically)

Experiments

- Try something and note the effects.
- Controlled experiment (laboratory) or a field-experiment.
- Field-experiments often used in engineering to study some aspects of a prototype system that has been designed.

Simulations

- A simulation is an *active model* that is executed and the results measured.
- Since nearly all branches of engineering deal with dynamical systems, simulations have become an engineering research necessity.

Method selection
(Olivier Chapter 2)

- One or more methods are normally combined, but a good project does not necessarily combine a multitude of methods.
- Most research projects have one major goal. Your goal will determine your methods.

Method selection…

- Method selection:
  - A careful analysis of the problem to be solved will often give an indication of the applicable methods/tools.
  - Methods which dominate publications applicable to your study.
  - Journals you want to / must publish your results in. If the vast majority of papers employ a certain method or set of methods, you will find it difficult to publish using other methods.

Method Survey

Class assignment: *Using research problems from your sample journal papers, discuss the methods used and suggest alternative methods.*

Literature Review (Mouton, Chapter 6)

- **Use your University's referencing guideline.**
- Average number of references in final thesis:
  - Health Siences (100 – M, 200 – D)
  - Natural Sciences (96 – M, 172 – D)
  - Engineering (70 – M, 110 – D)
- Less (50%) for research proposal

Literature Review…

- Effective reading:
  - Start with most recent sources and work your way back
  - Always read the abstract first
  - Read the introductory and concluding sections if the abstract seems interesting
  - If relevant to work – in depth study

Literature Review…

- Criteria for a good review:
  - Exhaustive and covers all main aspects
  - Fair in treatment of authors
  - Topical and not dated
  - Not confined to internet sources only
  - Well-organized

Literature Review…

- How to organize the review:
  - Chronologically
  - School of thought, theory or definition
  - By theme or construct
  - By hypothesis
  - By case study
  - By method

Sources of information

(Adapted from the TUT Citation and Bibliographic Reference Guide….make sure you know how to reference these !)

- Monographs (Books)
  - One, two, three or more authors
  - No author / anonymous work
  - Author and editor/ translator/ compiler
  - More than one book by the same author
  - Reference to a number of pages
  - A book without page numbers
  - Referencing a whole chapter
  - Different works of the same author

Sources of information …

- Multiple works by different authors
- Sets and books in more than one volume
- Books as part of a series
- Books in more than one volume
- Institution/organisation/corporate author
- Institution/organisation/corporate author with a subsection
- Secondary source
- Chapter in a collected work

Sources of information …

- Conference proceedings
  - Published conference papers
  - Unpublished conference papers
- Government publications
  - Departments
  - Constitution
  - Government Gazettes
  - Provincial gazettes
  - Commissions of enquiry

Sources of information …

- Green papers
- White papers
- Dissertations and theses
- Patents
- Study guides and course material
  - Author indicated
  - Author not indicated
- Encylopedias

Sources of information …

- Periodical / Journal Articles
  - Author unknown
  - Author known
- Newspaper articles/reports
- Interviews
- Letters
- Photocopies
- Internal documents
- Dictionaries

Sources of information …

- Electronic sources
  - Computer files
  - CD ROMS
    - Monographs: books/papers/reports
    - Encyclopedias
    - Periodical/journal articles

Sources of information …

- Internet
  - e-books
  - Conference proceedings
  - Government publications
  - e-mail

MORE ON 'TRADITIONAL' QUANTITATIVE RESEARCH METHODS

Surveys

What is meant by survey method ?

- Empirical and systematic *collection* of and *statistical analysis* of information: *Positivist paradigm. Presupposes that reality exist and can be described.*
- Survey is just a tool to collect data. *Obtaining information about a population and identifying associations between attributes*.

Two important questions

- Information needed ? *Executed by means of the construction of an interviewing schedule or questionnaire.*
- Target group from which to collect the information ? *Defining the study population, selecting the sampling procedure, and the size of the sample.*

Purposes of Survey Method

- Obtain information about a population
- Identify associations between attributes
- *Bioscope example…*

- *Census versus sample ? Generalisation ?*

Uses of Surveys: *describing populations, associations and trends..*

- *#1:* Describe populations by means of characteristics and attributes… *measures = sample statistics, estimates of actual values, parameters = measures of entire population.*
- *#2:* Test if characteristics of attributes are associated *(wealth + education ...)*
- *#3:* Study change and establish trends *(knowledge + attitudes + HIV)*

Population, sample, statistics and parameters

- Population: *full collection of elements*
- Defining characteristic: *geographical delineation …*
- Sample: *selection or sub-set. Why not entire population ?*
- Sampling: *drawing of elements*
- Element or sampling unit: *unit from which information is sought – dependent on objectives of study*

Population, sample, statistics and parameters…

- Attributes: *particular characteristics*
- Population or universe: *collective of all elements*
- Sampling frame: *list of all sampling units (telephone book, school register, etc.)*
- Parameter: *measure defined for population (mean value or standard deviation)*
- Statistic: *measure defined for sample (estimate of population).*

Sampling in survey research

- *Make an inference about unknown parameters using sampling statistics*
- Procedure (p81):
  - *Define population*
  - *Specify sampling frame*
  - *Specify sampling unit*
  - *Specify sampling method*
  - *Determine sample size*
  - *Define sampling plan*
  - *Select sample*

Types of Sampling Methods

- Probability sampling: *likelihood or chance of inclusion of each element is specified. Resulting sample can be used to make inferences … sampling error ?*
- Non-probability sampling: *selection of elements based on judgment of researcher or field interviewer. Sample does not provide basis of estimate of population.*

Types of Probability Sampling

- Simple random sampling: *each element has equal chance of inclusion.*
- Systematic sampling: *sampling applied to an ordered (numbered) sampling frame.*
- Stratified sampling: *population divided into manually exclusive strata (random sampling in each group).*
- Cluster sampling: *when dealing with very large populations (municipal areas etc.)*
- Multi-stage: *combines cluster and stratified methods*

Types of non-probability sampling

- Quota sampling: *resembles stratified sampling but not regarded as probability sampling.*
- Convenience sampling: *results of survey need to be obtained within short period.*
- Purposive sampling: *interview elements with specific traits without prior knowledge of size and distribution of population.*
- Snowball sampling: *info on specilized or obscure issues. Contact one … leads to another…*

Sample size

- Smallest fraction still representative of the population. *Less homogeneous ?*
- Smaller the population … larger the sample
- *10 % often used except, more for smaller populations*

Types of surveys

- Individual interviews: *face-to-face, advantage = personal contact, disadvantage = high cost.*
- Postal surveys
- Telephone surveys

Questionnaire – Interview Schedule

- Keep wording simple and easy to understand
- Translate questions into vernacular language of respondents
- Avoid long complex questions
- Use words having a single meaning
- Avoid leading questions
- Avoid implicit alternatives
- Don't use double-barrelled questions

Structure of questionnaire

- Request for cooperation
- A set of instructions
- Identification data
- Information sought
- Closing statement to thank respondent

Types of questions

- Open-ended: *express own perceptions or attitudes…high interviewer bias potential… >> time and cost to code responses.*
- Multiple-choice: *choose answer from a pre-formulated list …tend to bias data.*
- Dichotomous: *only two responses … many grades of feeling ?*

Variables and scale types

- Variables: *attributes and characteristics*
- Scale types: *way in which we measure variable*

Measurements often used

(Olivier Chapter 12)

- Nominal: *Select from a list of alternatives. No order.*
- Ordinal: *Uses numbers to express measurements but 'distance' between successive units are undefined.*
- Ratio: *Based on a measure in some unit where '0' literally means 'nothing'.*
- Likert Scale: *Used to specify degree to which particular statement applies to the respondent.*

Measures often used …

- LPC Scales: *Similar to Likert except that respondent has to indicate preference between two explicit alternatives.*
- Open Questions: *Response depends on respondent. More difficult to interpret.*

Sequence of questions

- Can influence nature of respondent's answers
  - *Simple and interesting opening question*
  - *Ask general question first*
  - *Embarrassing, sensitive or complex questions only later*
  - *Logical order*

Physical appearance and format

- *Sloppy work discourages participation*
- *Numbered serially (anonymity ?)*
- *Format of questionnaire can influence responses*

Pre-testing and revising

(Olivier Chapter 12)

- Done to avoid annoying problems such as the respondents or assistants misunderstanding directions or questions, most respondent not having the information available that is required (internet usage example) etc.
- Select a small group from population and conduct/ test survey on this group.
- Try to include as many atypical members of the population as possible.

Pre-testing and revising…

- At least one pre-test …. revise
- To ensure that you measure what you want to measure
- Pre-test early drafts using face-to-face interviews even when survey conducted by mail or telephone
- Open ended questions can be pre-tested to determine appropriate response categories for multi-choice.

General

- Repeat measure: *reliability of findings investigated by posing same question in different ways.*
- Don't know responses: *usually made provision for since also a legitimate answer. Convenient way to answer unpleasant questions ?*

Experiments

What is meant by experimental method ?

Method of *collecting and analyzing data* based on the *creation of a setting* in which we can *manipulate* one or more *independent* variables and examine their *effect* on the *dependent* variables

(Study skills courses = independent,

performance = dependent.

New drug = independent, response = dependent.
Pesticide = independent, death rate = dependent)

Cause-and-effect relationships and conditions for causation

- Experimental method – examine cause-and-effect relationships.
- Conditions for a causal relationship:
  - *Variables are correlated, i.e. both variables must change together.*
  - *Variability in the independent variable occurs before variability in independent factor*
  - *There are no alternative (third) factors which explain variability in dependent variable.*

Variables and treatments

- Researcher manipulates independent variable
- Variable that is influenced is called dependent variable
- Particular level of the independent variable is called a treatment
- Treatment in which the factor constituting the independent variable is called *control treatment* – inclusion provides basis for comparison

Error in experiments

- Try to minimize the variation due to error
  - Error brought about by the inherent variability of the phenomenon under investigation
  - Error brought about by accuracy of instruments
  - Errors brought about by the mistakes made by the persons conducting the experiments – can be systematic (values differ form true values in a systematic way – all observed values perhaps too high etc.) or can be random.

Dealing with errors

- Replication: *treatment is repeated two or more times*
- Randomization: *assignment of treatments to experimental units so that all units have an equal chance of receiving particular treatment*
- Local control (blocking): *used to separate error caused by environmental factors which cannot be eliminated – example page 105*

More on Experiments

Based on Chapter 11 in ***Information Technology Research*** by Martin Olivier, 2nd edition 2004.

Goals of an Experiment

- Exploratory – see if you can find something interesting.
- To *test* a theory.
- To *prove* a theory.

Exploratory

- Design an experiment
- Conduct experiment
- Observe
- If interesting then theorise
- Report

Test Theory

- State theory
- Design experiment
- Conduct experiment
- Observe
- Accept theory for further testing, modify or reject
- Report

Prove Theory

- State theory
- Design statistical experiment
- Formulate hypotheses
- Conduct experiment
- Collect data
- Process data
- Test hypothesis
- Accept theory as proven, modify or reject
- Report

Experimental Design Pointers

- Remove the human factor from experiment.
- Randomly split groups.
- Treat all groups exactly the same.
- If possible do not tell participants which group they belong to.
- Help if the researcher also doesn't know which group observed subject belongs to.
- Where total objectivity can not be guaranteed clearly report limitations of study.
- Be aware that in some cases participants can learn from study itself and can have an undesirable effect.

Experimental and Control Groups

- Select participants and then randomly split into two groups (experimental group and control group).
- Two groups treated in exactly the same way except for experimental variable.
- Observe effects of process and collect data.
- Fundamental assumption is that since experimental and control groups are composed randomly, they will be equivalent in important aspects.
- Pre-testing might be required to establish equivalence.

Single Group

- Only one group used.
- First test them for *control* value and then for *experimental* value.
- Observe – Experiment – Observe.
- Preferred method if learning does not occur or does not influence outcome of experiment

Blind Experiments

- *Blind:* Subjects cannot tell the difference in variable controlled – placebo versus real medicine – modified versus unmodified operating system, etc.
- *Double blind:* Observer does not know which group has been exposed to experimental treatment and which group not.

Formal Experimental Designs

- Time series design
- Control group design with pre-testing
- Random two-group design
- Two-group design with pre-testing
- Random block design
- Simple paired two-group design
- Paired design with pre-testing
- Yoked control group design
- Solomon four-group design
- Factorial Designs
- AB, ABAB and multiple baseline designs

Protocol

- Compiled *before* actual experiment starts.
- Spells out what where and when the activities of the experiment will be performed.
- Directs actions during the experiment and serves as evidence for others that experiment structured and conducted appropriately.
- Something tangible to scrutinise for validity problems.

Conclusion

- *Internal validity:* Were observations indeed caused by experimental inputs and nothing else ?
- *External validity:* Can the results observed during the experiment be generalised ?
- Although validity issues less important during exploratory experiments, it should still be given some consideration.

Qualitative Research

Based on Chapter 16 in Information Technology Research by Martin S. Olivier and TUT material

Problems with Quantitative Research

- Quantitative research cannot answer all problems (which versus why)
- Quantitative research is not always as objective as it has been touted to be (ozone layer research for example)

Qualitative research

- For qualitative data it is the researcher who considers data, selects what is appropriate and process it in some manner.
- The researcher is the measuring instrument

Ensure objectivity ?

- Do your best to minimise the impact of the researcher.
- Accept that one can never be truly objective, no matter what approach is used.
- See the researcher as an agent with an agenda with the explicit intention of changing that which is being researched.

Differs from quantitative methods ?

- Inductive reasoning
- Insider (emic) perspective. Researcher immersed in data
- Idiographic *(aims to understand meaning people attach to everyday life)*
- Regards reality as subjective
- Data = words, quotes, transcripts
- Flexible, unique and evolves *(no fixed steps)*
- Unit of analysis is holistic: *whole more than sum of parts concentrating on relationships between elements.*
- ***Collection, integration and synthesis of nonnumeric narrative (verbal) data***

Case Study

Case Study Design

- Single case or multiple case design
- Holistic approach (case studied in its entirety) or only certain aspects.
- Multiple case design preferred as this will facilitate comparisons.
- Single cases sometimes used to confirm, challenge or extend a theory – referred to as a Critical Case.
- Other single cases include *extreme, unique* and *revelatory* cases.

Protocol

- Sets out precisely what is to be studied and how it is to be studied.
- Spell out what you expect to learn from the case.
- Helps you to remain focused and not deviate from original intentions.
- Protocol may contain questions to be asked to people forming part of the study.
- Questions usually allow for more detailed response compared to survey questions.
- Protocol should be committed to paper before study commences

Protocol…

- Pilot study can be helpful to identify potential problems. Not possible if there is only one single case to study.

Case Selection

- Should not be selected because they fit the theory.
- First select few cases in a random manner.
- Then select cases where theory is least likely to apply.
- Literal replication and theoretical replication.
- Popular to select 4 cases for literal, and 3 for theoretical replication.
- Number for literal replication cases depends on subtle differences between your theory and rival theories.
- Number for theoretical replication cases depends on the complexity of your theory.
- In single case studies: random or strong motivation.

Data Analysis and Reporting

- Plan your data analysis before you start collecting data
- Should be described in the protocol.
- Pattern matching.
- Different theories lead to different predictions.
- If data collected fits your predictions based on your theory, the case supports your theory.
- If data collected does not fit your predictions, consider if rival theories are perhaps not correct.
- Sometimes your theory merely needs some fine-tuning.

Generalizing results

- Sometimes single case enough for significance– if proof that X *sometimes* works or X *sometimes* causes Y
- Multiple-case studies used to prove general results
- Case studies not useful to obtain percentages of population for which some statement holds.
- Why ? Case studies not selected totally randomly.

Conclusion

- Many inconclusive reported case studies caused this approach to be questionable.
- Thorough planning is required to convince others about your theory use a case study approach.

Appreciative Inquiry

- Starts with an *appreciation* of what already exists (not by defining a problem).
- Phases:
  - Discover
  - Dream
  - Deliver
- Researcher acts as a facilitator

Ethnography and participant observation

- Ethnography – *Treats participants like a foreign tribe that is studied.*
- Participants studied in natural setting
- Researcher participates – becomes one of community
- Researcher also the one who observes, hence *participant observation*

Focus Group

- Brainstorm approach
- Rely on dynamics of interaction to stimulate thinking and creativity
- Researcher plays role of facilitator

Grounded Theory

- Conventional research starts with a theory and then proceed by testing or proving it.
- Grounded theory allows the *theory to emerge from what is observed.*
- Use purposive sampling. Not sampled randomly. Select participants based on their differences (commonalities) and those already interviewed.

Hermeneutics

- Hermeneutics – *Interprets a text from the point of view of the author .*
- Text can be written, oral or other.
- Extract intended meaning and refrain from imposing your own meaning.
- Must understand context