What is an MSc *"Thesis"*

J.N. Oliveira [1]

[1]Departamento de Informática, U.Minho

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University of Minho, Braga

Preamble

Context: Learning cycles

BSc — 1st cycle: student expected to learn and apply **general**, well-established theories

The **“repeat”** *phase*

MSc — 2nd cycle: student expected to learn **specialized** theories and build solutions from them

The **“build”** *phase*

PhD — 3rd cycle: student (who thinks she/he can do better than his former teachers) expected to pursue a new **conjecture** (thesis) and provide scientific evidence of it

The **“create”** *(“invent”) phase*

Mind the terminology

MSc, PhD — post-graduation academic **degrees**

MSc, PhD thesis — a scientific **result** (from the Greek $\theta\varepsilon\sigma\iota\zeta$ = position)

MSc, PhD project — an action, **initiative** taking time (from the Latin *proicere* = throw forth)

MSc, PhD dissertation — a piece of **text**, originally a *discourse* (from the Latin *dissertatio* $<$ *disserere* = discuss)

Doing a post-graduation course

Post-grad **projects** are a standard way of advancing human **knowledge**.

Post-grad **programmes** range over the

- human (social) sciences
- natural sciences
- exact sciences.

However, what does **"science"** mean? What tells science apart from other forms of human knowledge?

Post-grad students cannot ignore these questions!

Overview of the Scientific Method

Science? Pre-science?

In an excellent book on the history of scientific technology,

> *"How Science Was Born in 300BC and Why It Had to Be Reborn" (Springer, 2003),*

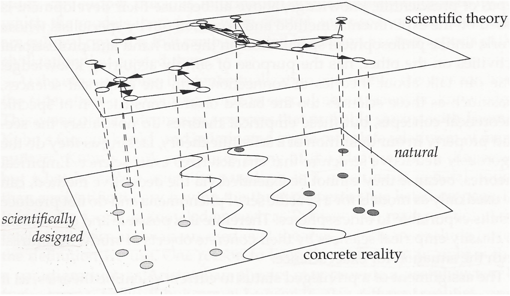
Lucio Russo writes:

> *The immense usefulness of* **exact** *science consists in providing* **models** *of the real world within which there is a guaranteed method for telling false statements from true. (...) Such models, of course, allow one to describe and* **predict** *natural phenomena, by translating them to the theoretical level via* **correspondence rules**, *then solving the "***exercises***" thus obtained and translating the solutions obtained back to the real world.*

Disciplines unable to build themselves around *"exercises"* are regarded as **pre-scientific**.

Scientific engineering ($e = m + c$)

Also from Russo's book :



Vertical lines mean **abstraction**, horizontal ones mean **calculation**:

engineering = model first, then calculate
($e = m + c$)

Example

Natural phenomena — planetary motion, objects falling down...

Correspondence rules — Newton (1642-1727)'s laws of mechanics and gravitation stemming from **model**

$$F = G\frac{mM}{d^2}$$

"Exercises" — Earth gravitational field,

$$g = \frac{GM}{R^2}$$

then $F = gm$, then $F = m\frac{dv}{dt}i = ma$, then... (you know the rest!)

Translation back to the real world — ballistics, space missions, satellite technology, etc

Computer science — back to 45 years ago

Phrase **software engineering** seems to date from the Garmisch NATO conference in 1968:

> *In late 1967 the Study Group recommended the holding of a working conference on Software Engineering. The phrase 'software engineering' was deliberately chosen as being* ***provocative****, in implying the need for software manufacture to be based on the types of* ***theoretical foundations*** *and practical disciplines, that are traditional in the established branches of engineering.*

Question:

- Provocative or not, how "scientific" do such foundations turn out to be, 45 years later?

Complexity, complication, obfuscation

Software engineering (SE) is complex:

- **Complexity** — property of being intricate but with formalizable structure.

Negative aspects of software engineering research:

- **Complication** — messy, lacking structure
- **Obfuscation** — formalization intended for bewilderment rather than enlightening (worst of all).

So — in your project:

- Don't expect an easy task
- It will be **complex** — so, don't **complicate** it further.
- Never dare going into obfuscation!

Planning your dissertation

What is involved

Questions:

- **How** should I structure it?
- When should I start?
- What should I write?

Likely questions, aligned with the so-called **Aristotelian categories**:

> *Wherever your are, whatever you do, your ideas, concepts, "things" etc. are multidimensional in nature:*

What	*the thing is about*
What for	*the purpose of the thing*
Why	*bother with the thing*
When	*did the thing happen?*
Where	*is the thing taking place?*
How	*is/was the thing carried out?*

What is it?

Recall that:

- A dissertation is a **document** which should provide scientific evidence of some result(s) in some area of knowledge
- Following the **scientific method**, the concepts involved in such results should be **formalized** first (vertical arrows in Russo's diagram) and then **reasoned** about (horizontal arrows in the same diagram).

This entails some structure in the text:

- **Definitions** for each correspondence rule (in Russo's sense)
- **Theorems** for each "exercise" (in Russo's sense).

What about the overall text?

How should I structure it?

Recall the typical structure of a mathematical argument, leading to results in the form of **theorems**, each involving:

1. Thesis (T)
2. Hypothesis (H)
3. Proof ($H \Rightarrow T$)
4. Corollaries
5. Lemmas
6. Others' theorems.

How should I structure it?

Since the purpose of a dissertation is that of providing scientific evidences, its **overall structure** should mirror the shape of a mathematical argument. Here it goes:

Maths	**R&D** (parallel)	**Dissertation**
Thesis (T)	Main result	Contribution chapter
Hypothesis (H)	Context	State of the art [1]
Proof ($H \Rightarrow T$)	Evidence	Core chapters
Corollaries	Application	Case studies
Lemmas	Support results	Appendices
Others' theorems	Evidence elsewhere	Bibliography

So, in a sense, writing up your dissertation means *proving* **your** *"theorem"*.

[1] Inc. previous work.

How should I structure it?

Therefore, it's no wonder that a dissertation should be structured as follows [2]:

- Introductory material:

  1st Chapter — Context, motivation, main aims
  2nd Chapter — State of the art review; related work
  3rd Chapter — The problem and its challenges.

- Core of the dissertation:

  4th Chapter — Main result(s) and their scientific evidence
  5th Chapter — Application of main result (examples and case studies)
  6th Chapter — Conclusions and future work.

[2] Number of chapters not strict: may vary according to the needs.

How should I structure it?

- Auxiliary material:

  Bibliography — List of works referred to in the main text
  Appendix A — Support work (auxiliary results which are not main-stream)
  Appendix B — Details of results whose length would compromise readability of main text
  Appendix C — Listings (should this be the case)
  Appendix D — Tooling (should this be the case)

This should be complemented by some extra matter, as in the following slide.

How should I structure it?

1. Front matter:

   Title page — institutional, as a rule

   Abstract page — summary of the work (a short, smart account of the thesis)

   Acknowledgements — thanks to tutors, colleagues, institutions (funding), etc

   Table of contents — overview of the whole document

   Glossary — list of acronyms and their meaning

   Lists — of tables, of figures etc (automatically generated if using a proper authoring system).

2. Rear matter:

   Index of terms — index of mentioned entities, with references to where (page numbers) they occur in the text.

How should I structure it?

Last but not least:

- Don't **nest** your dissertation too much (Dewey Decimal Classification works against you if you do so)
- A chapter is not a section (**length**!)
- Each chapter can be regarded as a *mini-dissertation* (thus it shares, in a sense, the same structure — introduction, summary at the end [3], etc)
- Don't forget to **spell check** the whole document!
- **Symmetry** — introduction and conclusions should be "*matching* parentheses" (check at the end)
- **Aesthetics** — style, elegance and design alone are not enough, but help.

[3]Introduction chapter excluded, whose summary should be an overview of the structure of the dissertation.

Writing up

When should I write it?

- You should start writing up your thesis on the **very first day** you start your project.
- Of course, this assumes you've understood your project theme sufficiently well.
- On that day only a **sketch** of the dissertation can be written — but already mentioning the standard chapters.
- Use this skeleton as a **road map** and **diary** — you can always keep auxiliary information in the form of comments.
- Comments may even include **time stamps** — these will tell how fast you've done your work (useful in measuring effort and productivity).

Whom should I write it for?

To **everybody** — ... I mean:

- Introductory and conclusive matter should be written in a style easy to understand by non-specialists.
- Core chapters will inevitably be technical, so they are bound to be written for the **specialist**.

Final check up — the question is

> *Do I master my domain of knowledge upon completion of my project?*

Well...

- you should be able to **explain** what you did to **anyone** you may meet in the street. (abstraction!)

How should I write it?

Two sides of the question:

- **Style** (text quality, etc)
- **Production** (editing and publishing)

Style:

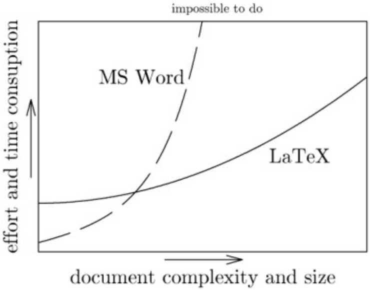
- Avoid colloquialisms and any form of *majestic* style (*"we"*, *"our"*, ...) — be **modest**.
- Avoid past tenses (scientific writing is **not** story telling).
- Text "comes in pairs":
  - Backward integrity — **declaration** always before **use** (eg. definition before application).
  - Forward integrity — make sure you **fulfill** whatever you **promise**.

  Cf. offer / demand , client / server, etc

How should I write it

Production — use a proper **text authoring system**. By **proper** I mean one that:

- Handles **references** and maintains **referential integrity**.
- Automates **routine tasks** such as numbering, bibliography, generation of lists and indices.
- Integrates well with **other tools**.



One such system is the Knuth-Lamport's LaTeX's text preparation system (Goossens et al., 1997).

(Maybe you know of others).

How do I write it?

Handling references:

- Concepts, entities etc have a **name** (reference) and often a type.
- Textual information (implicitly) contains a set of **name spaces**.
- A name in each name space identifies a unique object — it is a **reference**.
- Name spaces call for **referential integrity**.
- Most of these are ensured by the text authoring system itself — eg. names (numbers) of **figures**, **tables**, **sections**, **theorems**, etc.
- One should be very careful about handling any other references (names).

How do I write it?

For those not handled, here is how I like dealing with them (for LaTeX users only — sorry!): for each **entity**, eg.

- **Entity**: University of Minho
- **Acronym**: UM

define (under package `hyperref`) its (unique) reference **name**:

```
\newcommand{\uminho}[1]{
     \href{http://www.uminho.pt}{#1}
     \index{UM!University of Minho}}
```

Mind that, every time you write eg. `\uminho{the university}`,

- you provide a link to the website you've chosen for the mentioned entity;
- an entry is added to the **index of terms**, that is, the occurrence of term `uminho` in the **current page** is recorded.

How do I write it?

Then an acronym (short-cut) can be defined:

```
\newcommand{\UM}{\uminho{\textsc{u.m.}}}
```

So, every time you use acronym `\UM`, LaTeX typesets U.M. and does the same as above concerning hyperlinking and index-management.

This saves you from referring to relevant entities which are not in the list of terms.

Last but not least:

- Keep your dissertation in a document **version-control system** like eg. SVN or DARCS — among many other alternatives, often web-based.

Interfacing with others' work

Last but not least, we need to be concerned with **bibliography** management:

- Nobody doing relevant research is alone.
- Research is actually a **social** activity, with continued interaction in the form of meetings, conferences, and so on.
- Giving **credit** to the others' **contributions** is the main rule of the game.
- With the information resources of today, managing this may be hard (too much data!) without a proper infra-structure.
- This should take the form of a **bibliography database**.

Interfacing with others' work

Systems around BibTEX provide for very easy management of bibliography data:

- A BibTEX record is like a database record, eg:

```
@book{GRM97
   , title     = {The LaTeX Graphics Companion}
   , author    = {Michel Goossens and
                   Sebastian Rahtz and Frank Mittelbach}
   , publisher = {Addison-Wesley}
   , year      = {1997}
   , note      = {ISBN 0-201-85469-4}
}
```

- You may add your **own attributes** (which don't get printed) like IDs of books in your own library, bibliometric stuff, and so son.

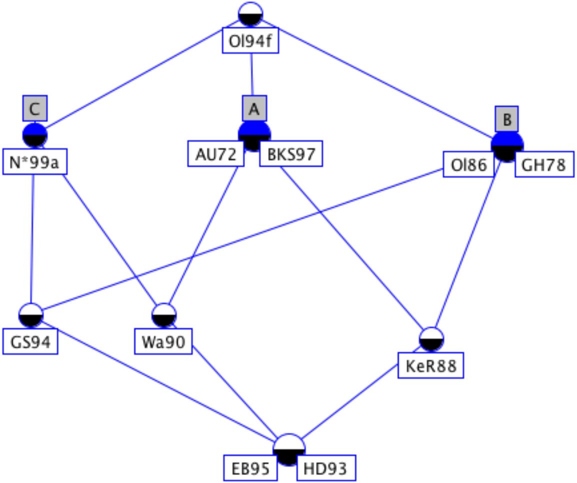
Interfacing with others' work

Classifying your bibliography:

- In particular, you may add a BibTEX attribute named `keywords` to each record of interest.
- This will **classify** your records according to keywords relevant to your research.
- You many even use the technique of **formal concept analysis** (FCA) developed by Ganter and Wille (1999) to structure your bibliography in a **lattice of concepts**.
- Some FCA systems (such as ConExp) offer you a user interface to manage and display your concept lattice (next slide).

Interfacing with others' work

Example concept lattice (11 records, three attributes A, B abd C):



Interfacing with others' work

The classification which generates such a lattice is as follows:

BibTEX key	A	B	C
Ol94f	0	0	0
AU72	1	0	0
Ol86	0	1	0
N*99a	0	0	1
KeR88	1	1	0
GS94	0	1	1
Wa90	1	0	1
EB95	1	1	1
BKS97	1	0	0
GH78	0	1	0
HD93	1	1	1

Such concepts should help in organizing your review of the state of the art.

Interfacing with others' work

Careful review of the **state of the art** in the area you intend to work on is valuable in itself and can be published.

An example of this is reference (Couto et al., 2011) — a paper which emerged from the UCE15 report by Luís Couto (pg15260) on reviewing literature on software architecture quality, last year.

Using FCA, Luís Couto's enunciates a number of **research questions** which he tries to answer by generating FCA lattices for each of them.

(Worth having a look.)

Some links

- *BibSonomy* (a system for sharing bookmarks and lists of literature) — www.bibsonomy.org
- *DBLP Computer Science Bibliography* (comprehensive account of BibTEXrecords) — www.informatik.uni-trier.de/˜ ley/db/index.html
- *Writing and Presenting Your Thesis or Dissertation* — www.learnerassociates.net/dissthes/
- *How to Write a PhD Thesis* — www.phys.unsw.edu.au/˜ jw/thesis.html
- *Small guide to making nice tables* — www.inf.ethz.ch/personal/markusp/teaching/guides/guide-tables.pdf

among many others Google will offer to you.

Closing

Final suggestions:

- **Interact** with other researchers in your field.
- Once you have something to show, build a **research blog**.
- Try and **publish** your work in good conferences — the best way to validate your contributions.
- Good **papers** convert to good chapters in the dissertation.
- Offer your **services** in OC/PCs of **conferences** in your area.

and don't forget

- to be **creative** (recall K. Popper)
- to have **fun**: if you don't get excited with your project — who will?

References

L. Couto, J.N. Oliveira, M.A. Ferreira, and E. Bouwers. Preparing for a literature survey of software architecture using formal concept analysis, 2011. Proc. of the SQM'2011 workshop, colocated with CSMR 2011, Oldenburg, Germany.

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