SCIENTIFIC RESEARCH METHODOLOGIES AND TECHNIQUES

Unit 5: THESIS ORGANIZATION AND VALIDATION

Luis M. Camarinha-Matos
cam@uninova.pt

PhD PROGRAM IN ELECTRICAL AND COMPUTER ENGINEERING

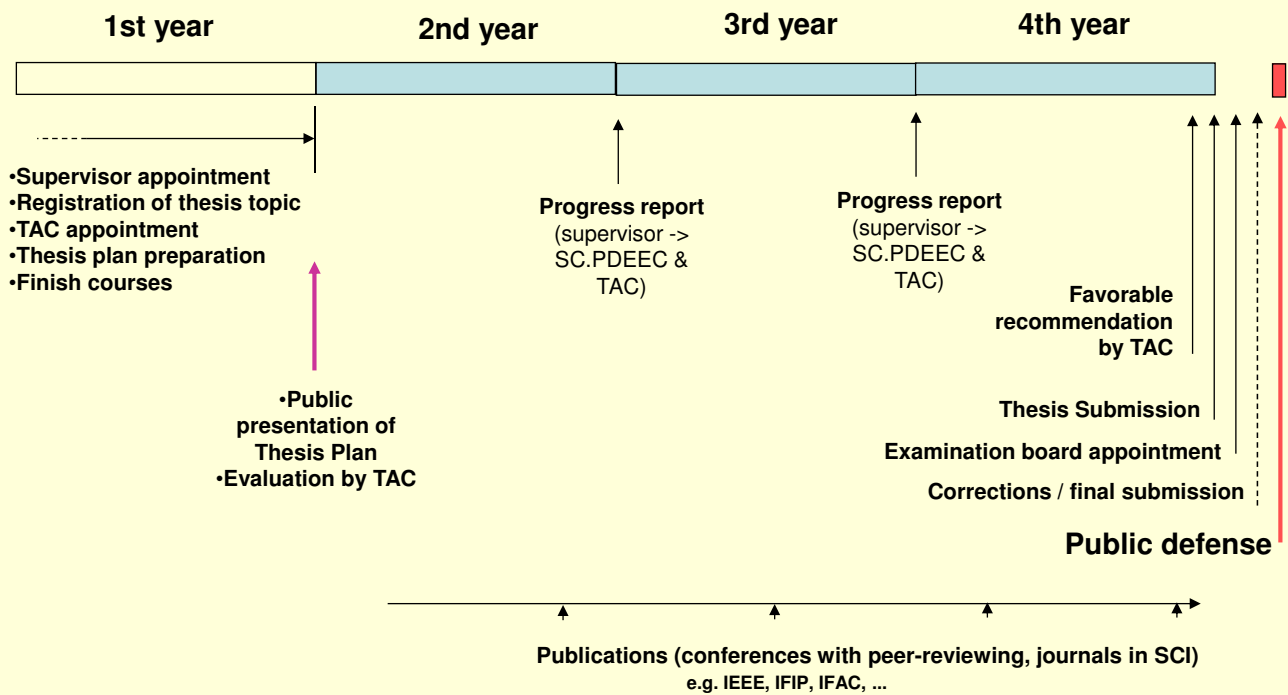When you are about to begin, writing a thesis seems a long and difficult task.....

That is because it is a long and difficult task.

Joe Wolfe, University of New South Wales

General steps

1st year	2nd year	3rd year	4th year

•Supervisor appointment
•Registration of thesis topic
•TAC appointment
•Thesis plan preparation
•Finish courses

Progress report
(supervisor ->
SC.PDEEC &
TAC)

Progress report
(supervisor ->
SC.PDEEC &
TAC)

•Public
presentation of
Thesis Plan
•Evaluation by TAC

Favorable
recommendation
by TAC

Thesis Submission

Examination board appointment

Corrections / final submission

Public defense

Publications (conferences with peer-reviewing, journals in SCI)
e.g. IEEE, IFIP, IFAC, ...

---

1. THESIS PLAN

Structure

Thesis Plan includes the definition of the **research question**(s) and **its motivation**, **hypothesis**, analysis and synthesis of the **state of the art**, and **planning** of the research activities.

Recommendation:

- **Abstract**
- **Introduction / background**
- **Research question and general approach**
- **Literature review**
- **Research method**
- **Aimed contribution**
- **Detailed work plan and scheduling**
- **Validation method**
- **Dissemination plan**
- **Integration with other research activities**
- **References**

Size: 35 to 60 pages.

Public defense of the plan

At UNL the Thesis Plan must be presented in a **seminar** for the Thesis Accompanying Committee (TAC). The seminar is open to the **public**.

After the presentation, there is a discussion between the TAC and the candidate.

This event serves to collect feedback / suggestions from the TAC ... and thus a fundamental element to give the candidate confidence when starting his/her research work.

If the TAC considers that the Plan is not mature yet, the candidate may be asked to resubmit if after some months.

2. THESIS STRUCTURE

PhD thesis or dissertation ?

In informal talking people call "thesis" the document that is in fact the dissertation.

In reality a PhD dissertation may include more than one thesis.

What is a thesis / PhD dissertation ?

- Demonstration of a clear understanding of the state of the art
  - Critical appreciation of existing work

- A novel contribution
  - The distinguishing mark of a PhD work is an **original contribution to knowledge**
  - Your research must discover something previously unknown
    - Not something for which the examiners already know the answer ... *and they are experts in the field*.
  - Evaluated systematically

- A sound research report, well-written, carefully edited / revised

9

What a thesis is **not**?

- A description of what you did in the lab over the last 3~4 years
  - *I first read the background material*
  - *I then implemented an algorithm*
  - *I ran some experiments*
  - *…*

- A "brain dump" of everything you've done
  - *You have to leave out the dead-ends and irrelevant aspects (even if you spent a lot of time with them …)*
  - *But you have to fill in any obvious gaps!*

- **A thesis is a *logical* "reconstruction"**
  - **Not a historical narrative**
  - **With a *single* coherent message**

10

Typical Table of Contents

Preliminaries

1. **Introduction**
2. **Background information (optional)**
3. **Literature review**
4. **Conceptual contribution**
5. **Experimental developments**
6. **Validation / Discussion**
7. **Conclusions and future work**
8. **References**

Annexes (optional)

Some of these sections may include a number of chapters!

Size, style, etc

A typical size for an engineering thesis is between 120 and 200 pages.

Language: recommended English, as it can get more readers ...

**Style of writing: A thesis is a formal document.
Avoid informal writing.**

Recommendation: Have a look at other thesis.

3. THE COMPONENTS

Preliminaries

The actual contents of this part depend on the formatting rules adopted in each university.

Examples:

Abstract ... At UNL this must be written in Portuguese and English

Acknowledgements
- **To people: supervisor, colleagues, other people that helped.**
- **To funding agencies / projects when resources where provided to support your work**
- **To host institution / Lab, etc.**

Table of Contents

List of Figures

List of Tables

Introduction

- **Brief summary of the research question**

- **Motivation or reasons why it is a worthwile question**

- **Your hypothesis / thesis**
  - **The reader will be looking for your thesis. Make it clear, strong and easy to find.**

- **The research method adopted (instantiation of scientific method)**

- **Perhaps an overview of main results**

- **Not just a description of the contents of each section !**

www.rsc.qut.edu.au/studentsstaff/training/workshop_materials/2007/writing_your_thesis_Danby_260607.ppt
Examples of good thesis statements

Introduction ...

What a Thesis Statement is Not:
Your Thesis Statement is NOT Your Topic!

✏ Your topic tells your reader what you are talking about. For Example:

  ✏ I will compare marijuana usage over the last 5 years.

This is not a thesis, it is only A Topic.

✏ Your thesis tells your reader your position on your topic. For Example:

  ✏ Marijuana usage has decreased over the past five years due to the successful "War on Drugs."

This is a Successful Thesis Statement

A strong thesis should not be too broad, not too narrow

What a Thesis Statement is Not:
You Thesis Statement is NOT A Fact About Your Topic!

✏ Surprisingly, your thesis should be an arguable OPINION - NOT A FACT!
  ✏ WHY?
    ✏ Because that is what makes your paper / thesis interesting to your reader!
    ✏ Your thesis should always be a statement that demands PROOF!

Your Thesis Should Take A STAND!

✏ You spend the rest of your paper / thesis CONVINCING your reader of why YOUR OPINION is TRUE!

✏ Your thesis prepares your reader for the facts that will prove your opinion about your topic to be true- it can not be a fact itself.

www.clc.uc.edu/documents_cms/TLC/Your_Thesis_Statement.ppt

Introduction ...

"**Does an engineering thesis need a hypothesis?**
Hypotheses may be relevant to science theses, but are they relevant to engineering theses? Because engineers *invent* rather than *discover*, does an engineering thesis need a hypothesis?

Yes, all the more so, because invention is a more tightly directed activity than discovery; and the two are not mutually exclusive any way!
I prefer the word hypothesis: that which underlies a thesis; you may be more familiar or comfortable with *aims* or *objectives*.

The hypothesis is the electromotive force for your thesis.
Suppose your project involves using Artificial Neural Networks (ANNs), in conjunction with appropriate hardware, to sort good apples from bad.
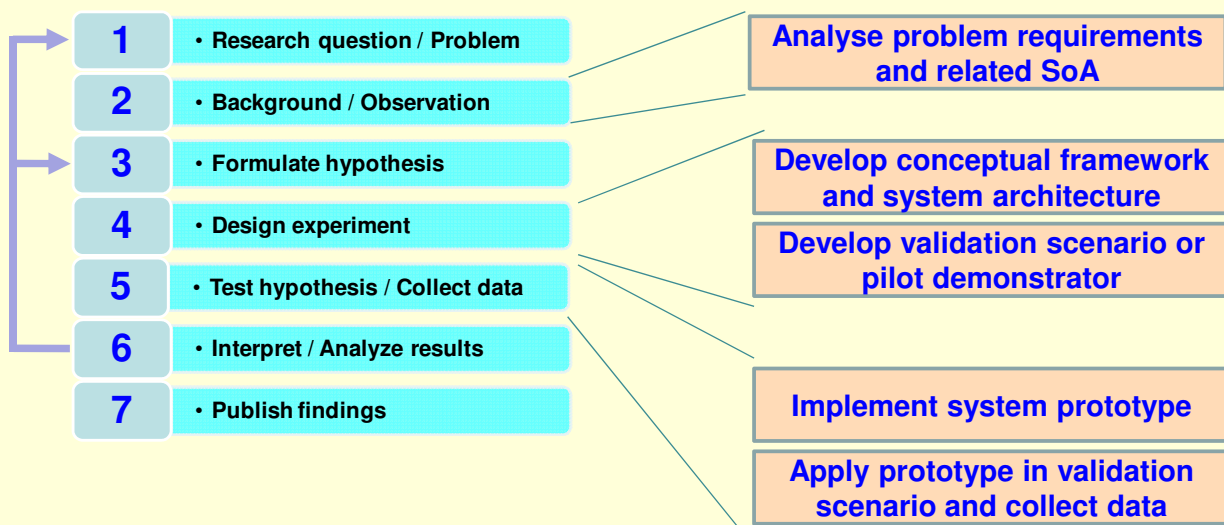The **hypothesis** for this project may be,
  '**It is possible to sort good apples from bad [if we use] using ANNs and suitable hardware**'. Note that implicit in your hypothesis is a definition of acceptable levels of accuracy (how do you quantify the words 'possible', 'good', and 'bad'?)."

[Chandrasekhar, 2002]
How to write a thesis: A working guide

Introduction ...

"Tuning" the scientific method to the specific research topic (an **example**):

1 • Research question / Problem	**Analyse problem requirements and related SoA**
2 • Background / Observation	
3 • Formulate hypothesis	**Develop conceptual framework and system architecture**
4 • Design experiment	**Develop validation scenario or pilot demonstrator**
5 • Test hypothesis / Collect data	
6 • Interpret / Analyze results	**Implement system prototype**
7 • Publish findings	**Apply prototype in validation scenario and collect data**

Background information

An optional section ... that may be needed to provide additional information ... specially if the work has a multi-disciplinary nature

A brief synthesis of the most relevant aspects related to the thesis in order to help the reader understand the context and the contributions coming from other disciplines.

It can also be used to better motivate the research question.

**The research method can be described here (instead of in the Introduction).**

Literature review

This section may have other titles
e.g. State of the Art in ....

Not a literature survey in general, but rather a synthesis of the state of the art <u>related to the thesis</u> !

Identify gaps / limitations

Background & related work may overlap
  - Need to discuss related work at start to set scene
  - Need to discuss related work at end to demonstrate your originality

  - But not cut and paste!
  - Exercise your synthesis and critical skills !

Do not underestimate the effort !!!
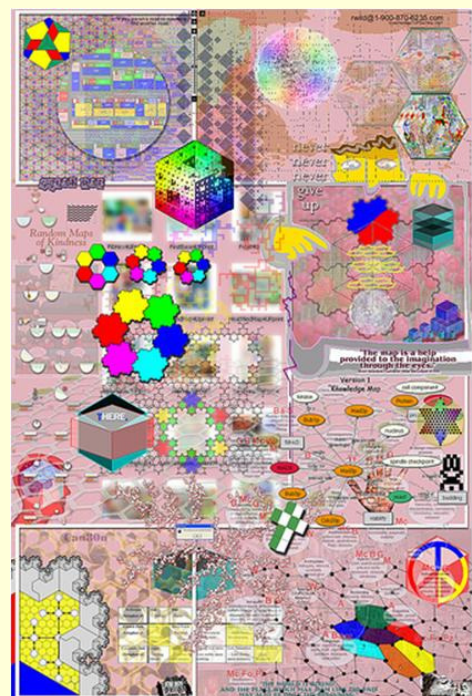
Conceptual contribution

Here you develop your conceptual contribution

- Discussion of the thesis and different perspectives of analysis of the research question
- Formulation of concepts, definitions, theories
- Elaboration of frameworks, models, architectures

Are you answering the research question?

Is it an original / innovative contribution?

"If there were blind alleys and dead ends, do not include these, unless specifically relevant to the demonstration that you answered the thesis question !"

[Chinneck, 1999]

Experimental developments

High-level (cleaned up) description of the research experiment

e.g.
Description of a prototype system implementation and its use towards solving the research problem
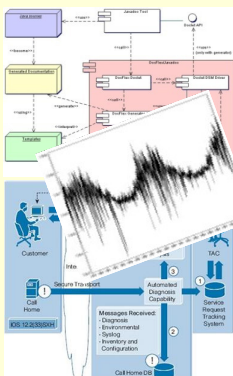
Can include some context information
(e.g. Development software, test environment, procedure, limitations, assumptions, range of validity)

But not too many details !!!

... Just enough to:

- Let the reader believe in your results
- Allow another (experienced) researcher replicate your experiment

Avoid technological details that get outdated quickly!

Validation / Discussion

One of the most critical parts !!!

Developing a prototype is (usually) not enough to validate the thesis
... at most it is a proof of feasibility of your system

Example of hints for discussion:

1. What are the major patterns in the observations?
2. What are the relationships, trends and generalizations among the results?
3. What are the exceptions to these patterns or generalizations?
4. What are the likely causes (mechanisms) underlying these patterns resulting predictions?
5. Is there agreement or disagreement with previous work?
6. Interpret results in terms of background laid out in the introduction - what is the relationship of the present results to the original question?
7. What is the implication of the present results for other unanswered questions in your domain?
8. Multiple hypotheses: There are usually several possible explanations for results. Be careful to consider all of these rather than simply pushing your favorite one.
9. Avoid bandwagons: A special case of the above. Avoid jumping a currently fashionable point of view unless your results really do strongly support them.
10. What are the things we now know or understand that we didn't know or understand before the present work?
11. Include the evidence or line of reasoning supporting each interpretation.
12. What is the significance of the present results: why should we care?

www.ldeo.columbia.edu/~martins/sen_sem/thesis_org.html

Validation / Discussion ...

What if ...

Experimental results are really difficult to obtain?
... or what if they would require a time frame that goes well beyond the duration of the thesis work?

> **e.g. If you want to verify the impact in the economy of a new organizational form for networks of companies**

Try some indirect approaches ...

- **Simulation ... but be careful about its validity**
- **Questionnaires / Interviews (experts in the domain)**
- **Partial case studies (trends)**
- **Feedback from conferences, workshops, focused meetings**
- **...**
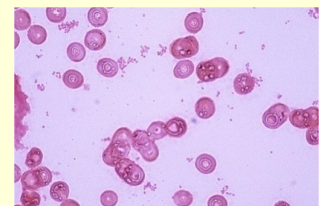
i.e. Collect enough evidence !!!

Validation / Discussion ...

The essence of a PhD dissertation is **critical thinking**, not just experimental data... but experimentation is needed!

Validation is about

both
- **Collecting (enough) evidence**
  - **... using a proper (systematic) method**
- **Organizing argumentation**

to convince the other researchers about the validity of the thesis.

Analysis and concepts form the heart of the work. It must state **what was learned**, not only the facts that were gathered ! **Argumentation** is an important element.

Validation / Discussion ...

Some "instruments" ....

☑ **Mathematical proof** .... Quite difficult if not impossible in many engineering thesis

☑ **Benchmarking** ... Comparing your (experimental) quantitative results with current best results in the field
- ☑ It needs a set of "acceptable" <u>indicators</u>

☑ Collecting **supporting "testimonies"** from relevant stakeholders / experts in the application field (a kind of etnographic approach)

☑ Collecting **acceptance by peers**
- ☑ Publications in good journals
- ☑ Publications in good conferences

☑ ....

☑ A **mix** of all of them

Conclusions and Future work

- **What is the strongest and most important statement that you can make from your work?**
- **If you met the readers at a meeting six months from now, what do you want them to remember about your thesis?**
- **Refer back to the problem posed, and describe the conclusions that you reached from carrying out this investigation, summarize new observations, new interpretations, and new insights that have resulted from this work.**
- **Include the broader implications of your results.**
- **Do not repeat word for word the abstract, introduction or discussion.**

www.ldeo.columbia.edu/~martins/sen_sem/thesis_org.html

Some dissertations just restate the research findings ... The reader has seen them before (in the text) ... Now help him/her understand what it all means !

Include a set of recommendations (to overcome limitations) or directions for future research (maybe new directions opened by this work).

!

Bibliography

- **Carefully organize the reference list using a common "standard"**
  - Most frequent: alphabetical order

- **Cite all ideas, concepts, text, data that are not your own**
  - Most common: (Author, year), (Author1, Author2, year), (Author1 et al., year)

- **If you make a statement, back it up with your own data or a reference**

- **All references cited in the text must be listed**

- **Try to avoid inclusion of references as footnotes**

  - ◆ **Are you forgetting any major related work?**
  - ◆ **Citing some works from members of the thesis evaluation committee?**

Annexes

This is an optional part.

It can include:

-Implementation details
-Detailed experiment data
-...

that may be important to
       Convince the reader
       or
       Help others replicating the experiment

... But are "boring" or too detailed to include in the main body of the thesis.

---

4. THE WRITING PROCESS

Main steps

- ◆ **Plan / elaborate the outline**

- ◆ **Get feedback from supervisor**

- ◆ **Start detailing / organizing the main sections**

- ◆ **After a few chapters, collect feedback from colleagues**

- ◆ **Revise them and start getting feedback from supervisor**

- ◆ **Go through several iterations ! THINK-PLAN-WRITE-REVISE cycle**

- ◆ **Write the Conclusions and then the Introduction**

- ◆ **Read the whole thesis to eliminate repetitions**
     Read it to verify / improve ideas
          Read it again for editing.

... And carefully take into account the recommendations of your supervisor !

Help from an English editor?

Hints

Generate an Outline:
- – **A 'plot' for your thesis writing**
- – **Several Pages - chapter headings / sub-headings / figure titles**
- – **Start with 'fleshing' the structure given**
- – **Target: 'logical story' for the document**
- – **Discuss / revise with supervisor**

Results
- – **Start with Tables/Graphs**
  - • *Make each 'stand alone'.. Detailed legends*
- – **Pick the pictures:**
  - • *What 'tells the story'?*
- – **Describe, *then* number crunch**
- – **Use Appendices for detailed items**

www.science.ulster.ac.uk/gradschool/pdf/writingthephdthesis.ppt

Re-use of your publications

"Can I include material from my publications in my dissertation?"

Yes, you can!

33

When to start ... and stop

Start soon ...

How long will it take?
... Longer than you expect !!!

... Your dissertation is not an application for a Nobel prize
... Your dissertation is not the last word on the subject
... Trust your supervisor
   and consider the feedback from your publications

34

Remember ...

"Students in high-ranked schools work between 60 and 80 hours per week

- **Faculty spend a similar amount of time**

- **Don't get fooled that you do better than some colleagues while spending a lot less time**

- **You will compete for jobs with students form other schools as well"**

[Borcea, 2008]

Hints

- Don't start with the Introduction or Conclusion

- Start where you feel happiest
    - Typically a middle chapter
    - Write outwards
    - Finally Conclusions and end with the Introduction

- Write everything with your thesis message in mind

- Get feedback before you write too much
    - One person to read each chapter as it is written
    - Another person to read the thesis in order
- Lay some good groundwork
    - Endnote
    - Indexing
    - ...

[Walsh, 2004]

Hints ...

- It's never possible to cover all issues
  - So you will never finish?
  - It's sometimes enough to identify the issues
  - Examiners greatly appreciate you identifying limitations and finding a few mistakes ;)

- Much of your thesis is joint work
  - Clearly identify some work that is yours alone
  - Include a statement at the start of your contributions:

    "Results from this thesis appear in the following publications…. Whilst much of this thesis is joint work with my supervisor, I made significant contributions to Chapters 3-6. In particular, … . "
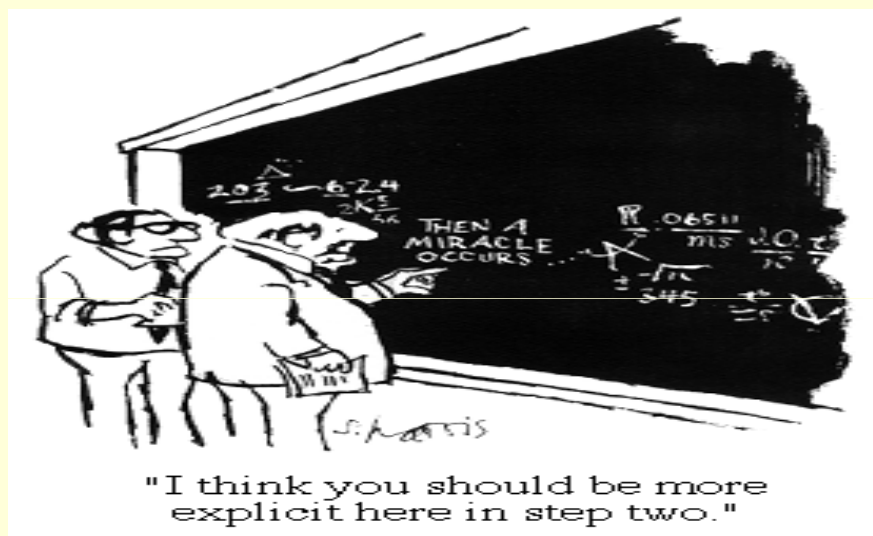
[Walsh, 2004]

The revision journey

Get early feedback from colleagues ... Starting with the key chapters

Carefully revise those chapters before giving them to your supervisor

If you are writting in a language other than your mother language, consider getting specialized editing help

"I think you should be more explicit here in step two."

When you have a complete draft ... consider 2 or 3 complete revision / editing iterations !

Hints in a matrix

|			
Answer the question.	A clear, logical structure is essential.	Give your own analysis, not mere description.	We want to see a fresh, original approach.
Clear, consistent references are essential.	Base your essay on extensive relevant reading and research.	Indecisive 'it's a bit of both' essays are disappointing.	Argue your case, with your own point of view.
Use commas properly. Learn how to deploy semi-colons.	We want to see evidence of independent thought.	Try to avoid formulas, clichés, and the obvious approaches.	Have a clear, relevant introduction and conclusion.
It's important to know the difference between "it's" and its alter ego, "its".	Don't allude to anything you've read without giving a reference for it.	Avoid a purely 'journalistic' style, in academic essays.	Don't waffle. It's not cunning, it just suggests you've got little to say.
Illustrate your points with up-to-date examples.	Construct your sentences carefully.	Use the internet — but with care and discrimination.	Don't fill an essay with irrelevant historical detail.
Use electronic resources to find material (see library website).	Check your spelling and punctuation. Seriously.	Ensure your essay is the required length.	Bring the subject to *life!*

(Gauntlett 2001)

Checklist for revising a draft

- does the content match the title ?
- are important points emphasised enough ?
- is the content within each section appropriate ?
- is there a logical sequence ?
- are information sources acknowledged ?
- do the conclusions relate to the objectives ?
- have you followed the conventions and regulations ?
- is the meaning of each sentence clear - or open to interpretation ?
- can long sentences be broken down ?

Dr. Richard Young, Quality and Standards Unit, University of Newcastle upon Tyne 1999
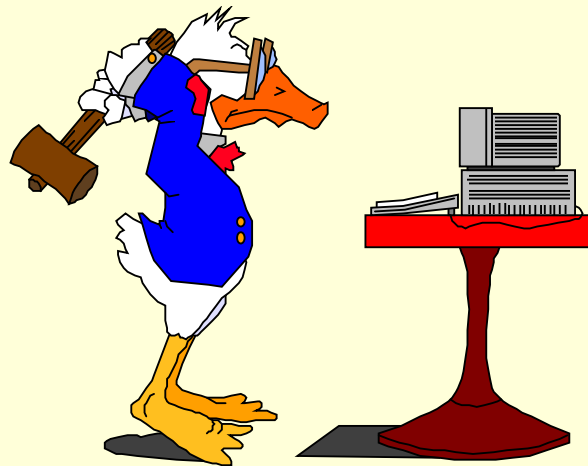
Always remember to Back Up!

Preparing for the defense

At UNL the PhD candidate is supposed to make a 20 min **presentation** before the **discussion** period.

The whole exam may last up to 3 h !

Your presentation should focus on the important results (no details !), including your research question, hypothesis and findings, conclusions and future work.

During the discussion period remember that among all presents in the room (it is a public exam), you are the one who better knows your work !

www.rictoons.com   c.2002 ric leonard

"Has the Jury reached a decision?"

What are examiners looking for?

- Review of literature:

  – Is the literature relevant?
  – Is the review critical or just descriptive?
  – Is it comprehensive?
  – Does it link to the method in the thesis?
  – Does it summarize the essential aspects?

- Research method:

  – Is there a clear hypothesis?
  – Are precautions taken against bias?
  – Are the limitations identified?
  – Is the data collected appropriately?
  – Is the method justified?

[Walsh, 2004]

43

What are examiners looking for?

- Presentation of results:

  – Have the hypotheses in fact been tested?
  – Are the results shown to support the hypotheses?
  – Is the data properly analyzed?
  – Are the results presented clearly?
  – Are patterns identified and summarized?

- Discussion and Conclusions:

  – Are the limits of the research identified?
  – Are the main points to emerge identified?
  – Are links made to the literature?
  – Is there theoretical development?
  – Are the speculations well grounded?

[Walsh, 2004]

Above all: Is there enough original work / innovation?
Does the candidate show scientific maturity?
Is there an extensive amount of work?

44

C. Borcea. Career advice for PhD students: How to get the most out of your time in the PhD program. http://web.njit.edu/~borcea/talks/phd-advices.ppt

R . Chandrasekhar (2002). How to write a thesis: A working guide.
http://www.ee.uwa.edu.au/~chandra/Downloads/Thesis/write-xelatex.pdf

J. W. Chinneck (1999). How to Organize your Thesis.
http://www.sce.carleton.ca/faculty/chinneck/thesis.html

T. Wals (2004). How to write a thesis. http://www.cse.unsw.edu.au/~tw/thesis2.ppt

 (Gauntlett (2001) - http://lange.himolde.no/lo-kurs/lo904/Buvik/Assignment-2006.ppt