Doing a CSE Thesis

(A collection of ideas to make it more effective)

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Rationale

In the past,

- CSE 4th-year theses have been introduced primarily by a set of requirements
- I've spent hours giving each of my students, individually, advice about doing their thesis

Doing a thesis has enough general principles that

- regardless of the topic of the thesis
- I've been saying much the same thing to each student

There's a clear need for more info about how to do a thesis.

Goals of Lectures

The goals of this small series of lectures:

- describe the general process of research/development
- discuss the specific requirements for a CSE thesis
- show how to go about achieving these effectively

At the end, you should be able to

- understand precisely what's required of you
- produce a better result (project, report and seminar)
- use your time more effectively

Topics

In these lectures, we'll talk about:

- goals/requirements of 4th-year thesis
- the process of doing research/development
- getting started on a project
- writing the literature review
- preparing/delivering the seminar
- evaluating your work
- writing the final report (thesis)
- relationship with supervisor

Goals/Requirements of Thesis

Aims of the 4th-year thesis:

- give you exposure to research/industry topics
- give you experience in tackling a sizeable project
- allow you to "put together" what you've learned

Requirements:

- *seminar* (project overview + plan) (S1, week 12) (5%)
- *report* (literature review + plan) (S1, week 12) (5%)
- *thesis* (project + evaluation) (S2, week 14) (90%)

Why a Thesis is not an Assignment

A thesis is significantly different from an assignment:

- it is, typically, open-ended
  - there is not a obvious single "correct" answer
  - you have more say in the direction the work takes
- it has a much longer time-frame
  - you need more self-discipline to get things done
  - you have more responsibility to plan your progress

If you're still in "assignment mode", break the task into small assignment-size steps and treat each one as an assignment (but, alas, no late penalty).

Different Types of Theses

Theses have been classified into:

RES	carry out a small focussed piece of research
DEV	build a piece of software or hardware
R&D	combination of the above two
COR	smaller scope, for pass-level students (can be any of the above three styles)

Expectations for each type are slightly different (see later)

What is Research?

Activity that advances the store of human knowledge, e.g.

- explaining a previously unexplained phenomenon
- developing techniques to do things better
- proposing a new viewpoint on a cultural system
- proving a theorem

Scientific/engineering research follows the "scientific method":

- Observe ... Hypothesize ... Test ... (repeat)

What is Research? (cont.)

Example: astronomer discovering rotating star pairs

Observation:

- individual stars that appear to pulsate/change
  (changing brightness, different spectra at different times, ...)

Hypothesis:

- such "stars" are actually rotating pairs (intuition)

Test:

- examine stars using different instruments
  (e.g. very powerful optical observation to reveal individual stars)

ICT Research

Writing a piece of software, no matter how complex, isn't generally regarded as research in itself.

However, it would be considered research if

- it uses a new method/algorithm/data structure
  (the new method must be *demonstrably* better than earlier approaches)
- it solves a problem not previously solved by computer
  (will typically involve development of new methods, anyway)

ICT Research (cont.)

Example: devising a new database indexing method

Observation:

- queries of type Y are not efficient with existing methods

Hypothesis:

- my new method (X-trees) will handle Y queries *better*

Test:

- analyse computational complexity of X-trees for Y queries
- build an X-trees indexing library, test on a variety of data

ICT Research (cont.)

Evaluation of ICT research:

- solves existing problem more effectively than before
- solves a wider range of problems than before (generalises)

Demonstrations of effectiveness follow two tracks ...

Theoretical, e.g.

- analyse complexity, prove upper/lower bounds, ...

Experimental, e.g.

- build prototype; measure performance on range of data

What is Development?

Construction of artefacts/processes based on research results.

Implicit notion that new constructions are *better* than existing.

There is still a research component:

- you must demonstrate effectiveness
- you must analyse and describe limitations

ICT Development

Aim: build a system to meet a demand or solve a problem.

May involve developing software, hardware, or a combination.

The goal is clearly to build the system, but you must also:

- follow a (software) engineering methodology (and document it)
- provide a demonstration that the system *works effectively*
- note any remaining problems and limitations

ICT Development (cont.)

Characteristics of effectiveness are problem-dependent, e.g.

- time and space, for most ICT projects
- bandwidth utilisation, for networks
- usability, if there's a user interface
- accuracy (precision/recall), for web search engines

Must use *appropriate* evaluation instrument for project.

Must be honest about effectiveness (even negative results are useful).

Doing Research

The process is an elaboration of "observe/hypothesis/test":

- understand the broad topic area
- establish an evaluation framework
- look at what others have done and evaluate
- find an area of "weakness" in existing work
- devise a solution
- evaluate the effectiveness of the solution

Hint: document all parts of this process **as they are done**.

Reporting Research

Reporting follows, more or less, the steps in the process:

Introduction	sell the topic, summarise aims
Background	set the context, review literature
Own Work	what have you done, exactly
Evaluation	convince us that it's good
Conlusion	summarise achievments (and failures)

Reporting Research (cont.)

Introduction:

- outline the topic area, significance, originality, ...
- give overall aims of your work, summarise contribution

Background:

- describe the problem you are trying to solve in detail
- establish evaluation framework (how to recognise a good solution)
- describe *and evaluate* what others have done already

Reporting Research (cont.)

Own Work:

- describe your proposed method/approach in detail

Evaluation: (experimental)

- describe evaluation process (what are you measuring, how, why)
- report *and discuss* results of evaluation

Conclusion:

- summarise what you achieved
- *and* what you didn't achieve ... and suggest how to fix it

Doing Development

Has similarities to research ... but like "observe/build/test":

- understand/refine the requirements
- establish an evaluation framework
- look at what others have done and evaluate
- look at what methods are available, and choose
- devise a solution (implement system)
- evaluate the effectiveness of the solution

Hint: document all parts of this process **as they are done**.

Reporting Development

Reporting follows, more or less, the steps in the process:

Introduction	sell the topic, summarise aims
Background	set context, evaluate approaches
Own Work	what have you done, exactly
Evaluation	convince us that it's good
Conlusion	summarise achievments (and failures)

Reporting Development (cont.)

Introduction:

- outline the topic area, significance, benefits ...
- give overall aims of the project

Background:

- describe the problem you are trying to solve in detail
- establish evaluation framework (how to recognise a good solution)
- describe *and evaluate* what others have done already (?)
- evaluate possible implementation methods/approaches

Reporting Development (cont.)

Own Work:

- describe implementation process (SE) and final product
- if it has a user interface, give a tour of this

Evaluation:

- describe evaluation process (what are you measuring, how, why)
- report *and discuss* results of evaluation

Conclusion:

- summarise what you achieved
- *and* what you didn't achieve ... and suggest how to fix it

Getting Started

What you should be doing as soon as you have a topic:

- thinking about the topic ... understand all aspects, etc.
- finding out what others have done before (Google)
- considering what's need to evaluate your work
  (don't bother considering evaluation-by-bluff ... it doesn't work)
- making notes on everything that you look at/think about
- set up a thesis web site? (for holding the notes)
- meeting your supervisor and find out what they expect
- establishing a consistent Thesis working pattern

Do all of this before week 6 and assignments get heavy.