

COMMENTARY

Going for a PhD: Joys and Pitfalls

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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 Zurich – 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 – 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 take too many or less suitable PhD students – the bigger the group, the more successful is the professor – and may lead undergraduates to aspire 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 also 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 behavior 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 toward his or her PhD.

Not only has the heterogeneity of the student and faculty population increased, but also progressive changes in the culture of the academic community, in the organizational structure within institutions and in the regulatory and financial framework under which they operate may also induce behavior 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 centers 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 skepticism, 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 behavior. This feeling is nourished by the reliance of funding agencies on what are often poor, nonrepresentative 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 analyzing 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 – 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-doctorates, technicians, and senior scientists. The PhD student has a temporary position at the university and is often paid by a third party. Most students 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, analyze 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 setbacks which inevitably occur when exploring unknown territory. It is definitely 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 also is in turn able to find one or more co-examiners willing to serve as coreferent 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 coreferents regarding the quality of the thesis as well as the performance of the student during the defense 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. Thus

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 a monography, as a cumulative dissertation, or as a hybrid of these forms.

When large, often multidisciplinary projects are pursued by a big group of scientists, it is often difficult, if not impossible, to determine the contribution of individual group members. When these are PhD students, this is problematic, because they have to demonstrate their individual ability to carry through original research by writing a PhD thesis on their own work and defending its contents. In such a case, a PhD student should be allowed to use the data of the project and to focus in depth on a particular aspect of the project in his or her PhD thesis, while another PhD student, also being a member of the group, would choose another point of view or aspect in regard to the project for his or her PhD thesis. Allowing multiauthor PhD theses would bar an examination committee from determining the individual ability to report in written form on the PhD work done. A PhD degree reflects the individual capability to carry through original research and report on it.

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-reflect and to deal 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 preeminent 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 analyze, and to address research and organizational 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	The PhD advisor
- lacks basic research skills	- has insufficient supervision skills
- lacks essential preknowledge	- has insufficient understanding of the topic
- lacks sufficient drive to conduct research	- has little interest in helping students
- lacks crucial social skills	- 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; and
3. help and guidance is needed to write up the results of research.

At some universities, graduate schools have been established, which constitute a community of PhD students and their PhD advisors. This fosters contacts between students of different research groups and with other established scientists than their own PhD supervisor, it forces them to look beyond their own research topic, and allows them to evaluate their own progress and performance by comparing their presentations and posters at graduate school annual retreats or literature clubs with those of others. Such graduate school communities may serve to signal emerging problems and may provide back-up in case of conflict between PhD student and supervisor. However, graduate schools may diffuse the responsibility for a successful completion of a PhD away from the individual student and his or her individual supervisor to other persons that may not be in a position or willing to solve emerging problems or settle conflicts. PhD committees may also help in signaling problems, but generally lack power to resolve problems or conflicts.

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 analyze papers of a prospective advisor and 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. The PhD student could also ask about the envisaged PhD topic, why it was selected by the prospective supervisor and whether the supervisor published work on it. What is the average length of a PhD period, do PhD students publish on their PhD work in the literature, are they allowed and stimulated to attend advanced research schools, workshops and conferences, and to go abroad for a stay in another research group? What equipment to carry out the project is available? What are the educational and infrastructural duties envisaged, and what percentage of time would these take?

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 setbacks and suffering frustration, while the capacity to handle setbacks 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.

Thus, PhD research offers a student an opportunity to follow one's curiosity, to enjoy the exploration of uncharted territory, and 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 endeavor 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, recognize and accept this early while one can still easily exploit other opportunities of life.

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