

# Going for a PhD: Joys and Pitfalls

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## ***Abstract***

With the number of students undertaking a PhD increasing and the nature of the working environment for these students changing, opportunities and problems inherent to this particular way of educating students are evolving. Challenges and difficulties that may arise during a PhD are considered and the ways potential problems can be avoided by PhD student and supervisor are discussed.

## ***1. Introduction***

There is an increasing demand for highly educated workers from both developed as well as developing countries. This has resulted in a concomitant growth in the size and number of institutions of higher education and an expanding body of PhD students at universities in the developed world. For example, at the ETH – the Swiss Federal Institute of Technology in Zürich – the number of PhD students has grown from less than 2300 in the year 2000 to almost 4000 in 2015, with students drawn from all over the world. There are about 400 professors at the ETH. This means that on average each professor is responsible for 10 PhD students. In the natural sciences it normally takes 3 to 4 years to conduct sufficient research to be reported in a PhD thesis. Thus about 1000 PhD theses are processed and defended each year by just this one institution alone. This leads to the question how or even whether under such circumstances the quality of the PhD work and the supervision, as well as the rigor of the examination process can be maintained. Considerations of prestige may lead professors to taking too many or less suitable PhD students – the bigger the group, the more successful is the professor – and may lead undergraduates to aspiring to obtain a PhD degree while lacking the required attitude and skills. This leads to mismatches.

Not only is the number of PhD students growing, but students are increasingly recruited internationally. This provides access to a larger pool of potential talent. It also makes the supervision of individual students more complex. The educational background of the students may vary significantly and cultural expectations and learned behaviour may be incompatible with practices at the host institution. These differences may even threaten scientific integrity. For example, in some cultures it may be considered inappropriate to question a supervisor's view or opinion, students may be conditioned to accept that a majority opinion must be correct, or may have studied in a corrupted system in which falsification of work or buying of exam papers was common. In some cultures objective criticism is considered to jeopardize personal relations, in others nepotism is

acceptable. Variation in undergraduate education, differences in culture, and a lack of understanding of the nature of a PhD all increase the complexity of supervising and supporting a student working towards his or her PhD.

Not only has the heterogeneity of the student and faculty population increased, but progressive changes in the culture of the academic community, in the organisational structure within institutions and in the regulatory and financial framework under which they operate may also induce behaviour that is ethically and academically problematic. Large, homogeneous research groups may lead to inwardly looking working environments. This can lead to a form of tunnel-view with excessive focus on own research results and insufficient checks and balances. Equally, large (inter)national research facilities, such as CERN in physics, NMR centres in chemistry or mouse facilities in biology, risk adopting factory-like approaches to the production of materials, experiments, observations, papers, and ultimately PhD graduates. This can leave little room for scepticism, scrutiny, criticism or even individual creativity. Without care the basic need for PhD students to be able to test their ideas and in essence be allowed to try and fail can be overwhelmed by a perceived need to justify the large sums of money invested in such facilities and to support the ambitions and careers of leading scientists.

During the past decade researchers have increasingly felt an obligation to produce papers, coupled to a growing focus on Hirsch factors or h-indices and citations. This can invite academic researchers to wander close to, if not beyond the boundaries of ethical behaviour. This feeling is nourished by the reliance of funding agencies on what are often poor, non-representative quantitative indices as basis for making decisions regarding which research to finance, rather than spending effort to elucidate the quality of proposals and proponents. Quality cannot be caught in numbers and such artificial drivers pose a threat to the independence of a fresh PhD student attempting to pursue academic research.

## ***2. Nature of a PhD***

The basic purpose of a PhD is to learn how to undertake research. That is, how to go from the initial conception and formulation of a basic idea or hypothesis, through the process of testing this hypothesis by planning and performing experiments or the development of theory, algorithms or software, to the final act of analysing a set of observations and reporting of the results obtained to the broader scientific community, whether orally or in written form. In the physical sciences, this is generally done within a limited period of 3 to 4 years during which students work full time on a topic. In the humanities, much longer periods are often required to master a topic and contribute new ideas and insights, while the research component of a PhD in the clinical sciences may be more limited given the time medical doctors have to spend with patients.

In the physical sciences, a PhD is generally undertaken within a research group under supervision of a professor or senior academic. Such a research group may vary in size from just one or two persons to large collectives including tens of bachelor, master and PhD students, post-docs, technicians, and senior scientists. The PhD student has a temporary position at the university and is often paid by a third party. Most will conduct

research for 70-80% of their time and help in teaching or otherwise assist the group for 20-30% of their time. Thus a PhD is a mixed activity involving learning from more experienced group members regarding how to gather data, analyse observations and to present results stemming from their own research, as well as teaching and supporting the next generation of group members. During the first year of a PhD, understanding the research topic is the primary goal. During later years significant contributions to the research of the group are expected. A PhD must have some freedom in the choice of the research topic and the opportunity to pursue his or her own ideas. That this is primarily a learning experience is reflected in a PhD's salary. While possessing a PhD degree may expand a student's employment opportunities, undertaking a PhD is not a way to make money. A PhD is for those who are innately curious, who are driven to understand natural phenomena and enjoy the freedom as well as frustration of investigating the unknown.

A PhD is generally considered the final completion of academic studies. Yet, it requires quite different qualities of a student compared to a bachelor or masters level of education including the ability to formulate goals, to work independently, to search for data in the literature, to be self-critical, to report orally and in writing, tenacity to keep going under adverse circumstances and the ability to deal with the many set-backs which inevitably occur when exploring unknown territory. It definitely is not a third study cycle after having obtained a bachelor and master degree.

### ***3. Obtaining a PhD***

To obtain a PhD one must conduct a body of independent research leading to a PhD thesis and be able to prove that one is knowledgeable in a particular field of research. At least at the ETH a PhD student must also be able to find a professor willing to serve as referent or thesis advisor who not only judges the PhD thesis to be of sufficient quality to be submitted for examination, but who is in turn able to find one or more co-examiners willing to serve as co-referent to examine the thesis. An examination committee is established and the student is provided an opportunity to defend his or her thesis in front of this committee. The reviews provided by the referent and co-referents regarding the quality of the thesis as well as the performance of the student during the defence are used by the chair and the examination committee to decide whether or not to advise the faculty to recommend the rector of the ETH to award the PhD degree. If the candidate fails the examination, he or she is normally offered one more opportunity to be examined. The exact procedures differ between universities, but at their core all involve a thesis submitted for examination being judged and guaranteed by academic peers who are faculty members at the same or other universities of similar standing. To simply have been enrolled as PhD student by a university and to have executed a body of research is not sufficient grounds to be awarded a PhD. Originality and depth of understanding must be demonstrated. This said there is no requirement that the initial hypothesis on which the PhD research was based must be corroborated or that the results obtained be exciting or unexpected. A thesis full of failed experiments and failed working hypotheses is perfectly acceptable, as long as the work is well documented, has been performed in an academically rigorous manner and the student can explain and defend the negative results. Thus, a PhD advisor cannot set the publication of a number of papers in the scientific

literature as a condition for submission of a thesis nor should a PhD be awarded simply because a student has published a prescribed number of papers. Both would constitute a violation of academic ethics. Of course the PhD student should have the possibility to publish his or her research during the course of the PhD research, i.e. PhD regulations should allow for a PhD thesis as monography, as cumulative dissertation or as a hybrid of these forms.

#### ***4. Requirements for a PhD***

In order to succeed, a PhD student needs intelligence, curiosity, drive to explore, tenacity and discipline. He or she must be able to self-reflection and to dealing with setbacks. Not only must there be a basic appreciation of the field of research, but also a strong interest in or rather love of the topic chosen for the PhD.

A PhD advisor must have a comprehensive understanding of the field of research and a genuine interest in the topic. He or she should enjoy teaching students, have sufficient time and be willing to help the PhD student when needed, and should provide a good and productive working environment. PhD advisors also need the personal skills to be able to provide leadership and guidance when scientific, social, psychologic or health problems arise. The German expression Doktorvater or Doktormutter (doctor father or mother) says it all.

Since a PhD involves charting unknown territory, the relationship between the PhD student and his or her advisor is of pre-eminent importance. If a hypothesis cannot be supported, if experiments fail or if other road-blocks appear during research, the PhD student often becomes critically dependent on the advisor, in particular his or her ability and willingness to grasp, to analyse and address research and organisational problems. A PhD student is also dependent on the other members of the research group for support and an effective working environment. Therefore, when joining a PhD program, the choice of advisor is of primary importance. The quality and atmosphere of the research group comes a close second, while the field of research and the specific topic are less critical.

#### ***5. Common problems***

The majority of cases that reach the ombudsman of the ETH involve problems between PhD students and their advisors. The first few months of a PhD generally go smoothly, yet it is important that PhD students use this time to find out whether they are at the right place. For example, to determine whether they personally are up to the task, whether they are ready to take ownership of the research project, whether the research project is sound, whether appropriate facilities are available, whether the PhD advisor is scientifically, pedagogically, socially and physically up to his or her task, whether the advisor is available to provide advice or mainly travelling or occupied by teaching, whether other group members are ready and able to provide support. Answering such questions objectively can help estimate and mitigate the risk of failure. If either the student or the advisor does not have the required qualities, if the atmosphere in the research group is unpleasant, or if there is merely an incompatibilité d'humeur between

the student and advisor, a student would be strongly advised to either address the problems directly or, if this is not possible, find another advisor and an alternative research environment. Attempting to work under poor conditions on an unsuitable problem or with an inappropriate advisor can leave a student with insufficient results to submit a PhD thesis even after years of work. Simply hoping that things will improve does not work and addressing problems earlier rather than later is always best.

Factors that may lead to failure to complete a PhD are manifold.

The PhD student

- lacks basic research skills
- lacks essential pre-knowledge
- lacks sufficient drive to conduct research
- lacks crucial social skills

The PhD advisor

- has insufficient supervision skills
- has insufficient understanding of the topic
- has little interest in helping students
- has allowed a poor working environment

It can also be that the research hypothesis cannot be falsified, or experiments may fail, or software turns out to be faulty, or academic ethical standards differ between student and advisor.

A proper match and trustful relation between PhD student and PhD advisor is of utmost importance when

1. road-blocks are encountered and help is needed to ensure the quality of the research at the level required for a PhD,
2. the research topic must be abandoned or the direction of research altered due to unforeseen circumstances or unsurmountable problems,
3. help and guidance is needed to write up the results of research.

## ***6. How to avoid difficulties***

The first and foremost consideration of every prospective PhD student should be to determine whether one personally possesses the qualities required to successfully complete a PhD. The second should be why he or she wants to obtain a PhD. Is it because of an intrinsic interest in research, because of external pressure, or because of believing that a PhD degree is helpful to get a specific type of job. All must ask whether obtaining a PhD is really worth spending a few years of one's life.

Before deciding on a prospective advisor, the PhD student should investigate his or her competence as an advisor. The student may consider undertaking a semester project or a master thesis project within the research group of a prospective advisor. Attending courses or presentations of a prospective advisor and talking to current and former group members about their experience with a prospective advisor may be helpful, the latter also because research groups reflect to some extent the personalities of their leaders. An exchange of e-mails or a Skype interview may serve as a first screening but is certainly not sufficient to properly evaluate the compatibility of the expectations of a PhD student and those of the prospective advisor and research group. Just like an internet date is not sufficient for finding a partner for a lasting marriage.

Likewise, before deciding to take on a PhD student, the advisor has a responsibility to evaluate the prospective PhD student. He or she should invite him or her to give a talk within the group and provide the prospective student opportunities to interact with group members. As indication of sufficient intellectual capabilities, a prospective PhD student should have high marks for one or a few undergraduate courses, but not necessarily for all. Students with only high marks may lack experience with set-backs and suffering frustration, while the capacity to handle set-backs is a basic ingredient for a PhD student.

Both student and advisor should use the initial months of a PhD to evaluate each other and the chance of successfully completing the proposed project. If difficulties arise, it may be possible to redefine the project to better suit the capabilities and interests of both student and advisor. Sometimes, however, it is best for student and advisor to go their separate ways. In this case the advisor should help the student find an alternative position or occupation. To discover that undertaking a PhD in a particular group is not appropriate for a given student should not be considered a failure.

## ***7. Conclusion***

Having PhD students allows an advisor to get research done. This comes though with the responsibility to evaluate the prospective student's capabilities as careful as possible, and then with an obligation to provide the PhD student with an environment, means and support to have a decent chance to successfully complete a PhD.

PhD research offers a student an opportunity to follow one's curiosity, to enjoy the exploration of uncharted territory, to feel the joy of achieving understanding the phenomena of life. One should be aware though that it can be a frustrating activity. Plunging into investigation of reality is a challenging endeavour haunted by risks to go astray. One needs a basic curiosity and drive to explore, without financial rewards or great career expectations. But, if one decides to go for it, the choice of PhD advisor based on knowledge of his or her scientific insights, ethical standards, pedagogical, social and managerial abilities, interest in students, etc. is of utmost importance, because these advisor qualities are dearly needed when the going gets rough during a PhD, which it inevitably will do. The fame of an advisor will be of little help under adverse circumstances. Thus, before plunging into a PhD, do choose advisor and group carefully. Finally, attempting to obtain a PhD is challenging and exciting, but it is not for everyone. If things do not work out, recognise and accept this early while one can still easily exploit other opportunities of life.

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