# A guide to getting the most out of your time as a research student

This guide consists of Chapter 3 of a dissertation entitled,
"The educational value of research as a teaching medium for chemistry"
submitted for the Diploma in Learning and Teaching in Higher Education by

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Oct 2005 – Sept 2006

"That's the trouble with science: you've got a bunch of empiricists trying to describe things of unimaginable wonder." Calvin and Hobbs

**Dedication**

This dissertation is dedicated to the nine years of undergraduate students who have been taught by me both at Oxford and Cambridge: I suspect I have learned more from the experience than they.

**Declaration**

This work is my own except where I have attributed it to others who are acknowledged with due references.

**Acknowledgements**

Thanks to all those people who allowed me to interview them, they have provided the critical experimental evidence without which this would not have been possible.

My thanks to three supervisors who have not fought my desire to teach, even when it seemed to them that it detracted from the work they were paying me to do.

**Personal context**

During ten years of research, I have played the role of mentor to many undergraduate and graduate students. Typically the student's supervisor will set a project title and general direction; meeting the student from time-to-time to check progress. My role has varied, ranging from occasional help with experimental set-up to almost total directional control over the whole project. This year I have taken on a supervisory role and the next few years will see my first cohort of DPhil students begin their studies. I decided to take this opportunity to reflect on my experiences of mentoring and on my observations of supervisory practice. I have seen a number of post-graduate students complete research projects having gained little from the experience and having not enjoyed doing them. By considering my own experience, adding to it the educational literature and candid discussions with students I hoped to prepare myself for research supervision. To this end the final chapter in this dissertation will take the form of a guide which I hope will: make the purpose of research projects explicit to students, and remind myself of the educational value of research.

**Rationale for this guide for research students**

Many of the aims of interested parties would flow more smoothly if the important aspects of research projects were explicitly stated in a user-friendly document which provided some guidance for negotiating the hurdles and getting the most out of the limited time available.

## Chapter 3: A guide to getting the most out of your time as a research student.

In this chapter I shall bring together the reviewed literature and the evidence of my interviews to produce a guide to making the transition from taught undergraduate to DPhil. In Chapter 1 I showed that a student's conceptions of learning and research were both important. I also showed that students often had an unsatisfactory understanding of both learning and research, and that much good might be done by bringing students face-to-face with the conceptions held by practising scientists. In this guide, I try to set out the reality of research and the aims of Part II and DPhil in a practical and helpful way that should be accessible to a student about to start either course.

Although this guide is meant to be read by students, I hope it might trigger some reflection in supervisors since they will need to support the students in acting upon my thoughts.

**Part A - The Part II year in chemistry.**

During my study of student experiences of research, I interviewed three Part Is who were trying to choose a Part II supervisor. During the interviews we discussed what the point of Part II was. Some of their responses are given in the table below:

| **Student H** |
|---|
| *MC: What do you think part II is about? What do you think it's for?*<br>*E: To give you experience in the lab and in a real research environment. I'm personally going to use it to see if I want to do a DPhil. […] So it will give me a chance to experience what that might be like before I actually get to that stage. And to see whether I'd want to do research as a career. […] we haven't really seen what real chemistry's like.* |
| **Student I** |
| *MC: Let's start by asking you what Part II is? What's it about?*<br>*F: I think that Part II is where you get to do research for a year. Having done all the theoretical and learning side of chemistry, […] Then you can choose someone, somewhere, something that you want to do for a year that's more in depth, not so broad. I don't know. So […] how to do the actual research and experiments and things and procedures in the lab and stuff. And then also how to write.*<br><br>*MC: So what are you hoping to get out of it?*<br>*F: I'm hoping to enjoy it. And have the experience of working in a research group so that I can then go into a work place or even go on to a PhD having known what it's like to have done that for a year.* |
| **Student J** |
| *MC: What I wanted to start with, was what you thought part II was about?*<br>*G: For me it's an opportunity to see whether I want … whether chemistry is something I want to do forwards, when I leave university. It's … to me it seems a lot more real than going to the teaching labs and following a set of instructions and you know where everything has been done a hundred times before. So I guess it's about an experience of … yeh um a bit closer to the real world, but also still structured enough that there's going to be people around to help you out. And to keep you on track so that you're going to get something out of it at the end.*<br><br>*G: Because chemistry's a practical subject I think. And obviously you have to have a basis of knowledge and you have to have done all your academic study and things. But, it is a practical subject so I think you need to sort of understand not only the background and the academic stuff, but how things actually work in the lab in practice.* |

They all see Part II as a chance to get to know what research is like and they all see Part II as being different from Part I. Phrases like 'real world' and 'in practice' are key to describing the difference and are key to understanding what Part II is for. I've have had quite a bit of contact with Part IIs and much stress is caused by people believing that they need to make an original contribution to research during their Part II year. This is not true – it would be nice, but it's not essential. Some quite serious educational research has been published on making the transition from taught courses to the professional world and it broadly agrees with the three students comments[1, 2, 3]. The main educational purpose in Part II is to change your perceptions of chemistry by requiring you to use the tools we taught you in Part I to solve real research problems. The best way to do this is by immersing yourself in a research group and learning to see problems the way they do.

*Understand why the group wants you to do your project*

The chemistry supervisors in Part II almost always set projects that they hope will yield publishable results of importance to their group's work. You should make sure you understand why they've asked you to do what you're doing and how it fits with the rest of the group. You'll enjoy doing what you're doing much more if you understand the importance of it.

*Understand the black box.*

In many projects you will have to prepare a substrate or compound and apply a test to it. There will be a reason for this and if you don't understand what the test does, how it does it and what the physical basis is for the experiment you cannot hope to understand why you're using this test and where it might be useful in the future. You are likely to get bored just pushing buttons and recording numbers. Part of the process of understanding how professional chemists see the world is understanding the relationship between the observations your group makes and the decisions they then make. Ask and keep asking. This applies as much to column chromatography and DEPT NMR as to atomic force microscopy and protein mutagenesis.

*Understanding options and decisions.*

Related to black boxes are experimental decisions. Try not to ask what you do next without first trying to think through your Part I course to see if there are any techniques you might be able to apply. It's so much more fun to supervise someone who makes a suggestion as they ask the question. If your suggestion turns out not to be right or you can't think of one, don't worry, but do make sure you understand why the suggested next step is the best thing to do. For example, if you are trying to get a product out of a reaction mixture, why did your post-doc suggest column chromatography rather than distillation, crystallisation, acid-base extraction etc? It is quite possible that they have fallen themselves into the habit of doing things one way. There might be an easier way. The same applies to literature procedures. Why did they do it that way? Is there a better way? Does their method really apply to your problem? Trying to ask awkward questions like this usually makes half-decent mentors more interested in supervising you. If it annoys them you might need to ask for (or find yourself) another mentor.

*The course as a whole*

As you might have gathered asking questions features a lot. You are trying to change the way you look at the world and make sense of it. This means getting inside other people's heads and finding out how they see the world and you can only do this by talking to them and asking questions that will probably seem pretty basic to them. My last thought is therefore choose your supervisor and group with care. It may be more important that you feel completely comfortable bugging your mentor and supervisor with questions than that you think you might be interested in the work. Most of the groups here do quite cool stuff really and you'll see that once you understand why they are doing it. Once you've narrowed it down to Physical, Organic or Inorganic I wouldn't worry about the choice of project area too much.

## Part B – Doing a DPhil.

The University, the RSC and the funding councils all agree that your most important task over the three or more years of your PhD is to make a substantial and original contribution to your field. I believe that the most important word in the previous sentence is '*your*'. It should be your responsibility to make the contribution.[4] It is perfectly possible to get a DPhil by simply performing the work set out for you, but you will gain far more from the process if the contribution is yours. You will also be quite a lot more employable. Many employers value holders of scientific doctorates. This ranges from academia and the chemical industry, where a PhD can often be a ticket onto the fast track; to management consultancies and banking firms. Why do these employers value rather technical and specialist qualifications? I believe part of the story is that they perceive that you will be literate and numerate in a way that few other people are; however, I also believe that there is a bit more to it than that. To hold a doctor's degree should mean that you have shown yourself to be capable of independent work that is the equal of that being done by other independent workers. The most concise description of what being a doctor means in practice was given by Philips and Pugh[5], in a book that I recommend reading:

> "*First, at the most basic level it means that you have to have something to say that your peers want to listen to.*
> *Second, in order to do this you must have a command of what is happening in your subject area so you can evaluate the worth of what others are doing.*
> *Third, you must have the astuteness to discover where you can make a useful contribution.*
> *Fourth, you must have a mastery of appropriate techniques that are currently used, and be aware of their limitations.*
> *Fifth, you must be able to communicate your results effectively in the professional arena.*
> *Sixth, all this must be carried out in an international context; […] You must be aware of what is being […] by your academic community across the world.*"

In other words employers value the fact that you have been trained as an entrepreneur in your field. If you can do this in chemistry maybe you can do this for their business too.

The most important thing to remember is that you are not required to develop all these attributes by yourself and you shouldn't try. After all, not only are we supposed to be "standing on the shoulders of giants"[6], but gaining team work skills at the same time. So ask people. A large majority of students that I have supervised or mentored will go to almost any lengths to avoid talking to people, especially those outside the immediate group, but in my experience most people are usually sufficiently chuffed at being thought the local expert, that they are usually only too happy to give you a bit of time. Result: twenty highly informative minutes that would have taken you hours of personal research in the library.

If we take the first of Philips and Pugh's criteria as the goal, namely being able to say something that your peers want to listen to, how do you get there?

*Having a command of what's happening.*

You can only make an original contribution if you know what has been done. This can be easier said than done. The volume of chemical literature is enormous and you will not have time even to read the graphical abstracts of all the chemical journals, let alone the papers themselves. So, you must find out what journals people in your field read. You need to know what papers you are likely to want to read and in how much depth. You will need to read the papers immediately pertinent to your project in some depth, but you also need to get hold of the general literature – the DPhil examiner can in theory ask anything about the general field of for example organic chemistry.

A colleague of mine at Cambridge told me how his supervisor (a very eminent chemist) had introduced them to the current literature in a controlled way. He was told, in the beginning, to read only the title of the papers (or maybe the first few lines of the abstract), the author names and the institution. The idea was that after six months he should have an idea of who is doing what where and also what he was interested in. Only then was he to start reading the articles that particularly interested him in more depth and start following-up the references. The idea was to develop his interests and expertise without it feeling like an impossible slog.

You will need to be an expert in the literature related to your project. Your supervisor will give you a starting point, but you could consider trying to write a journal style review of the topic. You'll need to update it from time to time, but you'll need something like this for your thesis anyway. If you're lucky, your field will not have a recent piece of work like this and you might be able to publish it. The key point is that you are not trying to list every piece of work in the field, but to bring it all together in a coherent story and help you understand how all the work relates to each other and to your project. This process of review is formally used by some universities at early stages in graduate training[7].

*Understanding where you can make a contribution.*

Once you are getting in touch with the literature your expanding knowledge should start to trigger ideas for research, especially in your project area. Your supervisor is likely to be delighted by you coming up with your own ideas, even if he/she doesn't feel they will work. By testing your ideas out on your supervisor you will start to get an idea of how the standard of your ideas compares to the standard of other people's ideas. Once the ideas are coming, think some of the more interesting ones out by thinking through how you'd actually set about doing them in the lab. Towards the end of the first year you should be aiming to be able to convince your supervisor to let you run with some of your ideas. Ideally by the end of the second year you should be able to write a proposal for an undergraduate project and get your supervisor to accept it in principle. At Stanford University final year PhD students are required to present a PhD proposal to three faculty members. The proposal has to be of a high enough standard that it could be submitted to the NIH – one of the bodies like our EPSRC that funds PhDs. The students are not allowed to submit their own thesis until they pass this hurdle.

*Communicating*

Communicating your results and describing what you have done are different. When you present work, even to your own research group you should aim to make the talk a coherent and persuasive story that leaves the audience in no doubt as to what you've contributed to the field. Group meetings can be very informal affairs and probably don't warrant you spending all week preparing the talk, but even if the visual aids are handwritten transparencies you need to try and develop the skill of describing your contribution rather than listing your experiments. Talks to the group should be taken seriously, since you probably won't ever have this sort of opportunity to practice in front of such a sympathetic audience ever again.

Even if you hate doing it, take every opportunity to talk in public. Go to conferences and research seminars. Watch how other people talk and get yourself entered to present your work. Writing your thesis is a form of communication and story telling will be much easier if you have done it before.

*The relationship with your supervisor.*

Many people have commented that the relationship between you and your supervisor is critical. When such relationships break down the pattern of your development will suffer and the research may also be derailed. Although it is not common in chemistry, the EPSC suggests that you keep a written record of supervisory meetings[4]. However you proceed you should not allow the relationship with your supervisor to degenerate. It may take courage and hard work sometimes, but you need to talk to them before it becomes a problem. Quite a few people, myself included, have had periods when they are actively trying to avoid contact with a supervisor or post-doc employer. The result is usually disastrous. The following is an attempt to give some guidance on what you can expect from each other.

There is no getting round the fact that working in a science research lab is much like holding down a job. If this is true your supervisor expects things of you. The following is based in part on Philips and Pugh, Chapter 8[5], and in part on the university's guidelines[4]. Your supervisor will expect you:

- to be reasonably independent,
- to produce written work that is not just a first draft,
- to meet with them regularly,
- to prepare for meetings so that work done and ideas had can be presented coherently and in a way that's easy to absorb in a short time,
- to work according to an agreed timetable and to keep accurate records,
- to be honest when reporting progress and results,
- to follow advice when it was given at your request,
- to raise difficulties promptly,
- to be excited by your work,
- to surprise them,
- to be fun to work with.

If you have duties towards your supervisor then your supervisor has duties to you. Again Philips and Pugh[5] form the basis of this list. You can expect:

- to receive a reasonable level of supervision,
- to have your work considered in well in advance of any meeting,
- to have constructive feedback on your written, oral and lab work,
- to have access to your supervisor when needed,
- your supervisor to be open, friendly and supportive,
- your supervisor to have a good knowledge of the area,
- meetings in which it is easy to exchange ideas,
- your supervisor to be interested and involved in your ultimate success.

Research has suggested that these expectations are common to many students in a wide range of disciplines.[4, 8, 9]

*The whole course*

The key thing about becoming a DPhil is the ability to independently perceive opportunity, gather resources, give your ideas life and communicate your contributions. This will take a lot of energy on your part and all of the three years you have been given. If you are to develop fully you will need to carve out some time to do more than the experiments. Manage the flow of results so that you always have something new to tell your supervisor. This may mean holding some tit-bit back from last week. The benefit of this is that it helps your supervisor feel that you are making steady progress, which will take some of the pressure off and help you feel like you have time to think about wider reading, developing your own ideas etc.

**Summary**

The Part II and DPhil courses have very different timescales and objectives. If you are doing Part II it is important to remember that you don't have to shake the world this year. At some point perhaps, but not this year. Your job this year is to get yourself competent and comfortable in a laboratory; thinking like a scientist and making experimental decisions based on observations. If you've moved up to DPhil, then you must step up your goals. You cannot continue as if you had a rather long and relaxed Part II to do: you are going to have to take control of you studies and take more and more of a hand in directing them towards a communicable contribution. On the other hand you don't have to be independent from day one and people have come unstuck by trying to be. You must be independent when you graduate, but you can afford to take a little time getting there.

**Good luck!**

## References

[1] J. Seely-Brown, A. Collins and P. Duguid, *see http://www.ilt.columbia.edu/publications/papers/JohnBrown.html*, **1989**,

[2] J. Ryder and J. Leach, *Research projects in the undergraduate science course: students learning about science through enculturation,* in *Proceedings of the 4th international student learning symposium*, G. Gibbs, Editor. 1997: Bath 1996.

[3] J. Ryder, J. Leach and R. Driver, *Final year projects in undergraduate science courses*, in *Undergraduate learning in science Project working paper 3*. 1996, University of Leeds.

[4] http://www.admin.ox.ac.uk/epsc/guidance/resdegrees.pdf

[5] E. M. Philips and D. S. Pugh, *How to get a PhD*, Open University Press, Buckingham.

[6] Taken from a letter written by Isaac Newton to fellow scientist Robert Hooke on 5th February 1676, where he very modestly claimed that his success had been built on the achievement of others: "If I have seen further it is by standing on the shoulders of giants"".

[7] C. S. Bruce, *Studies in Higher Education*, 1994, 19, 217.

[8] M. Kiley and G. Mullins, August 2001, 1.

[9] C. J. Pole, A. Sprokkereef, R. G. Burgess and E. Lakin, *Assessment and Evaluation in Higher Education*, 1997, 22, 49.