

PhDs in Computer Science

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Monday 11 December 2017

FAIRS'17

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OVERVIEW

1. What is a PhD?
2. Deciding on a suitable topic
3. Conducting your research
4. Monitoring progress
5. Writing up
6. Are publications important?
7. Trouble shooting
8. Summary and conclusions



WHAT IS A PhD?

- A PhD (Doctor of Philosophy) is a piece of focussed research resulting in a thesis that is examined in the form of a Viva.
- The result should not be a text book!
- The result should not be a diary of events!



What do we mean by focused?

- The work is directed at a particular end goal, i.e. the answer to a research question (hypothesis) in a particular research area (*domain*).
- It is not a collection of unrelated, or poorly related, investigations.



What is research?

- Research is “*original investigation undertaken in order to gain knowledge and understanding*”.¹
- The process of research implies a systematic approach.
- It is not invention!

There is a difference!

1. The QAA “Code of practice for the assurance of academic quality and standards in higher education”

Systematic?

- A systematic approach implies the adoption of some research methodology to arrive at the desired end goal.
- There are many treaties on research methodologies (Dawson).
- Invention, however, is founded on flashes of inspiration not rooted in a systematic research methodology.
- The danger of invention with respect to PhDs is that you may invent something that somebody else has already established, or (even worse) invent something that has long been discredited!

What is thesis?

- A thesis is a series of related arguments, building on top of one another, that seeks to establish a proposition (*research hypothesis, question or statement*) in such a way that the proposition cannot be (easily) refuted.
- The subject of your PhD should not simply be an application (although in many cases this may well be the evaluation medium).
- Generic research statements:
 - X is good for Y (in the context of Z).
 - X can be extended to achieve Y (in the context of Z).
 - The application of X to Y produces an improved result (in the context of Z).
 - The adoption of X facilitates Y (in the context of Z).
 - An X approach to the problem of Y avoids the need for Z.

Example Research Statements (1)

- XML interfaces can enhance the operation of remote microscopy. (X is good for Y)
- The use of variable fan-out index trees, coupled with sequential data mining, offers efficiency benefits for mobile computing. (X and Y is good for Z)
- The representation of functional MRI scans as quad trees supports effective classification of such scans using graph mining techniques. (The use of X for Y is good for Z)
- The use of wrappers facilitates multi-agent data mining in the context of ease of use and overall effectiveness. (X is good for Y in the context of Z)

DECIDING ON A SUITABLE TOPIC?

- There are some obvious (possibly related) general reasons for choosing an area in which you wish to conduct your research:
 - Interest
 - Experience
 - Knowledge
- Identifying a suitable topic within that area is harder.
 - It has to be at the “cutting edge” of research (you can not do something that has already been done).

Where is The Cutting Edge of Research in Your Chosen Field?

- Knowing where “the cutting edge” in your research field is can be difficult.
- It requires in depth knowledge of the domain; knowledge that the new PhD student often does not have.
- In fact the new PhD student often has no idea.
- Supervisors can help (and may be able to suggest a research question).
- It often takes a good year into the programme of work to identify the final research question (so don't worry), but it is a good idea to formulate a working question as soon as you can.

Pushing at The Knowledge Envelope?

- A PhD thesis should contribute/extend our current knowledge and understanding.
- However, this contribution/extension does not necessarily have to be substantial. (although of course every PhD student would like it to be!)



CONDUCTING YOUR RESEARCH

- Research methodology.
- Background reading.
- Software.
- Evaluation and experimentation.
- You and your supervisor.
- Professional development.
- Working hours.



RESEARCH METHODOLOGY

- Research is a slow (sometime infuriatingly slow) step by step process of building on top of what has already gone before. (We do not want to reinvent the wheel!)
- This implies the methodology in our definition of the term “systematic”.
- Once you have a feel for your research question start thinking about how you are going to work towards clarifying your thesis and the methodology to establish it. (What are the criteria for success?)

A Generic Methodology

Work Package	Duration	Deliverables
Back ground reading	6	Literature review
Playing around with ideas and preliminary experiments	6	“Paper and pencil!” exercises, prototype software
Confirmation of thesis (research question)	2	A clear idea of what you are trying to achieve, detailed methodology
Generation of test bed/framework	8	(Usually) well engineered software
Experimentation and evaluation	6	Questionnaire returns, Graphs, tables, etc; a deep insight into what has been achieved
Write up (revisit literature review, carry out any additional work)	8	Final dissertation

Background Reading



- Most PhD programmes of work start with a “literature” or “state of the art” review.
- Objectives of this are:
 - To be aware of existing work (i.e. not to “reinvent the wheel”).
 - Assist in determining your thesis/research question (try to identify deficiencies in current work, open questions, things that have not been addressed)
 - Become aware of other (parallel) work in the field.
 - At the end of the PhD you should be able to consider yourself to be a (world) expert in your field of study: thus you need to know your literature.

Knowing your research domain

- Identify the key forums for publications in your domain; there are lots of specialised journals, conferences and workshops etc.
- References to recognised conferences and journals carry more weight than obscure workshops.
- Identify the key players in your field, who are the big names? (Your supervisor might be one!)
- Identify the major research groups working in your field (you may be in one).
- Know your research community (networking).

Scheme for Background Reading (1)

Text books,
Lectures

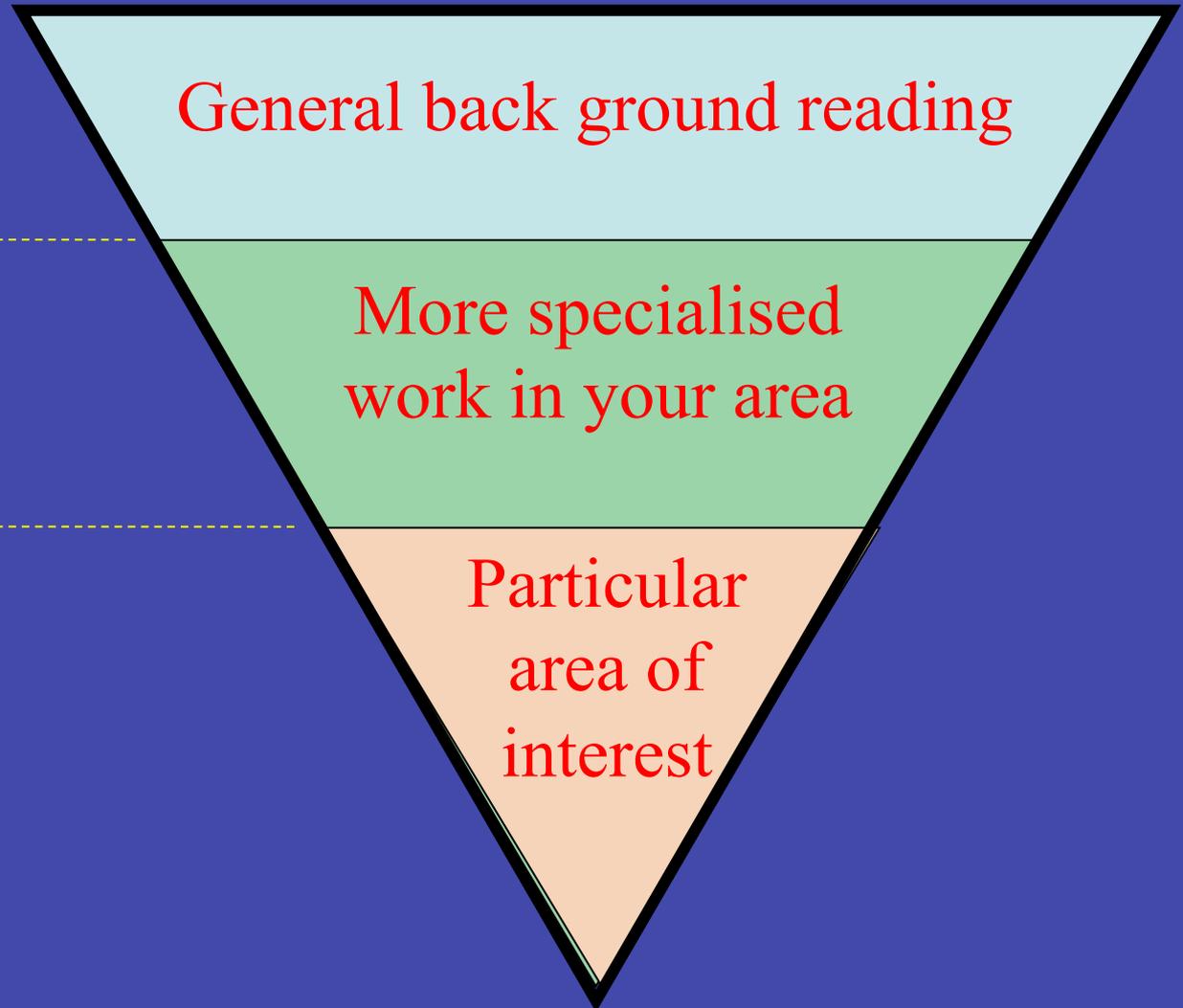
General back ground reading

Review
papers

More specialised
work in your area

Specialised
papers, other
dissertations

Particular
area of
interest

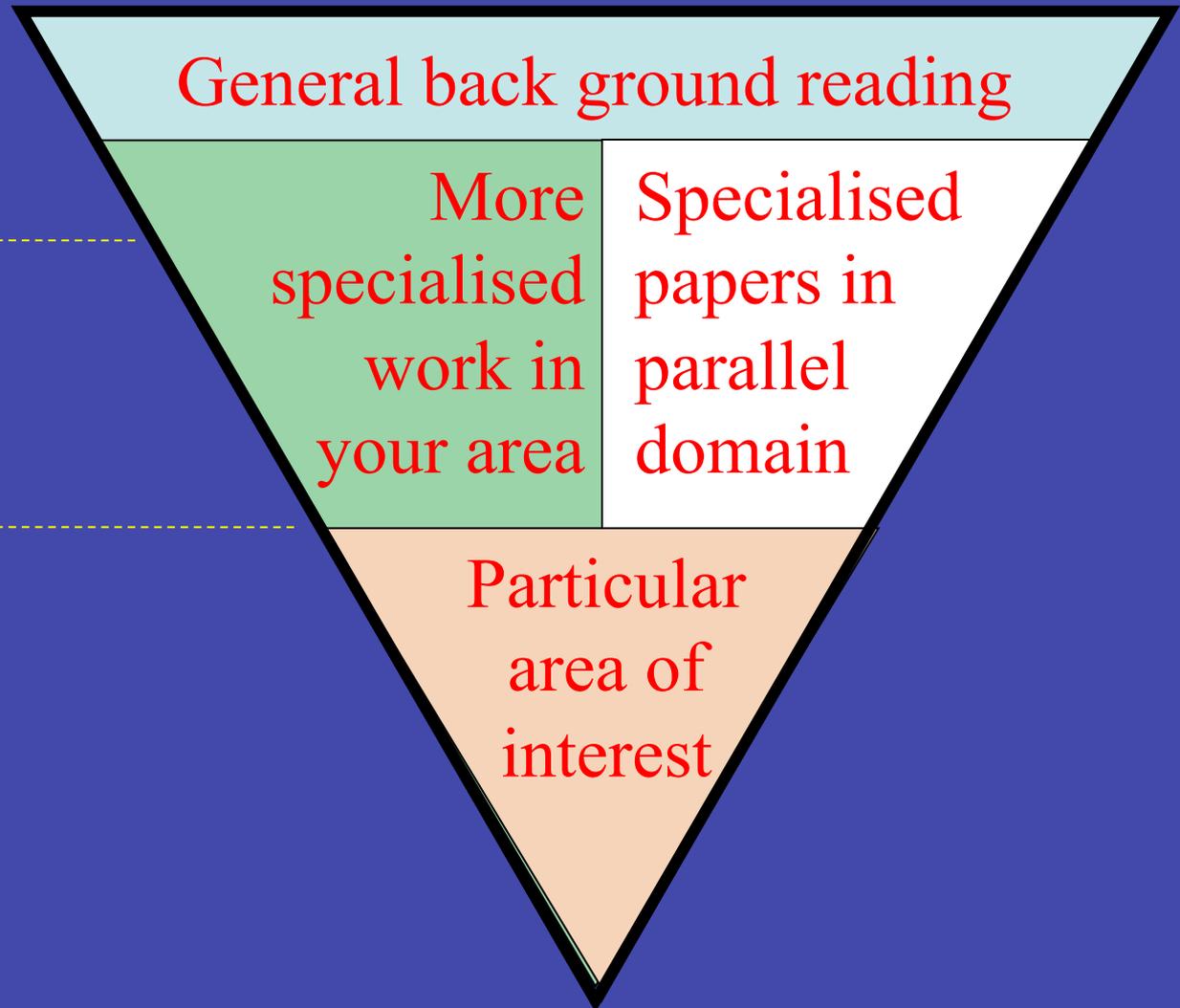


Scheme for Background Reading (2)

Text books,
Lectures

Review
papers

Specialised
papers, other
dissertations



Notes on Reading Papers

- Reading papers in your area of interest can be hard going (especially if English is not your first language).
- Start simply with text books and review papers; take care with WWW sites (e.g. Wikipedia) whose provenance may be questionable.
- Make sure you annotate papers you collect with all the necessary reference material (bibtex).
- Make notes (in computer readable form) as you will need this for your literature survey.
- Mix reading of papers with other work.

Notes on Software

- For many PhD students their research involves producing the largest software system that they have ever built.
- Use sound software engineering techniques (all the stuff you learnt as part of your undergraduate study was not just to get you your first degree).
- Commenting your code is especially important. (Functions that seem obvious at the time of writing may not seem obvious 18 months later.)
- Make sure you test your code appropriately (discovering a logic error late in your PhD may invalidate large parts of your evaluation).

Evaluation is V. Important

- The evaluation of your thesis is the most important part of the process as this is where you establish that your hypothesis is correct!

Do not neglect it!

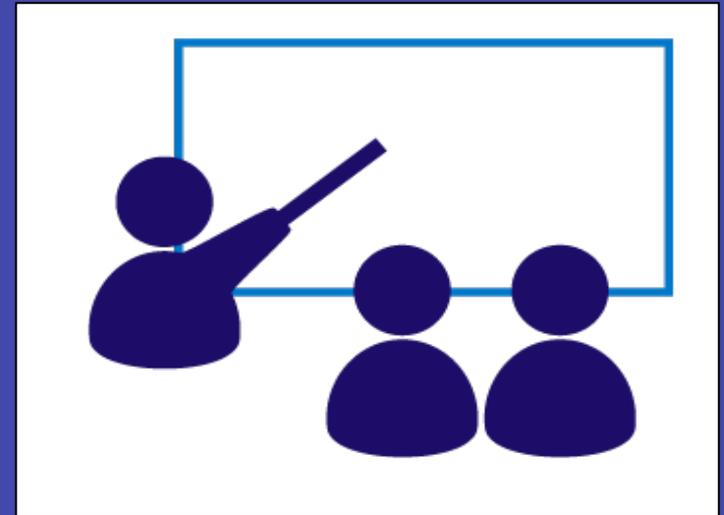


Notes on Experiments

- Some PhDs can involve a considerable amount of evaluation conducted using experiments.
- When conducting experiments make sure you have some structured way of recording the results.
- Make notes on each experiment undertaken in such a way that when you come back to your notes many months (years?) later you can actually understand what the experiment was about! Include:
 - The reason for the experiment.
 - Parameters of the experiment (and why selected).
 - The outcome.
 - The conclusion/interpretation of the results.

Professional Development

- Universities are required to “*provide research students with appropriate opportunities for personal and professional development*”.
- Typically this includes short courses (sometimes only one day) on things like doing presentations, using library facilities, software, creating a CV, etc.



Working hours

- Draw up a sensible schedule.
- Working long into the night on a regular basis is bad for your health (and your social life).
- Try and allow your self some time off.
- Take advantage of the social and recreational opportunities that universities offer.
- If you are from overseas it can get lonely ☹.



Stay Focussed

- There is a danger that, as your research progresses, you get side tracked (usually simply out of interest in some other area of work that you come across).
- Do not allow yourself to get side tracked to the extent that you spend months working on some sub-topic that has little or no direct bearing on your PhD.



You are a Scientist!

- Remember that (whether you like it or not) you are a scientist: a Computer Scientist!
- So behave like a scientist: be objective and enquiring at all times.



You and Your supervisor



- Quoting from [1]:

- *“Institutions will appoint supervisors who have the appropriate skills and subject knowledge to support, encourage and monitor research students effectively.”*

- *“Each research student will have a minimum of one main supervisor. He or she will normally be part of a supervisory team. There must always be one clearly identified point of contact for the student.”*

- The relationship between you and your supervisor is important --- so work at it.

Selecting an External

- Your thesis will be examined by an external examiner appointed by the University.
- It is not up to you to select an external (this is one of your supervisors responsibilities).
- However there is nothing wrong with suggesting people. (Or indicating people you would prefer to not be your PhD external!)
- Remember that most universities insist that external examiners are:
 - 1) Of senior lecturer status or above, and
 - 2) Have some authority in your field.

Monitoring Your Progress

- Universities are required to “*put in place and bring to the attention of students and relevant staff clearly defined mechanisms for monitoring and supporting student progress*”. (It was not always like this.)
- But you should still draw up a schedule for yourself.
- Try and develop a plan (or at least a six month “look ahead”).
- Monitor your progress, set yourself goals and targets (mile stones).
- Keep in regular contact with your supervisor.

Keeping a Record

- It is a good idea to keep some sort of blog/record to record progress, significant results, goals and objectives for the future, etc.
- Some universities insist that you keep a log book (usually electronic).
- Universities are required to “*provide opportunities for research students to maintain a record of personal progress, which includes reference to the development of research and other skills*” (QAA).

Project WWW site (1)

- It is a good idea to maintain a project WWW site.
- This enhances the profile of your work and also your own profile in the international research community (with respect to your particular research area).
- The international impact of your work is a factor in the examination of your PhD.
- Having other people reference your work is an indicator of your international standing (you can help by making it easy for people to find and reference your work).
- Remember that people who come across one of your papers, if interested, will “Google” you to try and find out more about you; so have a “good” WWW page.

Project WWW site (2)

- Your WWW site can include things like:
 - Mini biography.
 - Research interests.
 - Review of your work (including preliminary findings).
 - Links to sites and conferences related to your area of study.
 - Details of conferences you have attended.
 - Links to papers, published and unpublished (refer to unpublished papers as technical reports).
 - Software for people to download.
 - Data sets (provided you are not infringing any copyright or privacy concerns).
 - Anything else you can think of that increases your profile.

WRITING UP



- The principal result of your three/four years of work is your thesis (this is your legacy).
- The thesis (as noted earlier) seeks to establish your research question (statement) and this question should run like a thread through out your write up linking the introduction to the conclusions via the intervening chapters

Generic Format (1)

1. Introduction.
2. Previous work.
3. Details of the work conducted to establish the research question.
4. Details of Experiments and evaluation.
5. Conclusions.
6. Summary.
7. Appendices.

Generic Format (2)

1. Introduction.
2. Previous work.
3. Application domain. (*)
4. Details of the work conducted to establish the research question.
5. Details of Experiments and evaluation.
6. Details of Further Experiments and evaluation. (*)
7. Conclusions.
8. Summary.
9. Appendices.

Some General Notes (1)

- Write in a scientific manner.
- Use what ever techniques are best suited to getting your ideas across. Do not be afraid of using lists, tables, bullet points, diagrams etc. (You are not writing an essay.)
- If including figures and/or tables remember to reference them in the text.
- If including algorithms present them formally accompanied by a textual explanation and if possible a worked “toy” example.

Some General Notes (2)

- Write out acronyms in full before using them.
- Do not overuse acronyms and symbols as the reader will not be able to remember them all (consider including a symbol table).
- There is a limit to the depth of sub-sections that a reader can cope with. Depth of four is probably the limit (Section 1.2.3.4).
- Be consistent: if you start off by writing “multi-agent” (hyphen) do not later start writing “multi agent” (no-hyphen).
- Keep to the point.

Style and Terminology

- I would suggest you avoid writing in first or third person. Instead of “we discovered that” write “It was discovered that” (easier to be objective when writing in this anonymous manner).
- Be careful using words such as: “multitude”, “gigantic”, “massive”, as they are difficult to quantify.
- I would suggest using past tense throughout.

Chapter 1: Introduction (1)

- Introduce thesis and research question and associated research issues (this will require some background work, but leave most of this for the previous work chapter).
- Use the introduction to define the scope of your thesis, what you have and have not looked at and why (you cannot do everything).

Chapter 1: Introduction (2)

- Identify the contribution of your work.
- Include your research methodology (how you set about conducting your research).
- Define the criteria for success, how you will demonstrate (prove) your research statement.
- Tell the reader what the main contributions are.
- Include list of published papers.
- Introduction should read like a self contained paper.

Chapter 2: Previous Work (1)

- Base your previous work chapter on your “state of the art review” conducted earlier in your PhD.
- Make sure you have kept up to date. (Reference your external examiner’s work only if you think it is relevant!)
- Divide the previous work conducted in your field of study into a hierarchy to identify groupings and sub-groupings of work.

Chapter 2: Previous Work (2)

- In individual groupings and sub-groupings consider ordering developments in chronological order.
- The previous work chapter is your opportunity to demonstrate your depth of reading.
- But only include relevant material! There is a temptation to write down everything you know or have read about!
- Throughout maintain a link with your original research objectives (might have to revise them).

Chapter 3: Work Conducted

- In Computer Science PhDs the work conducted to establish your research question often involves the definition of algorithms, pieces of code or substantial software systems.
- Use appropriate specification and design techniques.
- Use formal definitions (academic rigour).



Chapter 4: Evaluation (1)

- As noted earlier the evaluation chapter is the most important chapter in the entire thesis.
- It is where you provide the answer to your research question or demonstrate that your hypothesis is the correct one.
- Evaluation can take a number of forms, but common approaches are:
 1. Mathematical proof
 2. Comparison with alternatives (often those proposed by other researchers)
 3. User feedback in the form of questionnaires
 4. Combinations of the above.

Chapter 4: Evaluation (2)

- Remember that when describing experiments these were conducted in the past, so use past tense.
- The evaluation chapter reports on experiments that were conducted (they are not being currently conducted).

Chapter 5: Conclusions

- Summary (say what you have said).
- Main findings (linked back to the research issues and criteria for success identified in the introduction).
- Suggestions for future work.



Including Code?

- If a substantial software system has been produced it is nice to give the examiner an opportunity to run it (although in most cases they won't).
- Consider placing the code on your WWW site and reference this (see earlier discussion).



Referencing

- Some Universities insist on a specific referencing system (e.g. Harvard).
- If not adopt a system (but remember to be consistent throughout).
- Referencing WWW pages is OK, but take care; most WWW sites are not peer reviewed (unlike journal and conference papers).
- Remember that (as a rough guide) references to recognised conferences and journals carry more weight than obscure workshops.

ARE PUBLICATIONS IMPORTANT?

- If you manage to get some publications describing your work this is good: it means that at least some aspect of your work has been independently refereed and thought to be worthy of publication.
- However publications are not everything.
- Some students get very obsessive about getting publications, sometimes to the detriment of their PhD.



Are Publications Important? (cont)

- The student at the desk next to you will always have more publications than you (accept it).
- In your rush to publish be careful who you publish with (avoid “vanity publishing”).
- If in doubt ask around (“impact factors” are a good guide, also “acceptance rates”).
- Normally you work together on papers with your supervisor (or supervisory team).
- Never put your supervisor’s (or anybody else’s) name on a paper without asking them.

TROUBLE SHOOTING

- There are various things that can go wrong during your PhD.
- Examples:
 1. Funding problems.
 2. Discovering (late on) that somebody else has done the same as you.
 3. Breakdown in Student-Supervisor relationship.
 4. “Brick Walls”.
 5. Departmental problems and issues.
 6. Moments of darkness and despair.

Trouble Shooting: What To Do.

- It is in nobody's interest for you not to get your PhD.
- Tell somebody as soon as possible (“a problem shared ...”).
- This person should normally be your PhD supervisor (unless your supervisor is the problem).

Funding Crises

- Many students have funding problems. If your bursary/grant covers both your PhD funds and all your living expenses then you are lucky.
- There are various funding bodies all with various strings attached: i.e. only for:
 - Particular subjects
 - A specific university,
 - Students from a particular country or geographic location.

Competitors

- If you discover that somebody else has done some similar work to you, but you did not know about it till the writing up stage of your work then:
 1. If it is high profile and
 - The work is very recent then report it as a parallel study (nothing wrong with this).
 - Otherwise (not recent) you should have known about it, reference it and state that you were unaware of it at the time of conducting your work.
 2. If it not high profile, i.e. published at some obscure workshop, ignore it.

Brick Walls

- In (nearly) every PhD a point is arrived at where the student discovers that he/she cannot progress the research any further because it *appears* (for example) that:
 1. It simply cannot be done (this is why nobody else has done it).
 2. Your software skills are not up to the job (and you suspect nobody else's are either).
 3. You are clearly not intelligent enough and should have gone into refuse collection instead (no disrespect to refuse collectors intended).
 4. You have “lost the plot” and no longer know what you are doing.
- i.e. you have hit a “brick wall”.

Brick Walls --- getting round them

- When hitting what seems like an insurmountable problem the first thing to do is to step back and take a break from it for a few days.
- A fresh look after a few days away is always beneficial.
- Try and get round the problem somehow (i.e. go round the side of the “brick wall”).
- Do not be afraid of backtracking, even if you have spent several months pursuing a particular route of enquiry.
- You can include negative results in your thesis (but if it is all negative, i.e. the answer to your research question is “no”, then think about changing your research question).

Supervisor-Student Relationship Breakdown (1)

- It does not often happen, but sometimes the relationship between a student and supervisor breaks down.
- For example because of a personality clash or academic disagreement.
- Who do you turn to?
- Most universities insist on a second supervisor and/or an advisor. There may also be a director of Post Graduate Research (PGR), or ultimately you Head of Department.

Supervisor-Student Relationship Breakdown (2)

- Sometime the student-supervisor relationship breaks down because the supervisor has accepted a post at some other institution and you do not want to (or can not) move to that institution.
- At least in this case the breakdown is not an acrimonious one.
- Your university and department does have a certain responsibility to you, and should make appropriate arrangements.

Departmental Problems

- Sometimes difficulties are encountered with things like: library resources, hardware, out of hours access to buildings, print quotas, etc.
- There should be some formal mechanism for you to raise such concerns (e.g. a Postgraduate Staff Student Liaison Committee).
- Details are normally to be found in a “post graduate student handbook” that it is now customary for universities to provide.

Moments of Darkness and Despair (The Mid-Term Blues)

- Every PhD students has moments (days, weeks, ...) of self doubt: “Why am I doing this?”, “What’s the point?”, “Am I wasting three/four years of my life?”.
- This is a well recognised (almost) medical condition know as the *mid term blues*.
- *Mid term* because it typically strikes in the middle of your second year when you can no longer see the beginning, and the end is no where in sight (often coinciding with the brick wall syndrome).
- Knowing in advance that this is going to happen helps to get over it.

Complaints

- Hopefully things will never get this bad!
- However there is a legal requirement for universities to ensure that: “*independent and formal procedures will exist to resolve effectively complaints from research students about the quality of the institution's learning and support provision*”.
- Also to provide “*formal procedures to deal with any appeals made by research students*”.
- Again details are normally to be found in your PG student handbook.

SUMMARY

1. What is a PhD?
2. Deciding on a suitable topic
3. Conducting your research
4. Monitoring progress
5. Writing up
6. Are publications important?
7. Trouble Shooting
8. Summary and conclusions



CONCLUSIONS

- Doing a PhD is terrific fun.
- It is a once in a life time opportunity to apply your intellect and wit against a significant challenge.
- So relish it.

