

## PhD Research : Three Keys to Success

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**Abstract – starting a PhD can be daunting. There is the long time-scale and lack of deadlines. There is the uncertainty about what is really required to achieve a “significant contribution to knowledge”. This brief gives three useful keys to successfully completing a PhD.**

### I. INTRODUCTION

How one does PhD research is very dependent on the research field, the specific topic and the personalities of the supervisor and the student. The discussion in this document is based on my own experience. As every field has its differences it is recommended that you discuss your research approach with your supervisor and other PhD students in your research group or school/department.

Note: though this document is formatted like a technical paper, the style of writing used in it is informal and not always appropriate to a technical paper.

### II. WRITING

*You should start writing on day one of your PhD and continue every day after that.*

You are awarded a PhD on the basis of your thesis alone. Thus writing is a key skill. Some people are born knowing how to write well however anyone can develop good writing skills with sufficient practice and feedback.

It is useful to write conference and journal papers during the course of your PhD as they provide clear short-term deadlines, produce and define research contributions, and improve your writing skills.

A common mistake is to rely on the philosophy to “leave the writing up till I have done all the work”.

#### A. Starting Writing From Day One

The best approach is to start writing early and do it continually [1]. My recommendation is to start writing about your research on day one and set aside some time (even 30 minutes) to do some writing on every day after. Most engineering theses are roughly 150 to 250 pages long. For instance if you write a page a day, that is 200 pages a year, or 600 pages after three years which leaves a factor of two to four margin to account for continual revisions.

But how does one start writing from day one? How about listing possible research areas and writing down what you know about them.

#### B. Writing as a Log-Book

Writing down ideas clarifies them and allows you to spot errors. For instance, assume you have just spent a productive morning collecting data in the laboratory. Use your writing time to write up the experiment as a brief report. Summarize the aims. Draw a block diagram of the test arrangement. Describe the experimental procedure. Plot out the data and compare with the predictions from analytical equations. Add some discussion of your results highlighting key points.

This process is useful to get your ideas neatly organized, making it easier to spot mistakes in the reasoning or the test procedure. It also makes it easy to share your work with your supervisor and colleagues to get feedback from them. These short reports can be incorporated into future papers or your thesis.

#### C. Good Figures are Important

During the process of writing, spend time producing good quality figures (e.g. block diagrams, flowcharts etc.), tables and graphs which highlight your main points. Good figures are the foundations on which excellent theses are built. Remember that when you are writing up a thesis at the end of a PhD, it is much easier to write new text rapidly than to generate high-quality figures.

### III. RESEARCH APPROACH

*With curiosity and a love of learning and discovery, research can turn from hard work to enjoyment.*

#### A. First the Fundamentals

Start from the basics and build up. It is a good engineering principle to start with the simplest possible model of the system which can be used for the purposes you need. Once you have characterised and understood the capabilities of this model, you can then gradually add enhancements/refinements to the model, step by step. At each step you can develop an understanding about how significant each refinement is.

A normalization approach can be useful to produce general results to explore the effects of input parameters on a given output. For more details including several case studies, see [2].

A good researcher has curiosity. Be determined to learn as much as you can from every situation. As you continue in your research you should seek to develop a clear understanding in your mind of how everything fits together.

Research is about gaining understanding. It is about trying to develop theories and analytical methods for designing and predicting phenomena.

#### B. Writing, Analysis and Experiment

You need to balance your time between writing, analysis, simulation and experimental work. Analysis is using fundamental equations to determine analytical relations. Simulation uses numerical tools to predict results.

I recommend doing all four from day one. Research is a balance between these aspects. Focussing on one to the exclusion of the others for long periods can cause problems.

Analysis and experimental work go hand in hand. It is good to start with some simple analysis (analytical or numerical) to develop physical understanding of the problem and the key variables. If experimental work is possible in your research field it is also useful to run some simple experiments.

At the start of your research you may want to identify what theory, software and equipment you will require during your PhD and to dedicate time to learn these well.

#### C. Literature Reviews

Given any particular topic, with a good search engine it is generally not difficult to find dozens of reference papers bearing varying degrees of relation to it. How does one cope with this?

A good first step in doing a literature review is to select and use criteria to classify or group the prior work. Thus initially one will be scanning the papers quickly with the aim to identify suitable criteria. These criteria are also selected to help differentiate what you plan to do versus what has been done by others. The resultant classification can sometimes be usefully displayed as a figure or table.

The second step is then to review carefully the papers which are most closely related to your proposed research topic and be able to explain their contributions and hence why your concept is original.

#### IV. MANAGEMENT AND ORGANIZATION

*Completing a PhD is made easier if you are able to efficiently manage and organize yourself.*

##### A. Managing Yourself

Be organized. Identify or develop an efficient system to categorise and file both your computer and paper files in a logical fashion. Make sure your computer files are backed up. Find the best method which works for you in keeping a record of tasks to be done and deadlines to be met.

Plan ahead. Three years may seem a long time at the start, but your seniors will tell you it goes by awfully quickly! Think about where you are going in your research and what you want to achieve and then set medium-term goals (e.g. finish conference paper in two months time) and short-term goals (e.g. this week I want to complete the simulations of the first test case).

Be flexible in your research. Research is hard to plan. During the course of your PhD, your research direction may change substantially.

Be pro-active. Try to solve things yourself (you learn much more that way) but also seek help from others if you find things are not working out and you are wasting time.

Be patient. When you first start your research, there is a lot to learn. Other senior PhD students may seem like they know everything. However relax and be patient, it won't take long before you learn the ropes and start helping new PhD students!

Stick with it. Doing research has its ups and downs. Some days everything will work great, while other days you may wonder why you ever chose to do research in the first place. Perseverance is an important research characteristic!

##### B. Managing Your Supervisors

You should have regular meetings with your supervisor(s). Generally this should be roughly at one to two week intervals at the start of your research and can extend to longer intervals at the end when you are working more independently.

Prepare for meetings. Preferably send any documents for the meeting at some agreed time before the meeting. If there is lots of data/results provide a summary which gives a discussion of the results, lists the key achievements and clearly indicates areas which you need help in. As a supervisor it is not very helpful receiving a document which contains pages and pages of simulation results with no discussion or comments!

At the end of the meeting set a date for the next meeting after some appropriate time interval or else corresponding to when you expect to have more results to discuss.

After meetings it is suggested you email your supervisor(s) summarising the agreed actions from the meeting. This should include both actions which you need to take and which your supervisor(s) agreed to take. They can then correct you if there is a misunderstanding. This action list can also be reviewed at the next meeting.

Try your best to meet deadlines but if you run into difficulties don't panic. Contact your supervisor early to discuss the situation when you recognize there may be a problem. Suggest to them some ideas for possible solutions.

##### C. Helping Others and Avoiding Distractions

Develop friendships with your fellow research students. Be willing to make time available to help others. When someone is having a problem with their research they really appreciate a listening ear. It is not uncommon when someone is explaining a problem to you that they realise what the solution is, without you even having to say a word. In addition you can offer ideas which they may not have considered. You may also find you learn new things which may be applicable to your own research.

Be aware however, not to end up in a situation where you so much enjoy helping others that you do it excessively and never seem to have any time to work on your own research!

When doing PhD research it is easy to get distracted. Sometimes you may even unconsciously distract yourself when you are in the midst of a task which you prefer not to. It is thus important to stay focussed, to set plans and to try meet them. For instance "I am going to spend two hours after lunch writing up my analysis results."

##### D. Handling Disappointments

When working with other people you are going to get hurt sooner or later. Life is not always fair and you will be in situations where you may have a legitimate reason for feeling that you have been taken advantage of or treated unfairly. It is appropriate to stand up for your rights, however sometimes you need to let it go, put it behind you, and keep moving forward. Try your best to keep a positive attitude, people who constantly complain about unfairness in their life may soon find that others avoid them.

##### E. Enjoy The Trip

Doing a PhD is a long journey towards a distant destination. Don't forget to enjoy the trip with your fellow travellers. Take time off to relax. Develop close friendships. Join a sporting, social or spiritual organization.

Make the most of your time as a research student!

#### V. REFERENCES

- [1] R.M. Felder and R. Brent, Tomorrow's Professor Msg.#900, "How to Write Anything", <http://cgi.stanford.edu/~dept-ctl/cgi-bin/tomprof/posting.php?ID=900&search=writing>, accessed Jul. 2010.
- [2] W.L. Soong, "Parametric Analysis in Power Engineering," PEBN #11, Nov. 08. See <http://www.eleceng.adelaide.edu.au/research/power/pebn/>

#### A WORD FOR TODAY

*There is a time for everything, and a season for every activity under heaven: a time to be born and a time to die, a time to plant and a time to uproot ... a time to search and a time to give up, a time to keep and a time to throw away, a time to tear and a time to mend, a time to be silent and a time to speak, a time to love and a time to hate, a time for war and a time for peace.*  
Ecclesiastes 3:1-2,6-8 (NIV)