Research Methodology I

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Reference Material

- **Thesis Projects – A Guide for Students in Computer Science and Information Systems**, M. Berndtsson, J. Hansson, B. Olsson, B. Lundell, Second Edition, Springer, 2008

What is Research?

- **Research** is used to refer to the activity of a diligent and systematic inquiry or investigation in an area, with the objective of discovering or revising facts, theories, applications etc.
- The goal is to discover and disseminate **new knowledge**
- The outcome of the scientific research process should be an **original contribution**

- “For an idea to survive, other scientists must be persuaded of its relevance and correctness—not with rhetoric, but in the established framework of scientific publication.” [Zobel 2004, p4]

Good Research

- Avoid unsubstantiated claims ("believe me", "I know", or "guru X says“ is NOT good enough)
- Trustworthy evidence (proof, actual data, ...)
- Trustworthy line of reasoning
- Objectivity
- Many sidedness (also provide other views, e.g., from competing research "camps")

Scientific Research vs. R&D

- Scientific research
  - Learn and understand complex phenomena
  - Establish new knowledge (public, often by conferences)
  - Not driven by profit
  - Relatively free research questions
- R&D
  - Often business goal
  - New products or services
  - Trends in technology
  - Evaluation of technology
  - Research prototypes
  - Experts within organisation

Research

- Systematic problem solving activity
- Researcher trustworthiness
  - **Process** of undertaking research
  - **Phenomenon** being studied

Research and Thesis Project

- Core aspect in both is the systematic process
- Outcome might differ
  - Scientific contribution vs. own learning
- You should be able to carry out a bigger project systematically and independently, apply previously acquired knowledge, and to acquire new knowledge
- Projects of scientific nature or R&D benefit from a systematic way in tackling a research question

Aims, Objectives, and Methods

- Your project should have one overall **aim**
- In order to reach the aim, a number of **objectives** are formulated
  - A small, achievable, and assessable unit, i.e. a sub-goal of the project
- Each objective can be achieved by different **methods**
  - You might want different methods for different objectives
  - Project results can be of poor or good quality depending on which method you choose and how you use it

Research Questions & Hypotheses

- **Research questions** ask what you want to learn
- **Hypotheses** are statements of your tentative answers to these questions
- Research projects normally start with a basic question you want to study
- Once you have it => choose a **systematic method**

What is a Research/Scientific Method?

- A method that represents the means, procedure or technique used to carry out some process in a logical, orderly, and systematic way
- An organised approach to **problem-solving**
  - Collecting data
  - Formulating a hypothesis
  - Testing the hypothesis
  - Interpreting results
  - Stating conclusions (can be evaluated by others)

Theoretical and Empirical

- Research can be **theoretical** or **empirical**
- Quantitative, empirical computer science research is based on the scientific method, which involves **experiments**

Computer Science

- Computer science (CS)
  - Is not part of the traditional sciences but
  - Concerns more than engineering
- Should we experiment in CS?
  - Some would claim that
    - Since computers and programs are human creations,
    - CS phenomena appear manufactured and synthetic
  - However, computers and programs can be studied as models
    - Modeling is necessary in the traditional sciences as well

Quantitative vs. Qualitative Methods

- Quantitative
  - Origin in natural sciences
  - Generally driven by hypotheses
  - Repeatability of experiments
  - Measurement is fundamental
- Qualitative
  - Roots in social sciences
  - Concerned with increasing understanding rather than explanation for it
  - Often associated with fieldwork
  - Repeatability might not be possible

Quantitative vs. Qualitative Methods

- Quantitative research methods: such methods collect **numerical data** (data in the form of numbers) and analyse it using statistical methods
- Qualitative research methods: such methods collect **qualitative data** (data in the form of text, images, sounds) drawn from observations, interviews and documentary evidence, and analyse it using qualitative data analysis methods

Methods

- Literature analysis
  - Literature analysis != review of existing work != Systematic literature review (SLR)
  - You do not need SLR for a good “Background and Related Work”
- Interview
- Case study
- Survey
- Implementation
- Experiment

Survey/Case Study Examples

- Qualitative data using open ended questions
- Quantitative data using closed questions
- An experiment may include observations of participant behaviour as well as measures of response time and accuracy
- A case study may incorporate quantitative data (e.g. system usage statistics) as well as qualitative data (e.g. interviews with users)

Validity and Reliability

- **Validity** is the relationship between what you intend to measure (or examine, or develop) and what you actually measure (or examine, or develop)
- **Reliability** is the accuracy of your method (e.g. implementation, questionnaire, interview style) in measuring (or examining, or developing), i.e. how robust your method is

Threats to Validity

- Research methods help ensure **validity**
- Valid conclusions are dependent on valid results, which in turn are dependent on a valid **experimental design**
- **Validity threats**: (1) statistical conclusion validity, (2) internal validity, (3) external validity, (4) construct validity, (5) context validity => many ways to group these…

Why User Studies?

- Developing new metrics and designs
- Making algorithms more efficient
- Evaluating perceptually adaptive graphics
- Optimizing perceived quality
- Enhancing the user experience
- Deciding on the most promising method

Conducting User Studies

- It is important to design controlled experiments
  - Gives more robust answers to a question
- Experiments are costly
  - Run pilot studies (identify problems, revise)
  - It is an iterative process
- Number of participants
  - Depends on the study (repeated measures)
  - Appropriate statistical analysis
- Setup, procedure, documentation
- Ethics (informed consent, storing data)

Some Validity Threats

- Wrong questions
- Task appropriateness and understanding
- Willingness, ability, social desirability
- Learning effects (mature, repeated tasks, hear about the experiment, etc.)
- Bias due to culture, groups, age, gender, experience, personality, mental and physical capabilities
- Instrument change
- Measuring behavior might change behavior
- What is measured is not what should be measured
- Differential mortality (drop outs)
- Regression to mean (children worst at reading…)
- Time event changes
- Dependencies between independent and dependent variables

Mitigating Problems

- Testing vision (acuity, stereo, color blindness)
- Experimenter bias
- Task instructions (written)
- Trial randomization
- Counterbalancing (order, age, gender, experience)
- Breaks (fatigue etc.)
- Garbage answers (outliers)
- Training task (example: novel interaction techniques)
- Double-blind technique (experimenter and participant)

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- Tony Gorschek, Robert Feldt, Andrew Moss
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