

# Structure of Research Study

Justin Zobel

University of Melbourne, Australia

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# Elements of RHD candidature

literature review      *ethics*      conference attendance  
independent research      *development of questions*  
experimental design      examination      progress reports,  
annual reviews      data analysis      *PhD committee*  
coursework      submission      *completion seminar*  
student-supervisor meetings      *mentoring*      poster abstract  
confirmation      data preservation      internship      *examination*  
critical thinking      milestones      *refereeing*      paper writing

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- ▶ independent research!
- ▶ critical thinking!

# Challenges

There is a relative lack of structure to the three (or more) years of work.

Most of the deadlines must be self-imposed.

Many of the activities are novel or unfamiliar.

Some of the activities are intimidating.

Expectations and standards are determined by a research community as much as by the institution – and are learned by doing research, not taught ahead of time.

The division between supervision and collaboration is vague.

PhD study requires independence and self-management.

Identify a goal and research question that match your strengths.

Be organized – careful planning, filing, and backing-up. Keep a notebook. And maybe a blog.

Actively reflect on your behaviour and working practices; be honest with yourself about limitations and bad habits.

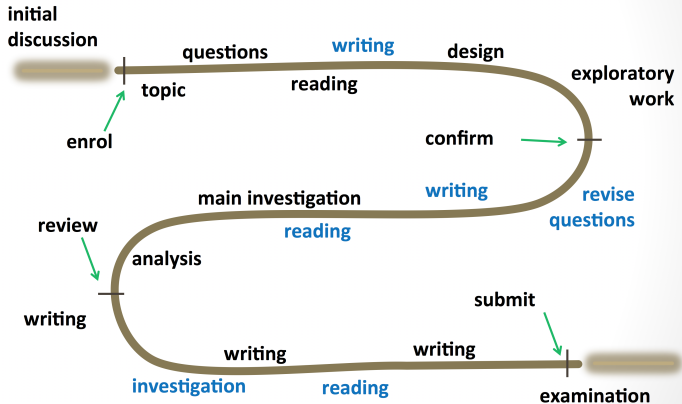
Build an effective routine, with sufficient time commitment right from the start.

Develop a productive, open relationship with your supervisors.

Create a good working environment.

Pursue a healthy, diverse balance of activities.

# The thesis timeline



# Structuring research

Your field of research is a landscape of ideas, concepts, and potential discoveries – or of directions to explore.

There should be interesting long-term goals that give meaning to a program of activities. Research can be defined in terms of working towards a long-term goal on a route that takes in interesting landmarks that are achievements in their own right.

A concrete example: improved response to natural disasters.

- ▶ Rapid-build accommodation
- ▶ Low-cost water cleaning
- ▶ Matching of people with medical needs
- ▶ Connecting people with family, rapid identification of who is missing
- ▶ Building standards, innovative safe zones
- ▶ Messaging and communication
- ▶ Rapid workforce training
- ▶ Computational models of the effect of response plans, sourcing of resources



# Research is about questions

A good question:

- ▶ Solves a genuine problem, with a genuine challenge. (Avoid work on methods where there is no motivating problem or task, or on solutions to non-problems.)
- ▶ Relates to real data, of a realistic volume. Synthetic data allows exploration, but is unlikely to confirm predicted behaviour on real data.
- ▶ Can plausibly be answered in the negative.
- ▶ Can plausibly be answered in the scope of your project.
- ▶ Suggests something useful to measure.
- ▶ Should have a clear answer.
- ▶ Has results of interest even if the gains are small.

What if there a simple solution that solves the problem well enough?  
When the problem is simplified, does the solution change? (Become trivial?)



# Assessing a question

Consider whether:

- ▶ It is a good match to your strengths. (More on this later.)
- ▶ Answering the question involves access to data and if so, whether the necessary data can be obtained or created.
- ▶ The question is of interest to the field and can be clearly linked to existing research literature.
- ▶ The volume and diversity of the research literature is likely to be manageable.
- ▶ The answer to the question is already essentially known.
- ▶ There is a feasible methodology for pursuing an investigation.
- ▶ It genuinely relates to your goal.
- ▶ Other people will care about the outcome.

# Dimensions in research

observation	vs.	innovation
exploratory	vs.	exhaustive
study	vs.	case study
qualitative	vs.	quantitative
simulation	vs.	field trial
primary sources	vs.	secondary sources
theoretical	vs.	applied
mathematical	vs.	empirical
principled	vs.	pragmatic

# What research isn't

'I am planning to build a new ...'

'I am going to find out about ...'

'I am going to show that A is better than B ...'

'I think that Q is a good tool for ...'

'I am going to collect data on ...'

'I have an interesting algorithm ...'

'I want to use method X ...'

# Being a research student

At the beginning: many different starting points; a wide range of strengths, skills, weaknesses, and gaps.

- ▶ In some cases: no more than a few months experience in a tightly defined, tightly controlled project.
- ▶ In other cases: diverse but typically unfocused experience.

During: an active researcher, exploring, interacting, learning, self-directed learning, being an apprentice, having mistakes and failures, succeeding.

At the end: a maturing researcher. Better at knowing what to work on. Better at knowing your own limitations. More diverse in how you approach problems.

Skills of a mature researcher: knowledge; questioning and skeptical; inventiveness; clear thinking, rigorous argument; experimental design; systematic organization of ideas; critical analysis; communication.

# Developing as a researcher

For example, in an experimental research area in computing:

- ▶ Learning basic skills – getting in the habit of keeping notebooks and writing about current activity; becoming familiar with equipment, establishing a productive and tidy working environment.
- ▶ Laying groundwork – creating tools and investigating data under direct supervision, perhaps to replicate previous results, and making use of public data.
- ▶ Taking responsibility – specifying the program as well as writing it, and working with less hands-on supervision.
- ▶ Leading the research – determining an experimental regime to settle a point in question.

In a PhD: there tends to be a cyclic pattern of starting new investigations under increasingly light supervision.

# Developing as a researcher ...

## A rounded researcher:

- ▶ Initiates, designs, evaluates, and reports a complete investigation, with a supervisor in the background in a relatively passive role.
- ▶ Decides whether something is worth pursuing, and whether the investment in time needed to investigate an idea is likely to pay off; or, even whether a program of work is ready to be abandoned (or written up while incomplete).

People's strengths vary; good teams are based on a mix of people with a mix of abilities and experiences.

Persistence, thoroughness, etc. can be as important as intelligence or imagination or 'genius' (whatever that is) – there are many kinds of successful PhD.



# What defines a researcher?

Undertakes research, creates knowledge.

Independent critical thinking, independent action.

Provision of impartial, expert advice.

Knowledge of and honesty about limitations.

Is informed and up-to-date.

Keeps an open mind; learns.

Communicates, mentors, forms the next generation.

# Getting started

Work with your supervisor on a question; make sure it meets your needs, as well as your supervisor's.

*Match the topic to your strengths* – though you may not know what they are yet! A single research area can offer many different kinds of topic. Consider web search:

*Statistical.* Identify properties of web pages that are useful in determining whether they are good answers.

*Mathematical.* Prove that the efficiency of index construction has reached a lower bound in terms of asymptotic cost.

*Analytical.* Quantify bottlenecks in query processing, relate them to machine and network properties.

*Algorithmic.* Develop and demonstrate the benefit of a new index structure.

*Representational.* Develop a formal language for capturing properties of image, video, audio, etc., to be used in search.

*Behavioural.* Quantify the effect of varying the search interface.

*Social.* Link changes in search technology to changes in public opinion on key topics.

# Framing the question

Expect development of a precise statement of the question to take time.

- ▶ An initial version may require a couple of months.
- ▶ It is common to have to revisit the question after some substantial work has been done.
- ▶ Development of a question is a good basis for early supervision meetings
- ▶ Consider alternatives, and their strengths and shortcomings.
- ▶ This may be how you discover whether your supervisor makes sense for you as a (senior) research partner.
- ▶ Work *with*, not *for*, your supervisor – who should be a guide, not a sergeant.

# Writing as research

Use your writing to define your work. Get into the habit of:

- ▶ Having action lists of plans and open tasks.
- ▶ Creating abstracts and summaries of research questions.
- ▶ Noting down uncertainties, issues, guesses, and speculation.
- ▶ Formally describing methods, innovations, hypotheses, and experiments.
- ▶ Listing and summarizing literature.

*Making progress is equivalent to having writing outcomes.*

# What is the purpose of writing?

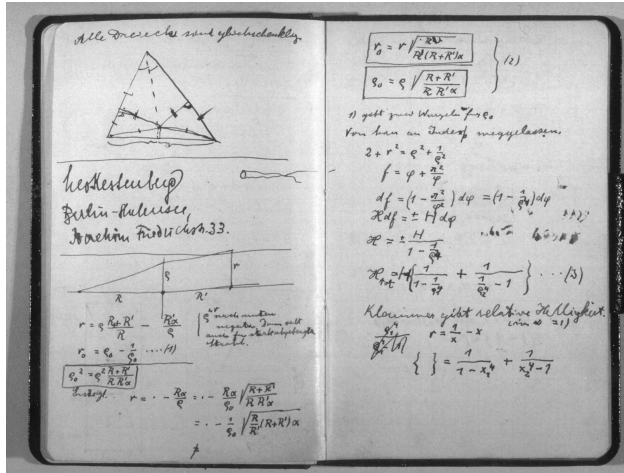
Doing an MPhil or  
PhD

Understanding  
research

Being a research  
student

Phases of research

Success in research



To record, think, analyze, understand.

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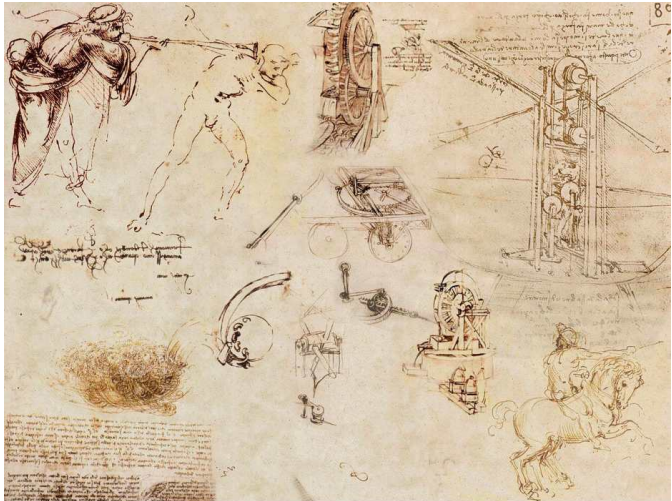
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# Phase One

Regard everything that you learn as potentially useful. Exploration of other academic interests can develop you as well as distract you.

Extend your skills with word-processing and data-analysis software; chat to senior students about approaches to working; e.g., learn programming & scripting languages and computing environments.

Become familiar with standard approaches to experimentation and data-gathering.

Talk to staff that you come in contact with.

Attend seminars – and not just in your narrow area. Good seminars in *any* discipline will be educational.

*Establish a definite question, with a defined scope.*

This may happen quickly, or may take several months.

Work through all relevant checklists of policy, procedures, requirements, etc.

## Phase One ...

Establish a routine, and write down milestones.

- ▶ Meet regularly (weekly!) with your supervisor.
- ▶ Clarify your mutual contributions and responsibilities.
- ▶ Develop a program of milestones and targets:
  - ▶ Detailed early activities that lead up to confirmation.
  - ▶ Broader plans for the remainder of the PhD.
- ▶ Set weekly targets, and monitor your progress. Discuss bottlenecks with your supervisor as soon as they arise.
- ▶ Have action lists of plans and open tasks.
- ▶ Work on a balanced mix of activities: reading, writing, doing.

## Phase One ...

Read (or re-read) the general literature, especially area-specific classics that everyone cites but are not often looked at.

Start reading papers comparatively – form opinions as to which work is more persuasive, and why.

Start to establish your own take on the core ideas.

Expect to complete an initial survey of the literature in the broad area of your research that is a draft of your Chapter 2, and in a MPhil or PhD can also be used in your confirmation application.

## Phase One ...

See if you can reproduce or re-analyse results in a paper that you thought was interesting. Obtain publicly available data from past work, or implement your own tools.

Learn the skills of doing a robust investigation or analysis in a context in which it will be obvious when you get it wrong.

In a PhD, expect to have generated a draft paper describing one of your investigations or proposals, that with a bit of polish might be submitted to a local conference.

*A critical success factor is the habit of regular writing.*

## Phase Two

Get this phase right, and everything else falls into place.

But get it wrong – and many students try to – and it can be miserable. It is easy to be plagued by doubts and despair when you are both a long way from the start and a long way from the finish.

It is also easy to succumb to personal distractions, or financial inducements, or the pressure (flattery?) of requests such as ‘We desperately need a head tutor for Enlightenment 101’.

It may be that your supervisor begins to leave you alone to a greater extent. This is one of several respects in which having an active advisory committee can help – talking to staff other than your supervisors can help keep things in perspective.

## Phase Two ...

By the start of the second phase, you should be tackling something substantial, and you should know what it is.

(Not everyone does. Some people are still in the midst of preliminary investigations.)

- ▶ It might be a significant experimental investigation implementation, or the details of a complex mathematical or algorithmic argument, or a rich synthesis of diverse existing results.
- ▶ It should be something that, when completed, will form the core 'theme' of your thesis.



## Phase Two ...

In a PhD,

- ▶ You should have a paper submitted and accepted based upon the work in the first year, and probably have a second paper in the pipeline.
- ▶ You should be taking the initiative in some areas, and trying to anticipate what the supervisor would tell you to do – ‘Hmmm, if I went and asked for advice or feedback, what would I get told to do next?’ ...
- ▶ If you are stuck for new ideas, try writing a Chapter 3 draft that explains the core contribution of your work.

By the end of the second phase, you should have published a couple of papers, have another paper in draft, and have written a draft of your Chapters 2 and 3 and of other blocks of text that will eventually be part of your thesis.

In an MPhil or PhD, you should have taken a proper holiday break of some kind. *Burn-out is real. Exercise daily.*

# Be persistent

Take the time to do things well.

Failure and dead-ends are a routine part of research – what matters is how they are used in the research program overall.

Actively seek out alternative resources, tools, approaches, thinking, etc. When something isn't working – neither give up too soon, or persist for too long.

All focused activity in the broad topic of your thesis is potentially useful; 'make-work' tasks may not be on the linear path to your goal, but can nonetheless be critical to the research.

If in doubt – be skeptical, ask questions.

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## Phase Three

This phase requires absolute commitment and focus.

Say 'no' to tutoring and casual lecturing requests, even if it means you have to live on instant noodles. Expect to give up (hopefully temporarily) your outside interests and social life.

List the tasks that have to be done, and allocate a one-week time slot to each – if they require more time, break them down. Pick a submission date and set a realistic timetable.

Give your timetable to your supervisor, and pin a copy on the wall near your desk.

*Software, data, and tools are secondary to the thesis.*

If you are creating software, don't get distracted by making it all-singing all-dancing, putting it on sourceforge, etc. It just has to get you the data you need to complete the tables and figures that demonstrate the validity of your conclusions.

## Phase Three ...

Your work needs to be the last thing you think about at night while you are falling asleep, and the first thing you think about in the morning when you wake up.

In a PhD: The second half of the final year will be entirely spent on thesis preparation. Or longer.

You need to get into a rhythm of writing, and it differs from person to person. Find your own rhythm, and defend it against intrusion.

Set daily targets, and monitor your progress. Discuss bottlenecks with your supervisor as soon as they arise. Don't tolerate anything that delays you.

Make designing graphs and figures a 'reward' for writing two pages of text. Keep the bibliography up to date at all times.

# Surviving a large-scale research project

Pace yourself through the stages.

Don't be too ambitious at the start, or too passive at the end.

Study as you expect to live in the longer term: work, rest, recreation. (A minor thesis is entirely different!)

Expect to learn skills as you go. Anticipate; do courses.

Plan out timelines.

Seek guidance from others; expect to offer it to others as you mature as a researcher.

Develop as an educator – deliver labs, tutorials, lectures; present seminars whenever you can.

Build networks with researchers in your area elsewhere, including overseas.

In a PhD: if you can, visit other institutions with strength in your area.



# What defines a successful research student?

A willingness to explore the broad topic, to read widely, to try things out, and to generally take part in the academic community.

The enthusiasm to build an interest in some area, and then ask for advice on how that interest can be turned into a thesis project.

The ability to undertake an intensely detailed investigation of some facet of a larger topic, something that is novel, and that, if executed properly, can form the centerpiece of your thesis.

The ability to survive or surmount some significant failed or unsuccessful activity. (In a PhD, loss of months of work is not unusual.)

Taking the initiative in terms of what needs to be done, and how to present it. Gradually assuming responsibility for all aspects of the research, from conception to write-up.

A desire for discipline, stringency, quality, and standards.

## Success factors

A good supervisor, or supervision team; a good relationship between student and supervisor.

A good research question that matches your strengths.

Products that look plausible – the outcome of work done to a high standard.

Organization – careful filing, naming, archiving, and backing-up.

Actively reflecting on habits and working practices, and seeking to improve them; being honest with yourself about limitations.

A healthy, diverse balance of activities.

Other work (within limits!), especially teaching.

Treating the lab and office as a workplace, and engaging with colleagues appropriately.

Asking a lot of questions, reading widely.

Recognising and managing anxiety and other mental health issues.

## Failure factors

Refusal to start writing, procrastination; inappropriate prioritisation of other tasks.

Obsessive engagement with irrelevant activities (computer games, socialising, work).

Failure to recognise that writing is a struggle and *takes a long time*.

Refusal to abandon failed lines of investigation.

Frequent changes of direction and lack of persistence.

Concealment from supervisors: of progress issues, lab issues, health issues, life issues.

Inadequate reading of or search for literature.

Failure to address issues such as problems in the supervision relationship.

Failure to finish work properly, stopping when the 'fun stuff' is done, not writing up regularly.

# What supervisors (should) usually provide

Guidance, suggestions on research direction.

Timely, detailed feedback on writing (English expression, technical arguments, critical analysis).

A broad perspective on the topic.

Motivation, encouragement, discipline, and rigour.

Introductions to relevant experts.

Collaboration and participation, and commitment. Collegiality. Availability.

Assistance with and collaboration in paper writing.

Familiarity with University procedures.

Credit for work done by the student

Pastoral care and advice, within limits.

# What supervisors usually expect

Student commitment and dedication.

Enthusiasm, ownership.

Self-management, independence, responsible working habits.

Writing, staying ahead of the curve.

Honesty and openness, frank communication.

Keeping of and preparation for appointments.

Recognition of and credit for the supervisors' contributions.

Maintenance of contact with the supervision team and (often) with the chair of the supervision panel.

# Some good questions

## Ask me ...

- ▶ What is the single most important piece of advice to give a student?
- ▶ What if the student is not a confident writer?
- ▶ When should a student switch from doing research to writing up?
- ▶ How do you know when a student is not on track to timely completion?
- ▶ Should a thesis include publications?
- ▶ What makes a great thesis?
- ▶ What should a student seek in a supervisor?
- ▶ When should a student start writing?
- ▶ What indicates that a student is ready to submit?

*Acknowledgement: these slides include material developed by Alistair Moffat.*