Chapter 6

Building a Strong PhD Programme

A PhD programme is the backbone of a research university, its most important facet, one which clearly separates it from institutions which focus on teaching. In fact, the basic definition of a research university in the Carnegie Classification framework for universities in USA is based on the size of the PhD programmes of these institutions (Carnegie 2000). In many countries, including India, PhD students are the main human resources, besides the faculty, for research in a university—while research is driven by the faculty, much of the work is actually carried out by its PhD students, who also provide a source of fresh ideas.

The PhD is a unique degree, quite unlike the bachelor's and master's degrees. While the goal of other education programmes is to build understanding and expertise in existing knowledge, the PhD programme's goal is to mould students into knowledge creators. Moreover, unlike the other education programmes where many students are taught together in a course, the PhD is fundamentally a programme wherein each student is 'taught' individually and progresses at an individual pace towards completion. It is more like an apprentice model for education, rather than the classroom-based model followed in other programmes. Due to its special nature, the programme often has a loosely defined structure. Further, while bachelor's and master's programmes are subjects of intensive discussions and debates in faculty bodies,

boards and senates and attract central focus in university accreditations, PhD programmes often do not get such attention.

We briefly discussed the evolution of the PhD programme in India in Chapter 1; a detailed discussion on its evolution and challenges can be found in Jayaram (2008). In this chapter we discuss various issues related to the PhD programme, for example, the characteristics of a strong PhD programme, desired attributes of a PhD student, what is expected from a PhD programme, what research universities can do to strengthen it, an example of a PhD programme in India which has many of the desired traits, etc. We start this chapter by first discussing the objectives and learning outcomes of a PhD programme.

6.1 PROGRAMME OBJECTIVES AND GRADUATE ATTRIBUTES

Programme objectives and graduate attributes are standard formulations for undergraduate programmes but are not commonly articulated for PhD programmes. However, obviously, they are as important here as in any other educational course, and there are now active efforts to establish them (Denecke et al. 2017). We discuss these aspects in this section. We also discuss the desirable attributes of a PhD scholar, as for achieving the objectives it is essential that the students in the programme have the desired attributes to successfully complete a PhD.

6.1.1 Objectives

The main goal of the PhD programme is to develop researchers who are well equipped to undertake research challenges of the future for the benefit of the society. As it is almost impossible for someone to claim that he/she has become a researcher without a properly documented record of actual research, an important objective of the PhD programme is to extend knowledge about some topic—this knowledge is generated by the PhD scholar with the guidance of his/her supervisor and committees that may be part of the doctoral education of a university.

To be a sound researcher, it is imperative that the researcher not only has research skills but also has wide knowledge in the chosen area of research. Only with extensive awareness and a deep understanding of the work done so far can a researcher claim that the work he/she has done is 'new' (which is the basic premise for it to be considered research), 'worthy' and 'useful'. Hence, developing knowledge in the chosen area of research can be considered another objective of the PhD programme. This skill of building the knowledge base and identifying the gaps in it is a fundamental research capability and is essential for a long career in research, as a researcher will work in different areas during the course of his/her career.

These two objectives are sometimes stated as the two basic goals of a PhD programme (Sorensen 2016): to extend knowledge about an important topic through research and to provide training to the PhD student to develop competencies needed to be an effective researcher. These together can be considered as *research competencies*.

Traditionally, PhD programmes implicitly or explicitly tend to train the PhD scholars as if they are being prepared for an academic career. Perhaps, this bias is natural, given that the supervisor of the student considers an academic career as the highest calling for a researcher.

While earlier most PhDs may have joined academics, this has changed—for example, a large fraction of PhDs in USA want to work outside the academia and take up alternative employments (Nerad 2004, 2015a). In applied areas like computing and engineering, this is even more skewed—a study found, for example, that only 20 per cent of the PhDs in Electrical Engineering opt for academia. (In India, such data is not available; however, from IIIT-Delhi, of the graduates in computing and electrical engineering in recent times, about 10 per cent went for academic positions, more than 50 per cent went for industry jobs, and about 30 per cent went for postdoctoral research overseas.)

It is expected that this trend will continue and more and more PhDs will be employed in areas other than academia. As economies are becoming innovation-driven and new businesses emerge in newer areas that will be powered by R&D, they are likely to use more PhDs. Think tanks and policy bodies, which have traditionally employed research scholars for their work, will continue scouting for PhD graduates. PhDs are also expected to take up more leadership roles in corporations, research groups, policymaking bodies and other institutions.

Keeping these reasons in mind, besides cultivating their research capabilities, it is desirable that PhD graduates also possess transferrable and translational competencies, to enable them to have a successful career outside academia, which often require skills beyond creating new knowledge in a chosen field of study (Nerad 2012, 2015b). These are sometimes called professional competencies, and developing these can be considered as another basic objective of a contemporary PhD programme.

Researchers have always viewed themselves as a global fraternity, with the output of research treated as quintessentially public property, available to all, regardless of where the knowledge might have been produced. Research was globalized much before globalization became a buzzword—stories of researchers travelling and staying in different countries and collaborating with scholars of other nationalities are many. With the rise of globalization and global corporations, with the world shrinking through myriad forms of connectivity and the ease of travel, this trend will only accelerate. PhD graduates are expected to be global researchers who can work in multinational teams on global challenges, staying in different countries for periods of time. To facilitate this, it has been argued that a PhD programme should also develop suitable cultural competencies in its PhD graduates (Nerad 2012).

We can thus say that the basic objective of a PhD programme is to develop researchers who have wide knowledge about their

area, have strong research skills that have been demonstrated by the generation of new knowledge, are well equipped with translational competencies to undertake a range of careers and have cultural competencies to work in different cultural contexts. In other words, a PhD programme should aim to develop research competencies, professional competencies and cultural competencies.

6.1.2 Graduate Attributes

The graduate attributes of a programme define the traits a graduate of the programme is likely to have. As discussed in the chapter on education, often, these outcomes are divided into general attributes, pertaining to the general capabilities and competencies of a graduate, and discipline-specific attributes, which specify competencies pertaining to a select field of knowledge. Unlike undergraduate programmes wherein discipline-specific attributes are key, for PhD, the general attributes are likely to be more important. This is because the main objectives of the programme, as discussed above, are independent of the discipline (in fact, in many universities, the PhD degree does not even specify the discipline). We discuss some of the desired general graduate attributes, many of them being based on the attributes for postdoctoral scholars given in Sorensen (2016).

1. **Independence:** A PhD graduate is expected to be an independent researcher in his/her own right, capable of forming his/her own teams and following his/her own research agenda. This, in some sense, is the most fundamental difference between a PhD scholar and a PhD graduate. As a scholar, one conducts research under the guidance of a supervisor, but after the PhD degree is awarded, the researcher is expected to work independently, and even guide some junior researchers (other PhD students, interns, master's dissertations, etc.).
2. **Innovation and creativity:** This might be understood as the ability to identify and formulate potential research problems,

as well as the approaches for addressing them. Identifying and formulating research problems are the core skills of a researcher—he/she has to be creative to identify research problems that are worthy of sustained effort and which may lead to good research outcomes and/or publication(s). Formulating research problems and pursuing them, particularly in the face of constraints and challenges, requires the ability to find innovative measures. Overall, having the creativity and imagination to spot a potential research problem, which is one of the most important challenges for researchers in many disciplines, is a key capability, along with the ability to evolve efficient and effective approaches for addressing the problem. A PhD graduate must have this competency.

3. **In-depth knowledge of the research area**: A researcher might have to work on different topics at different times. He/she must have the ability to quickly build the knowledge base and ensure that he/she has in-depth knowledge of related research and results. Without this, it is easy to spend time exploring problems whose results have already been published. This also requires developing a broader perspective and understanding of the different sub-areas of the research topic, including connections between the sub-areas.
4. **Ability to critically read research papers**: In-depth knowledge can be developed in a field by a researcher only if he/she has a strong ability to critically read research papers and understand the subtleties and nuances that might be involved in the work. For a researcher, the only way to be abreast of the latest developments in his/her area is to read research papers—textbooks are of no help here. Critical reading of papers also involves identifying the limitations of the work, how it can be applied or extended and what might be the related problems, among other critical concerns. It can be safely said that for many researchers, reading of research papers is also a source of getting ideas for their work, besides, of course, gaining knowledge about the latest developments.
5. **Ability to apply suitable research methods to rigorously explore a given problem**: Once a research problem is

identified, besides deciding on the approach for exploring it, a lot of effort has to be invested in applying recognized research techniques which can lead to robust scientific results eligible for publication in reputed platforms. Hence, a good understanding of research methods and the judicious discretion to apply them effectively is an essential capability of a researcher. This can also be considered as the ability to implement a high-level research goal—that is, to convert it into a sound research project and then see it through to completion.

6. **Aspiration to do high-quality work and publish in highly reputed venues**: Without the desire to do high-quality work and submit it for publication in critically acclaimed venues, average research is inevitable. All too often, PhD students are too focused on completing the thesis and acquiring the PhD degree, opting for an easy path of doing mediocre work of greater ease and lower risk, which is then published in low-impact forums. A PhD programme should try to develop high aspirations in the student.
7. **Ability to communicate effectively**: This is a critical capability of a researcher—to be able to communicate his/her work through writing (technical papers) as well as through oral presentation. Writing research papers is absolutely essential—without it, research cannot really be recognized. Often, researchers are requested to give seminars on their work in conferences, university departments and other intellectual gatherings. Hence, effective written and oral technical communication is an indispensable capability. Besides technical communication, it is also highly desirable that the researcher has the ability to communicate the problem and the results to a non-technical audience also—this is now needed not only to explain to a wider target group but also for collaborating across disciplines to address interdisciplinary challenges.
8. **Integration with the scientific community**: Research is essentially done by one global fraternity of researchers in an area. The union is preserved through its conferences, regular meetings, journals and digital interfaces. It is important for a researcher to be integrated into this fraternity—this not only

will help with staying updated regarding the latest developments, but engagement with the fraternity can also help in refining existing ideas or collecting new ones.

9. **Ability to collaborate with other researchers**: This is an essential cultural competency, as discussed earlier, as a researcher works in different contexts and with different collaborators who might often be of other nationalities and different cultural backgrounds.

These are general attributes, independent of the discipline, which a PhD graduate is expected to possess. It is expected that PhD graduates have some discipline-specific capabilities as well, which have to be developed by each discipline and will depend on the nature of the specific subject.

6.1.3 Being a Successful and Effective PhD Scholar

As the PhD is very different from other degrees, the traits that make an effective PhD scholar are likely to be different from those that make an effective student in, say, an undergraduate programme. An understanding of what attributes make an effective and successful PhD scholar can help a prospective candidate better assess whether PhD is the right option for him/her and if he/she has what it takes to successfully complete a PhD. It can also help PhD programmes in selecting the most suitable students in the programme.

First, let us clarify what we mean by an effective PhD scholar. We view a PhD scholar as effective if he/she can successfully complete the PhD with a good-quality thesis in a reasonable time (perhaps, the expected duration for the discipline) and who is able to secure a good position in the career of his/her choice after completing the course. In other words, an effective PhD student is one who (a) can complete the PhD in a reasonable time; (b) produces a good thesis demonstrating strong research skills; and (c) develops the professional competencies needed for the desired career. Such a PhD student is what PhD programmes also desire.

What are the key attributes of an effective PhD student? This is obviously a topic of great interest to prospective PhD students; consequently, there are many blogs, articles in the popular press and other forums which discuss this topic from different perspectives. If we look at the actual practices of selecting students for a PhD programme, perhaps, academic preparation is given the highest weightage by the committees who evaluate their applications. Although good academic preparation is necessary, it is also true that academic background as reflected in the CGPA, while a strong indicator of the readiness to do a PhD, is not the only factor that matters. Graduate admission committees routinely select students with a lower CGPA over ones with a higher CGPA based on a host of other factors like interest in the field of study, prior research experience, nature of academic preparation, etc.

Overall, what are the other attributes that make an effective PhD student? There are many perspectives on this question. Some of these attributes are discussed here (some are from Sorensen [2016]):

1. **Interest and motivation**: The student must have a keenness to undertake research towards a PhD, which might be demonstrated by their having attempted some research project in their education till this point. If a person has interest, he/she is more likely to be motivated and driven to work. It is also desirable that there is a clear and positive motivation to do a PhD, and PhD is not chosen simply because the student could not find a job or other opportunities.
2. **Initiative and independence**: This is a personal attribute or a work ethic as to whether the person takes initiatives on his/her own or is more dependent on the supervisor to give instructions. A person with initiative is also likely to be more motivated for doing the work. In general, people with initiative are more likely to achieve more than people who need direction.
3. **Creativity and ideation**: Research is about ideas—you cannot do research without having good ideas about what problems

to investigate, and ideas about how to overcome the challenges that might come in the way. One can say that great researchers are the ones who have novel ideas that others could not conceive of, and who have the ability and the traits to develop them and carry them forward.

4. **Integrity**: Research is in many ways a search for truth. While integrity is desired in all professions, this nature of research makes it even more important that researchers have the integrity to work ethically and report the results accurately.
5. **Ability to work hard and persevere**: For a researcher, these are perhaps the most important traits—it is well known that in research, while ideas are often what we talk about, to develop an idea to the level that it is accepted by peers and is recognized as a good contribution, a huge amount of work is often needed. Edison famously said, 'Genius is one per cent inspiration, ninety-nine per cent perspiration'. Besides hard work, learning to deal with failures and continuing to work after rejections is equally important. Whenever one is exploring the unexplored, failures are to be expected and will happen. A researcher will not always get the desired results, and an experiment might fail. Similarly, papers written on the research work done are, statistically speaking, generally more likely to be rejected than accepted (many journals have an acceptance rate of 25 per cent or less, implying that only one in four papers submitted are accepted). It should be clear that if one is mentally and physically not ready for this, a PhD, as well as a career in research, may not be suitable.
6. **Ability to work under uncertainty**: Research fundamentally is a risky venture—the outcome is not known. In fact, it is not even known whether there will be a successful outcome, and whether the research results will be accepted favourably is also uncertain. In the process of research, often, finding research problems to work on is also fraught with doubt. Overall, doing a PhD has many uncertainties. In undergraduate and master's degrees, the student can be certain that if he/she puts in the required effort he/she can complete the degree, but this

is not the case in a PhD; one might not even finish the PhD degree. Hence, having the ability to work under uncertainty is a key attribute of a good PhD student—having the confidence that finally, a positive outcome, though unknown at the start, is the most likely outcome if he/she perseveres.

7. **Interpersonal abilities**: Research is often done in teams, with multiple researchers working on a project and sharing results while still pursuing their own goals. Even during a PhD, often, the adviser will have a group of PhD (and master's) students and postdoctoral scholars working together on related problems. A good PhD student should have the interpersonal ability to work collaboratively with others in a team. Other things being equal, researchers who are good at collaboration are likely to do better in their research career than those who are weak at it.

6.2 CHARACTERISTICS OF A STRONG AND VIBRANT PHD PROGRAMME

Organizations routinely assess the quality of an individual PhD graduate—all universities and labs do this assessment during the recruitment process. In this assessment of graduates, the quality of the PhD programme of the university clearly plays a role—some universities are viewed to have strong and vibrant research programmes, and their graduates are often sought after. However, even the best of programmes produce mediocre PhD graduates, and there are graduates from average programmes who go on to excel. So how do we define the notion of quality for a PhD programme?

We will consider a PhD programme to be of a high quality if it consistently produces first-rate PhD graduates (as assessed by prospective employers). To ensure that more and more of its graduates are high-quality professionals, all the different aspects of a PhD programme—from admission of students to their thesis defence—play a role.

Traditionally, the quality of a PhD programme has been seen as largely dependent on the research reputation of the faculty.

While the quality of faculty undoubtedly plays a key role in the quality of a PhD programme, the quality also depends on a host of other factors: how well-designed the programme is, the level of mentorship and support provided to the PhD students, how well students are prepared for undertaking research, the guidance provided to the faculty for supervision, infrastructure, and so forth (Morrison et al. 2011). A study in USA considered a host of factors and their impact on the quality of doctoral education as perceived by the PhD graduates 10 years after their completion. The study found that graduates of the top-ranked programmes were only slightly more likely to assess the programme as excellent, as compared to graduates from other programmes. The study indicated that factors like academic rigour, clear programme requirements and support and guidance are viewed as being more conducive towards achieving excellence than the reputation of the faculty (Morrison et al. 2011).

In this section, we consider many different characteristics of a PhD programme, grouped around a few different themes or dimensions of the programme. However, before that, we discuss some of the expectations of prospective students in India regarding PhD programmes.

6.2.1 Expectations of Prospective Scholars from a PhD Programme

There are many studies about students enrolled in the PhD programmes—to better understand key aspects like time to completion, attrition, student experience and other related issues. While these studies help in understanding the PhD programme, they do not help in understanding what motivates people to join a PhD programme and what can be done to excite the brightest minds to take up a career in research by opting for a PhD. Developing countries like India have a special challenge in attracting students to PhD programmes in their institutions, as many of the graduates from their best institutions who want to pursue PhD opt to do it in overseas universities, most of which attract meritorious foreign students to their PhD programmes.

A few years ago, an informal survey of students who were about to graduate from BTech and MTech programmes of a few top engineering institutions was conducted (by the author) to get some data which could throw some light on the vexing problem of how to attract the best students to do a PhD in Indian institutions—a challenge that all top institutions in India have always struggled with.

The survey asked the students two questions. The first was why they may not want to do their PhD in India, and a set of reasons were presented to them from which they could choose as many as they wanted. The second was to understand what they would want in a PhD programme to seriously consider doing a PhD in India—for this also, a set of choices about what may be available from the PhD programme were given and they could select as many as they wanted. For these two questions, the choices given were decided based on discussions with faculty members and existing PhD students, as well as a general understanding of the prevailing situation. The students were also asked what they would prefer to do after graduation—a job, PhD, MBA, or master's. The survey was taken by about 275 students from three top engineering institutions, of which about 160 were BTech students and 115 were MTech students.

The first interesting observation was that while the vast majority wanted to do a job after graduation, over 15 per cent of them opted for a PhD. This number was higher than what many people expected. It revealed that there is a desire in a substantial number of graduates from the top institutions to do a PhD.

On the question of the main reasons why they would not want to join a PhD programme in India, the most common answers were:

- Have not thought about the PhD degree and career options after it;
- Job options after PhD are few;

- Do not want to be an academician; and
- PhD takes too much time.

The first three are career-related—these students do not understand what a PhD entails and the career possibilities after PhD, and might have been thinking that being an academician is the primary career (which many of them did not want to pursue). As discussed earlier, traditionally, PhD programmes have implicitly supported the view that after PhD, one should become an academic, and universities are often not aware of the range of possibilities that have been opening up for PhD graduates; hence, insufficient and incomplete information is given to the prospective PhD students which influences their perceptions about the programme.

It is also evident, as one may suspect, that prospective students are afraid that PhD takes a long time—implicit in this is also the fear of uncertainty about the completion time. In general, bachelor's and master's students perceive the PhD programme duration to be long and uncertain—perhaps strengthened by the anecdotes of students taking years to complete it and the jokes about the duration.

A considerable number of students also agreed with statements relating to the research scenario in India. Many students hold views like: the Indian PhD has a low market value, the faculty do not inspire them to take up higher studies, the range of research areas available in India is limited, as compared to foreign universities, etc. These are large research ecosystem challenges that a country like India faces.

Also, very few respondents chose the option that settling abroad was attractive. While experience—and some studies—shows that most students from India, when they do their PhD from universities in developed countries, choose to settle in those countries, this indicates that at least before they have actually moved abroad, the attraction of settling out of their country is not a strong motivator.

Students stated that they would consider doing a PhD in India if certain options are available, such as:

- If the PhD degree is jointly awarded by an Indian institution and a foreign university, with at least 1 year being spent in the foreign university; and
- If the PhD programme involves collaboration with R&D groups in companies, including an internship with these firms.

Two other career- and compensation-related options were found to be strongly favoured: if the job opportunities after PhD provide a good compensation, and if the stipend for PhD scholars is increased. Finally, one more option that was selected by many was that more information was needed about programmes and opportunities.

Results from a similar survey (also of engineering students) are given in Aggarwal (2018). This survey also identified many of the factors discussed above and discussed many challenges facing the PhD programme in India and some suggestions for addressing them. Though these studies are only of engineering students, some of the sentiments of these students will probably resonate with students in other disciplines as well, though there may well be other factors that influence their choices. Clearly, there is a need for similar studies for students in sciences, social sciences, humanities and other streams. However, an improved understanding of what prospective students are looking for can help in designing better PhD programmes in engineering. In fact, many of these studies directly impacted the design of the PhD programme at IIIT-Delhi, as will be explained later in the chapter in the case study section.

6.2.2 Admitting Scholars to the PhD Programme

While standard programmes are largely 'taught', the PhD programme builds upon what a student has already learned and aims to convert him/her into a researcher capable of creating new

knowledge. Engaging in research requires different skill sets than learning. As discussed, while academic preparation (in terms of sound knowledge and understanding of the discipline and area) is necessary to undertake a PhD programme, there are other attributes relating to motivation, drive and creativity that may be more important for a PhD student. Students without proper skills and other attributes may not be able to complete the programme or may end up doing a mediocre thesis—both undesirable for a high-quality programme. Also, having unmotivated students in a programme can have a negative effect on the other PhD scholars, as the group size is generally rather small (particularly when compared to the size of bachelor's and master's programmes) and PhD scholars are often under pressure and self-doubt, which makes them more susceptible to negativity. Overall, selecting students from the applicant pool for the PhD programme needs careful consideration to ensure that the quality of the programme remains undiminished.

- **Holistic criteria for selection and proactive search:** A careful selection based on capabilities that are needed for PhD is extremely important. No PhD programme can thrive with mediocre PhD scholars. As discussed above, only academic achievements and preparation is not a strong predictor of success in PhD, and there are other attributes like motivation and drive that may have a larger influence on how well a student does. A good programme will take a rounded view of admission and will consider other important criteria besides academic achievement or scores in tests like Graduate Record Examination (GRE) (Kent and McCarthy 2016). What could be components of the criteria for admitting students to a PhD programme? This is something which each university, and departments within the university, have to specify, keeping in mind the expectations from the university and the discipline. Some of the attributes of an effective PhD student have been discussed earlier in the chapter—they can provide some guidance to evolving the necessary criteria.

In countries like India, there is a need to go beyond selecting from a pool using these determinants, as the graduates who are most suited for doing a PhD often choose to go overseas for pursuing their PhD. Hence, universities cannot expect to attract a large pool of applications of highly qualified candidates and selecting from this pool. When a good portion of the talent has gone to corporations (jobs) or for higher studies across the world, there is a need to find talent from the non-obvious sources. It is known that many universities and colleges that have average-quality education still often produce top-calibre graduates who go on to do exceedingly well in life. While the fraction of such students might be lower in such a university/college, such graduates do exist. In the light of the challenge that the best talent is not available, this 'hidden talent' has to be searched for and identified and 'recruited'. In other words, instead of selection, Indian research universities that aim to build a strong PhD programme have to adopt a 'recruitment' approach for PhD students and find the best and most appropriate talent, perhaps from somewhat unlikely sources.

- **Diversity**: Research can improve if there is diversity of thought. This can be provided in a PhD programme if there is diversity in scholars—diversity in terms of gender, background, nationality and culture. A high-quality PhD programme will actively build in diversity into itself.
- **Group size:** A reasonably sized PhD programme is needed to do the level of research that a research university desires. There is a need to have a reasonable cohort size for PhD for another reason. PhD scholars support each other, perhaps more than any other group in the university. Very commonly, in the acknowledgements of PhD theses, students are seen thanking their PhD colleagues. This is another important reason to ensure that there are sufficient numbers of PhD students in each department, so they can form their support groups.

6.2.3 Preparing for Research

Most PhD programmes have some coursework, though globally there are PhD programmes (e.g., in UK and Australia)

which do not have any coursework. The main reason for having coursework in a PhD programme is to improve the preparation of the PhD student for undertaking research. In India, as discussed above, many PhD students may have graduated from universities and colleges with a mediocre-quality education that may not have adequately prepared them for undertaking a PhD programme. In fact, often, students may be weak even in the foundations of their discipline. Hence, in the context of a country like India, it is essential for a high-quality PhD programme to have a reasonable amount of coursework and to assess that the student is well prepared for undertaking research and completing the PhD programme.

- **Courses for preparing for research**: These are essential in India, as the students coming in are often not well-prepared. In fact, a strong coursework requirement can often be a good indicator of a sound PhD programme. In engineering education, for example, almost all of the main research institutes like the IITs and IISc, as well as IIIT-Delhi, have significant coursework. Some of this coursework is to strengthen the foundations and knowledge of students in their discipline so as to prepare them to undertake advanced courses and research. Some of these preparatory courses also train the students in research methods or pedagogy of research, including research ethics.
- **Advanced courses**: These are courses that are largely built around the current developments in an area rather than around the well-established body of knowledge. Often, these courses may not even have a textbook, and even if they use some books, these are commonly supplemented by recent papers and research results. These are also courses wherein the instructor's own research is often part of the syllabus of the course, integrating the research further with teaching. Some such courses help a PhD student in his/her research work.
- **Comprehensive exam:** There is a need to check, a few semesters after admission, if the PhD programme is suitable for the student, and if the student is suitable for the programme. PhD is not like a UG programme, where it is the responsibility of

the university to ensure that the student learns and graduates. This is a special programme wherein only a few selected people are expected to enrol and succeed. Hence, it is important to check the suitability; if not found suitable, it is desirable that the student leaves the programme earlier, rather than later, so as to minimize the loss in terms of time and the resultant frustrations that can accrue. Comprehensive examination (which may be called qualifiers or with some such similar monikers) is a commonly used method to ensure that the student has the capability to withstand the rigours of the PhD programme. Sometimes, only after clearing this examination is a student considered as a candidate for PhD. There is no common view of this test (Walker et al. 2008), and its nature and scope varies from breadth in the discipline to grasp of the problem area of research to genuine creativity and other factors. However, a good PhD programme is expected to have such an examination.

6.2.4 Conducting Research and Monitoring Progress

A PhD programme is a long undertaking that can easily last 5 years or more. It is also a programme wherein there is minimal schedule or structure; hence, unlike a student in a bachelor's programme who has a weekly schedule of lectures, lab work, assignments, etc., a PhD student in many semesters might not be attending any course, and so might not have any of these structural forces to keep the momentum going. Often, the progress is left to the adviser. However, this is too personalized and not fully reliable; sometimes, a supervisor might not be able to take appropriate actions due to the strong one-to-one relationship that often develops. Often, a PhD student takes up many years, not due to the dearth of new ideas or hurdles in the process of research but due to a certain slackness which leads to the detriment of progress. For a good PhD programme, it is imperative to have rigorous progress assessment that is systemic and not exclusively dependent on the supervisor.

- **Rigorous and regular progress assessment**: The PhD is a programme in which losing a year or two is very easy. It is largely driven by self-motivation, and this is something most PhD scholars do not understand (as a large number of them still have a student mentality whereby the pace is effectively driven by instructors of courses). It is imperative that a regular review be done which is rigorous. At the start of the programme, the review should focus on how the scholar is honing his/her understanding and depth and building necessary skills, but after a year or so, its focus can be on progress made in identifying research problems, working on them, getting results and writing papers. One of these evaluations may involve the student presenting the thesis proposal and an assessment of the same. In the thesis proposal, the student explains what problem he/she wants to work on and the approach he/she wishes to take. Sometimes, the thesis proposal may be assessed by a separate review.
- **High expectations of research output**: PhD scholars, and their guides, will respond to the expectations that are set by the PhD programme of the university. These need not necessarily be hard-coded requirements stated as the nature and number of publications, but can be more about expectations, what the university expects from a PhD and what scholars should aspire for.
- **Research culture among PhD scholars:** It is not an exaggeration to say that the culture among the PhD scholars, which in turn evolves within the research culture of the faculty and the university, will have a strong influence on the work of PhD scholars. If the PhD students in the university support the aspiration to do good work and publish in reputed venues, encourage curiosity and knowledge seeking (for example by organizing and attending seminars and talks), motivate and support other scholars for doing good work (e.g., by giving presentations to each other, reviewing papers written by others, helping colleagues in problems when they may be stuck, providing ideas, etc.) and encourage initiative and

exploration, it demonstrates a good and supportive research culture (Walker et al. 2008).

6.2.5 Preparing for a Career in Research

A graduate from a PhD programme is likely to pursue a career that will involve research. However, besides academics, research is important in a host of different environments and organizations, all of which can be potentially where a graduate may choose to build his/her career. For example, a PhD graduate may become a faculty member in a research university where teaching and research are both important, may become a faculty member in a teaching-focused university where teaching is the main job and research is given less weightage, may join a government research lab which may be working towards some national mission, may join an industry where research is done to help the business goals of the company, may join a think tank or an NGO which may be doing research to lobby or build public opinion around some important issues, may initiate or join a start-up to use research to create innovative products and services to generate value, may get inducted by government agencies where research-driven policies are being made—the possibilities are many. In future, it can be expected that opportunities are likely to expand. It is important for a PhD programme to prepare its PhD students for these diverse career opportunities.

- **Opportunities for research internships in the industry and other laboratory settings:** The close connection of research with industrial applications and, through it, with society is becoming increasingly important. Universities often are culturally inclined towards basic research, with less interest in exploring the potential applications for them or in deriving research problems from actual challenges in the field. To encourage the PhD scholar to take a wider view of research and also be cognizant of the possible impact of that research on innovation and business, a good way is to facilitate internships in the industry. Such internships will provide an

exposure to the scholar about the nature of work in industry, as well as how research can be applied in that context. It can help in evolving research problems rooted in the industry practice or business.

- **International exposure**: Research is a global endeavour, and researchers can expect to work with multicultural and multinational teams. Therefore, it is desirable that they have some international exposure during their PhD. This is particularly important for India, since its own ecosystem for research is still rather nascent. International exposure helps PhD scholars appreciate the research cultures of other countries, get different perspectives and also, perhaps, get the assurance that the work they are doing is at par with the type of work going on even in the well-respected universities. If a student can spend a semester or a year in some other research group in another country, the benefit of this would be tremendous.
- **Opportunities to present papers at international conferences**: During the course of the PhD, a PhD student should be able to present his/her work at international conferences. Such conferences provide a platform to present one's research to a global audience of scholars and experts in the field. They are also places where the latest results are shared, so they provide an excellent platform for students not only to hear great researchers present their work (and learn from this experience themselves) but also to find out both about the latest developments, as well as the open issues that the research community is excited about. This experience of presenting and listening to experts is immensely useful for improving the work the PhD student does, as well as his/her aspirations. As the top researchers in the field often come to these conferences, it is a great place to build connections with others and participate in the global network of researchers. Conferences often are the venues where job opportunities are shared and potential recruiters are present, which can help the PhD student in securing a good job after the completion of his/her PhD.
- **Developing teaching skills**: For a PhD graduate, academics provides an important career path, despite the other options

discussed above. While the percentage of students joining academics has been declining, academics remains the career of choice for many PhD graduates. In some fields, particularly humanities and social sciences, academics is likely to be the preferred career for most of the graduates. In a university, teaching and research are the two main missions; faculty members are expected to teach a few courses each year, and teach them well. While researching skills are developed during PhD, the PhD programme must also prepare the PhD student for the other dimension of an academic career, namely, teaching. It is here that many PhD programmes fall short (Walker et al. 2008). While often PhD students have to do some TA duties, they are more often treated as ways to reduce the load of the faculty, rather than as training for teaching. For future faculty, it will clearly be desirable if they develop some effective teaching skills during their PhD. It can also help them better appreciate the academic career. A good PhD programme will provide active support and guidance to PhD students to develop their teaching capabilities. The NEP of the Government of India also recognizes the importance of developing teaching skills in future faculty and suggests that the PhD programme should actively develop these skills in PhD scholars by exposing them to good pedagogic practices and also provide them experience in teaching (NEP 2019).

- **Developing transferrable skills for non-academic careers and leadership:** It is desirable that the PhD programme also prepares students to undertake industry careers and develop leadership and entrepreneurship capabilities. While conventional academic skills are often developed through courses and mentoring, alternative approaches may be more suitable for developing such transferrable skills. For example, exposure to entrepreneurship can be provided through entrepreneurship clubs and their events (for example, hackathons and bootstrapping programmes), suitable lecture and discussion series, intensive workshops, etc. Similarly, for helping develop leadership skills, students may be given opportunities and responsibilities for managing some events (for example, organizing

seminars), relevant workshops, aspects of PhD students' governance, and so forth. For developing their independence as researchers, they may be given opportunities to review papers, prepare research proposals, etc. If some patent is to be filed for a research project in which the student is involved, the student can be encouraged to take a leadership role in preparing the necessary documents, engaging with the lawyers and filing the patent. Much can be done to develop these attributes without diluting the academic rigour of the programme. Some more examples are given in Walker et al. (2008).

6.2.6 Supervision

A PhD programme is more like an apprentice-based individualized training. Therefore, its effectiveness depends considerably on the quality of advice or mentorship a PhD student gets. It should first be clarified that advising and mentoring are two distinct roles. An adviser helps the student progress towards completing the programme, ensuring that appropriate actions are taken at appropriate times and university requirements are fulfilled. A mentor, on the other hand, is a person who essentially guides a starting professional to develop skills and connections towards becoming a full-fledged professional.

- **Guidelines and/or training for supervision**: Generally, a PhD graduate who is recruited as faculty is free to take a PhD student and be a supervisor. As the PhD programmes themselves do not prepare the student for this role, it is expected that the experience of being supervised as a PhD student would have prepared a PhD student adequately for it. While this might often work, it is not sufficient and has no uniformity or consistency. It is therefore desirable that faculty members are provided with some training (through a workshop, for example) on different aspects of supervision. This is increasingly being taken more seriously in many universities. For example, in University of Melbourne, to be a supervisor, a faculty member has to undergo a training module every 5 years.

- **Multiple supervisors:** While the traditional apprenticeship model where the PhD student learns from one 'master' has worked quite successfully, it is broadly agreed upon that in the fast-changing and complex world, it is to the student's advantage if he/she has guidance and inputs from multiple supervisors. While it may not be desirable to legislate this as a rule, policies should support this so a good number of students are jointly supervised by a small group of supervisors.
- **Mentoring:** While the supervisor is often the primary mentor, having only one mentor has obvious limitations and risks, and a student is better served with multiple mentors (Walker et al. 2008). It is therefore important for the department or the university to provide mentoring to the PhD student, at least on how to successfully navigate the PhD programme and strategize career planning. It is sometimes done through a committee for the PhD student, which meets the student formally and regularly. Whatever be the mechanism for providing this, a good PhD programme is expected to provide good mentorship support to the PhD students, besides the support the supervisor provides.

6.2.7 Duration of the PhD programme and Attrition

Time to completion (along with attrition rates) is probably one of the most researched aspects of the PhD programme, particularly in USA, where the PhD programme is open-ended and, in many departments, time to completion tends to be rather long. Many studies regarding time to completion and attrition have been done (e.g., Bourke et al. 2004; Tuckman et al. 1989; Valero 2001).

While maintaining the open-ended nature of the PhD programme, it is possible to establish a reasonable completion time and then have support systems in place to achieve it, at least in most cases. A reasonable completion time, which is predictable for most candidates, is a desirable aspect of a PhD programme, which will also help attract more candidates.

It is important to have systems to achieve the desired completion times. It should be kept in mind that there is the possibility

of a conflict between the interests of the student and those of the supervisor regarding this aspect. Towards the end of the PhD, the student is most productive, and if he/she stays longer, it can benefit the faculty in terms of more research output. It is therefore important that a reasonable duration for the completion of the PhD is established, perhaps suitably adjusted for different disciplines, and the PhD programme makes efforts to achieve it. The desired attribute for the PhD programme can be a clear articulation of the expected duration of the PhD programme. When a new cohort joins, counselling on this aspect—including what factors can delay graduation, what the student can do to keep the duration in control and what support the PhD programme provides for the same—can be provided. The time to completion should also be monitored and analysed from time to time to understand the effectiveness of the programme and to take any remedial steps needed.

Sometimes, for different programmes, tentative plans for finishing within a stipulated duration can be provided. Often, universities and departments will hesitate in officially providing such guidance, as clearly there are other variables that can affect the duration and, officially, a department or a university might not want additional challenges. However, informal guidance by senior faculty members, senior PhD students and other competent individuals can easily be provided based on experience. (An example of guidance for completing a PhD in Computer Science in 4 years can be found in the blog post by Jalote [2011].)

Closely related to completion time is attrition rate—the fraction of students who join the PhD programme but do not complete it. PhD programmes are likely to have the highest attrition rates; they are loosely structured and have inherent risks and uncertainties, often without clear actions that can be taken towards completion. Unlike bachelor's programmes, which are seen as basic and essential qualifications today, the PhD programme is clearly a choice, and that too a somewhat eccentric and difficult one. It is not uncommon for a student to join a PhD programme and then discover after a while that it is not what he/she wants to do, resulting in his/her opting out of

the programme. There are clearly many other factors that affect the attrition rate, including the quality of support provided to students, level of guidance and culture of the department and the university, among others. Attrition is another factor that has been studied intensively, with many research papers having analysed the phenomenon (e.g., Bourke et al. 2004).

For a PhD programme, the goal is not to have zero attrition. Given the nature of the programme and uncertainties inherent in it, zero attrition is neither desirable nor achievable. It can also be argued that some amount of attrition is indeed desirable to allow the PhD scholar some room to revisit his/her earlier decision and plan for life—after all, doing a PhD is a long commitment which also alters the course of one's life and career. However, a large attrition rate is clearly indicative of issues in the PhD programme. What is desirable from a good PhD programme is that this parameter is monitored, the reasons for attrition are understood and necessary actions are taken to keep it in check.

6.2.8 Thesis Examination

Examining the thesis is the final check of quality. It is like the product acceptance test of a factory before the product is shipped out. In a production line, as is well established and known, the focus of quality assurance is to ensure that the production process is designed and geared towards producing a high-quality product. Still, at the end of production, before shipping the product out to consumers, most production systems will have a quality control check on the final item. The situation in a PhD programme is similar. Many of the attributes and dimensions discussed are to ensure that the process of the PhD programme has the desired features to produce a high-quality PhD. Still, before the student graduates, the thesis examination is the quality control check on the actual quality of the PhD work.

Actually, the methods followed for thesis examination are more than that and can impact the other attributes also. For example, if the thesis examination is lax, this message will be

picked up by existing and future PhD students, as well as by their supervisors, and this may then affect what they aspire to achieve through the PhD. It is of utmost importance that the PhD thesis review process is rigorous, which ensures that if a thesis has been accepted, it is of good quality, but which also communicates to future PhD candidates and to advisors that this is a rigorous check and that a thesis whose quality is not up to the standards will not pass through.

Given the importance of this final check, often, a good PhD programme will have two steps in it: a detailed examination of the thesis by experts and an open thesis defence. Setting high standards for this is crucial, as PhD scholars and their supervisors respond to it through a self-check of quality. Thus, if the review is rigorous, the scholar and the guide will ensure that the thesis is of a high quality before it is submitted. If the review is easy and more of a formality, it is likely to lead to many average theses being submitted (and approved). The thesis review depends on the committee of experts that reviews it and, finally, on the guidelines for forming the committee. For example, some universities require a committee of at least three external experts, all of them having a certain reputation in the field, with some of them from other countries and none of the experts having any conflict of interest with the PhD student or the supervisor.

- **Thesis review:** A good-quality PhD programme should have a rigorous thesis examination by a panel of (at least three) independent experts who are not related to the student directly, with systems to ensure that the experts can give a frank assessment of the thesis work and have a clear idea of the standards the university expects from its PhD thesis. The review report should provide suitable flexibility and room to the examiner to not only give comments and critiques but also clearly express his/her view about the thesis quality. For example, if only a binary choice (accept or reject) is given, it might be hard for a reviewer to have the heart to reject a thesis. On the other hand, if options include something like, the thesis is not worthy of a PhD but is worthy of an MPhil/

MS/…, it can provide the examiner another way of expressing negative views which may not be as hard to opt for. Similarly, the person(s) communicating with the examiners can impact the quality of the review; for example, if the supervisor is the negotiator, it might compromise the result.

- **Thesis defence**: If a thesis has been found acceptable during its review and changes have been made to address any shortcomings identified, it is often a custom to have an open thesis defence. The idea of an open defence is that the candidate should stand in front of all interested parties and defend his/her work. Anybody in the room has an opportunity to raise objections to the work done in the thesis. It also provides the final check to ensure that all comments raised in the review have been addressed satisfactorily. It also becomes a communication forum to share within the university or a department and with the rest of the community the work being done in a PhD thesis, and provides the PhD student with an occasion to explain her work to a wider audience. It provides an excellent opportunity for other PhD students to see what type of work qualifies for a PhD and exposure to the last stages of the PhD programme. The tradition of a PhD defence is, however, not universal. However, given the benefits it can provide, and the fact that the time and effort required for it are not much, it is desirable that a good PhD programme should have an open thesis defence that is advertised widely (perhaps even outside the university) and which is attended by many. It is clearly desirable for all thesis reviewers to attend the defence in order to ask any other questions they may have and to confirm that all the concerns raised earlier in their evaluation have been addressed adequately.

6.2.9 PhD Programme Administration and Student Support

It is of utmost importance that the PhD programme is administered efficiently, keeping in mind the interests of the PhD student. As PhD students are partly like staff, there should be an administrative unit looking after their interests and grievances. In

addition, there are many steps in a PhD programme (for example, comprehensive exam, thesis examination, thesis defence, etc.) which cannot be completed by the PhD student and the supervisor. They require inputs from the academic administration. It is not uncommon to find in some programmes delays in the graduation process of a PhD student by a few years, simply because of lack of reviews or delays in scheduling the defence. PhD students need a lot of support during the many years they work on their PhD. Some aspects of administering and assisting PhD scholars that are important for a high-quality PhD programme are discussed here.

- **An exclusive structure for administering the PhD programme**: It has been noted that PhD programme governance and administration cannot be left to just the non-academic staff. For a host of reasons, a senior academic should administer the PhD programme. The process should be bolstered by a range of policies and procedures; most of the aspects discussed earlier have to be documented and implemented in spirit and action.
- **Decent stipend/compensation**: PhD students, unlike the learners in bachelor's and master's programmes, contribute towards one of the main outputs of a university—research. They often help the regular faculty in education, which is the other important mission of the university. Therefore, they should be compensated suitably. In addition, there is an opportunity cost of doing a PhD—a graduate is not earning market wages while doing a PhD. If the opportunity cost is too high, it can strongly counter the incentives for joining a PhD programme. As it is, it is often hard for many people to choose to do a PhD. If the compensation is not suitable, it may dissuade them even further.
- **Career counselling and pathways**: This has been recognized as a common weakness in many programmes. Many universities just leave PhD students to their own devices or expect their supervisors to provide advice about career choices. Supervisors, having chosen academics as their profession,

may be out of touch with other professions for a long time and cannot always be expected to have the knowledge or skills to provide proper career counselling about all the new opportunities opening up. Hence, it is important for a PhD programme to provide suitable career guidance to its PhD students.

- **Infrastructure and other support**: PhD students need infrastructural support to do their work, including access to laboratories and libraries, hostel accommodation, computing resources, and others. They also need a variety of other assistance, for example, help in writing (thesis and scholarly papers), attending conferences, building a professional network and establishing their reputation. Many of these are often provided informally by the supervisor and mentors. It is also desirable to provide counselling support to these students. PhD is a very exacting degree, and students often go through very rough periods; having decent counselling support will help.
- **Setting the expectations**: What is expected from a PhD scholar for him/her to successfully complete his/her PhD? The answer to this question, unlike similar questions for a bachelor's or master's degree, is often not very clear. While the expectations cannot be articulated as precisely as can be done for an undergraduate programme, still, a department and a university should establish some expectations and articulate them clearly to the PhD scholars. Not being clear about the expectations is one of the most common complaints of PhD students. Similarly, there is often insufficient clarity about the rules regarding the different aspects of a PhD programme, in particular the rationale behind them (Walker et al. 2008). It is important that PhD students know the various stages involved during the PhD, the reason for the rules governing the different stages and the expectations of each of them.
- **Exit interviews and improvement**: It should be accepted that a PhD programme is not static and should continue to improve. As the goal of any programme is to deliver on its stated outcomes, feedback from graduating PhD students,

as well as those who graduated a few years earlier, will provide excellent inputs for further improvement. Learning and improvement is facilitated if there are processes put in place for collecting data, analysing it, learning from it, using the insights gained for deciding upon the subsequent actions to take for improving the programme and, finally, implementing the actions. A good-quality PhD programme will have some formal process for this learning and improvement which it will execute regularly. As with other programmes, such analysis should be discussed and deliberated upon widely, including with the PhD students.

- **External review of the PhD programme:** A PhD programme is often not assessed carefully. Accreditation programmes generally focus on undergraduate programmes, and department reviews often look at general issues, particularly relating to faculty. It is implicitly assumed that a PhD programme will be reviewed and refined internally. One of the main challenges of an internal review is that faculty often have different views and may even have turf wars leading to positions that are hard to reconcile. In the absence of conflict resolution, the attempt should be to avoid such conflicts, which often leads to guidelines that are not necessarily in the best interest of the PhD programme but are added to maintain decorum (Walker et al. 2008). Given that internal mechanisms might not work, an unbiased external review by peers can be highly desirable. Such a review will inevitably meet with PhD scholars, as well as with faculty supervisors, and identify challenges faced by both groups—the first step towards refining the system.

6.3 CASE STUDY: PHD PROGRAMME AT IIIT-DELHI

The PhD programme at IIIT-Delhi was designed such that it could address some of the key issues uncovered in the survey of prospective PhD scholars, as discussed earlier. The entire cycle of the PhD programme—from admission to thesis defence—was carefully thought out so as to address the challenges PhD

programmes in the country face. Partly as a result of this design, within a few years of starting the PhD programme in Computer Science, it became one of the largest programmes in the country. Data about placement of graduated students also indicates that the quality of PhD graduates is as good as the best in the country. We will discuss some key aspects of the programme.

6.3.1 Duration of the PhD Programme: Plan for 4 Years but Allow 5 Years

The duration of a PhD programme has always been a contested issue, and different models have been adopted. On one side is the model commonly followed in USA (and largely also in India), that the PhD is an open-ended degree, as creativity and new ideas and results are required, and whether sufficient work has been done cannot be predicted. Indeed, one cannot even predict if a scholar will complete a PhD. On the other side is the model often followed in UK and Australia, where a student starts the PhD with a good understanding of the problem he/she wants to work on and is given 3 years to complete it.

At IIIT-Delhi, a middle-of-the-road philosophy was adopted. The basic premise was that a PhD can generally be completed in 4 years, if progress is monitored carefully. However, there are situations wherein it may take longer, and while a longer duration should be discouraged, it has to be permitted.

This approach was implemented by an innovative approach. The fellowship of a PhD student starts from the first year and increases every year by a modest amount till the fourth year. In the fifth year, however, the fellowship reduces (to approximately the level of a first-year PhD scholar), and from the sixth year onwards, no PhD fellowship can be provided, even if the supervisor has projects from which he/she can provide support.

It should also be noted that, in the view of prospective PhD students, a duration of 4 years, which can mostly be achieved, is one of the most desirable attributes of a PhD programme—this

was revealed in the survey discussed earlier and also comes up in discussions with prospective students. Overall, having strong policies in place to see that students complete their PhD in 4 years is hugely desirable, so both students and supervisors can align towards achieving this. It is also a goal that is clearly achievable, particularly with allowances for more time in special situations.

6.3.2 Admissions

As mentioned earlier, research universities in countries like India face a special challenge finding good students for their PhD programmes, and hence the open application-based approach, which is the most common approach used worldwide, will not suffice. Hence, it was felt that multiple channels must be created. The main channels that are used are:

- **Open application process**. This is the standard approach, in which students apply to the PhD programme in different disciplines, along with their resume, score in graduate admission tests (GATE in India), transcript, etc. After screening based on the available information, candidates are invited for a test and interview. As most entrance tests in India are subject-based and do not assess general aptitude (e.g., quantitative, reasoning, logical, etc.), the test focuses on this aspect. The interview is used to assess the level of interest and motivation and communication skills.
- **Rolling admissions**. In this channel, the candidates first engage with a faculty member for research. The faculty member may offer internship or training or use other means to assess the potential and suitability. If the faculty member is satisfied, then the candidate may apply, with the faculty member being the proposed supervisor. The candidate is assessed by a committee that may recommend admission. With this channel, effectively each faculty member is empowered to look for potential PhD students, which opens up new possibilities to identify PhD candidates.

- **Conversion of master's programme to PhD.** Most universities have procedures for permitting a master's candidate to migrate to PhD. In IIIT-Delhi, this was formalized and incentivized to motivate the best master's students to migrate to PhD. The idea is to identify those students who have already shown potential to do a good PhD in the two or more semesters that they have spent at the institute and invite them to join the PhD programme. If the student decides to migrate, then he/she is deemed to have joined the PhD programme from the time he/she joined the institute. This implies that the course requirement for PhD will be what it would have been at the time of joining the institute (this can save a semester or so of coursework). More importantly, as there is no tuition fee for PhD students, the tuition fee of the master's programme is refunded to the student. This is a significant incentive, as the tuition fee of a master's is substantial.
- **Campus recruitment.** As mentioned earlier, it is desirable to 'cast the net wide' to find the few candidates that might be there in places which are not generally considered as sources for PhD candidates. For this, a few colleges are visited where tests and interviews are conducted to identify deserving candidates, who are invited to the institute for the final interview. This is an effort-intensive exercise and so is done only occasionally. However, some research universities that want to consider this channel can easily expand and refine it by getting into partnerships with selected institutions, whose graduates have shown good performance in the past, for admissions, whereby the partner institution can do the initial screening.

6.3.3 Preparing Students for Research and a Research Career

Generally, after a bachelor's or a master's degree, students are not adequately prepared to undertake research. In fact, they often might not have even had exposure to research and current developments in different fields. To address this, there is a requirement

in the PhD programme for a student to earn a certain number of course credits. The number of credits to be earned depends largely on the highest degree a student has. Such coursework requirement is common among the top research institutions in the country and helps not only in strengthening the background of PhD students, but also in developing an appreciation and understanding of research, before they undertake research themselves.

In India, it is widely recognized that even in the best research institutions, the PhD students often come from institutions which provide average quality education leading to students not even well prepared in foundations. To address this, some 'refresher modules' (which were introduced for master's students) are offered, some of which the students take during summer before starting their formal programme, and some like the module on 'Technical Communications & Research Methods' are taken during their first two semesters.

To develop teaching skills, all PhD students are required to be TAs for at least two semesters. To prepare them for their duties and help them leverage the experience to become better teachers, they are provided a short training. They are also given a handbook of best practices for TAs contains some strategies and best practices for conducting an interactive class, techniques for time-efficient grading and designing rubrics, some tips on the effective handling of score disputes, maintaining a professional conduct, handling academic dishonesty and student questions in office hours, etc. These are only initial steps towards using TA duties as training for a career in teaching—clearly, much more needs to be done so the TA experience can be leveraged suitably.

6.3.4 Progress Monitoring and Regular Reviews

The nature of a PhD programme is such it is easy for a PhD scholar to 'lose' a semester or two with minimal progress or contribution towards completion. To monitor progress and to send the message to students and supervisors that progress is

expected so that PhD may be completed in the expected duration of 4 years, regular progress review monitoring is done.

To assess the progress of PhD students, some expectation of what progress means from year to year needs to be understood, as the expected progress in the first year of the programme will clearly be different from the expected progress in the third year. Also, a holistic programme of a PhD student should look at the knowledge acquisition as well as knowledge creation aspects. At IIIT-Delhi, a template is provided for reporting the yearly progress. It captures different aspects, including: courses taken, areas in which expertise has been gained, papers submitted, plan for the next year, performance with respect to last year's goals, etc.

The yearly review is done based on the report and a presentation by the PhD student to the committee. A feedback report is given to the student (and supervisor), which, besides capturing whether the progress is satisfactory or not, provides constructive inputs to the student for improving his/her work.

In addition to the yearly review, which is generally done at the start of the academic year, quick, stock-taking mid-year reviews are also done. This review is different from the yearly review, and the purpose is also different. In this review, each supervisor summarizes the progress in a couple of minutes to the entire department faculty. This review is also meant to inform all faculty members about the PhD work going on in the department, which has many indirect benefits. This might appear as be a tedious exercise, but if done well, it can be done in an afternoon for a small department.

6.3.5 International Exposure

As the aim of a good PhD programme is to produce high-quality global researchers who are comfortable working anywhere and with colleagues from different countries, it is important for a PhD student to get some international experience. This exposure is even more important for PhD programmes in a country like

India, where the research ecosystem tends to be smaller, with fewer opportunities for researchers to engage with international academics and researchers. International exposure, particularly exposure to institutions with a vibrant research culture and a large population of researchers, can have strong beneficial effects on PhD scholars' motivation, aspiration, etc. To facilitate this, a few different schemes are made available.

- **International conference travel support:** Each PhD student has a budget for this purpose. While the budget is limited, it can easily be leveraged to support more travels, for example, by utilizing the support to get grants from government/agencies, support from conference organizers, travel grants by research labs, etc. The support is for presenting papers, and only in reputed conferences.
- **External co-supervisor:** PhD students may have, besides supervisors from the institute faculty, external co-supervisors from reputed institutions and labs globally. These co-supervisors have almost the same role as supervisors and are recognized in the same manner as the supervisors from the institute. Having regulations to enable co-supervisors not only helps international collaborations but also facilitates joint PhD programmes. (Of the students who finished their PhD in the last 2 years, about one-fourth had external co-supervisors.)
- **Overseas research fellowship.** This is the most ambitious scheme, which is financially the most challenging. In this programme a student can spend up to 6 months in a research university or a lab. During the visit, the student must work with the collaborators in the host institution on research that will contribute to the PhD thesis. The duration can be extended, if the collaborator wishes and can sponsor the extension. It would be desirable if the host is also an external co-supervisor. (About half of the recently graduated students spent a semester or longer overseas.)
- **Joint PhD programmes.** Joint PhD programme between two universities are those in which the PhD student has supervisors from both universities and in which the PhD scholar spends

substantial time in both with the respective supervisors and a degree with both Institution's names is granted. Clearly, such a programme is highly valuable for a PhD student who can benefit from supervisors from two different universities and countries, as well as get substantial international experience. It is also valuable for universities to increase their international collaboration for research.

There are, of course, challenges in operationalizing this, as the regulations of two universities have to be satisfied. One approach (which IIIT-Delhi has taken) is that the student has to satisfy the PhD requirements of both the universities. While this might look like it might overburden the student, in practice, it is not so, as, often, the requirements of collaborating universities are similar and are likely to have enough flexibility to be satisfied by another similar university regulation. Only minor adaptations are needed.

A key challenge for this programme is the funding—who funds the PhD student when he/she goes to work with the collaborator. This issue is particularly important for India, as the fellowship being provided here is clearly insufficient for staying in most developed countries. The current practice is that while the student is with the partner institution, that institution supports the student. The other main challenge in this is to form supervisor pairs who will guide the student. If some faculty members know colleagues in partner universities, this is not too hard. However, to increase the scope of the programme, it is desirable to facilitate the forming of supervisor pairs—this might require initial support for visits, workshops, etc.

6.3.6 Comprehensive Exam

The aim of the comprehensive examination is to check the understanding of the PhD student about his/her area of research (not just the problem on which the candidate is working). Though traditionally a comprehensive exam was meant to check whether the student has sufficient breadth, it was felt that this type of

breadth should be fulfilled through courses and the comprehensive exam should be used to test the 'comprehensiveness' of the candidate's knowledge about his/her main area of research. Hence, the comprehensive exam at IIIT-Delhi is not for checking the comprehensiveness of a candidate's understanding of the discipline, but for checking the comprehensiveness of understanding of the area in which the student is working.

Effectively, the comprehensive exam becomes a checkpoint, which establishes that the candidate has comprehensively understood the problem area and has a solid understanding of the area around the problem, that is, the area to which the problem belongs. The report submitted for the comprehensive exam can also form parts of the 'related work' chapter of the final thesis, thereby making it contribute towards the thesis and PhD completion also, rather than just being an exam consuming extra time and effort (which helps in finishing the PhD in the expected duration). There are guidelines for by when the student is expected to complete the comprehensive exam and the committee constitution.

6.3.7 Thesis Examination and Defence

In many ways, processes set for the thesis examination, and how they are executed, have a significant impact on the quality of the PhD. Perhaps, the most important aspect of defence is the selection of the committee and the conduct of the defence itself. The thesis evaluation committee is formed from a panel of names submitted by the advisors of the student. There are clear guidelines for who can be included in the panel—in terms of seniority (Associate Professor or above), from within India and outside (at least one member of the committee must be from outside the country), conflict of interest (anyone with a conflict of interest with the student cannot be included), etc. For each name in the panel, a statement about the person's suitability and some publications in the area are also provided. From this panel, at least three persons are selected as external examiners, one of

which must be from overseas. The names of the examiners are not revealed to the students or the supervisors (they are revealed only at the time of the defence).

The examiners are expected to send a detailed report on the thesis within a time limit. Based on the report, the student is required to provide a detailed response addressing each of the issues raised and what changes have been made in the thesis. Once the PhD administration is satisfied with the response, the thesis defence is scheduled. All examiners are invited to join—physically, if they can travel, or through electronic means. The supervisors also join the defence. The defence often lasts about 2 hours and is open to all—often, many PhD students attend it. After the defence, the committee submits its joint report using the template provided, which has multiple options like accept with minor changes, accept with major changes, reject, accept for an MTech, etc.

6.4 SUMMARY

A strong and vibrant PhD programme is the hallmark of a good research university. It is very different in its aim and methodology from the bachelor's and the master's degrees. Compared to these courses, however, it is also a programme that gets less attention from academic bodies as well as from accreditation frameworks.

The chapter begins by emphasizing the objectives and learning outcomes of the PhD programme and the desirable attributes of a PhD scholar. It then goes on to discuss the salient characteristics of a strong PhD programme. It first discusses, based on a study, what prospective students expect from a PhD programme. It then studies in close detail the PhD programme's many facets, starting from the admission process leading on to the preparation for research to the methods of monitoring progress effectively and mentoring scholars meaningfully. The proper procedures of examining the candidate and the final appraisal of the research done are foregrounded, with emphasis on the principles

underlying each stage of assessment. The chapter also considers various aspects of administering the PhD programme.

The chapter ends with a case study, that of the PhD programme at IIIT-Delhi, in order to provide a specific real-life instance of a programme that embodies many of the principles examined earlier. Thus, from charting the broad ideals of the programme to highlighting a particular application of the same, the chapter provides both the educationist and the aspiring research scholar with a comprehensive overview, as well as an analysis, of the important aspects of the PhD programme.

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