Chapter 3

Education

Delivering High-Quality Learning

Higher education was the original mission of universities, and remains the primary mission today, even for research universities. In fact, it is the presence of an education mission that distinguishes a research university from research labs. Manpower development through education is still the most significant and impactful contribution to society by universities, including research universities.

The importance of higher education is also increasing. As the world becomes more complex and more dynamic and is rapidly changing, businesses and societies are expecting universities to produce manpower that is adept at working with modern and fast-changing technologies in an increasingly complicated world.

Education is also the primary source of revenue for universities—even for many of the research universities. In UK, some of the universities support themselves largely through this per-student grant for education (Willetts 2017). The situation is similar in Australia, where the grant given to universities for education on a per-student basis accounts for the major portion of the revenue of a university, even for some of the top research universities. In India, most publicly funded universities get yearly grants from the government for their operation and expenses, and while grant for education is not earmarked separately, it is

fair to say that most of the government grant is provided for the education in these universities.

While access to higher education has increased in India over the years, particularly with the large presence of private players running affiliated colleges, the quality of education has declined. There are various reports regarding the poor quality of education being imparted in most of the HEIs leading to only a fraction of the graduates being employable. There are many reasons for the decline in quality, including narrow focus, lack of culture of research, old and outdated curriculum and teaching methods, uninspiring teachers, lack of quality governance and leadership, poor quality of faculty, etc., as discussed in Chandra (2017).

Research universities tend to be among the best institutions for undergraduate education, particularly for professional programmes. Even a cursory look at the national or global rankings will show that the best research universities are also the most sought after for admission in their undergraduate programmes. This is broadly true in India as well—the most respected institutions for research (e.g., IITs, Delhi University, Jadavpur University, etc.) are also the most sought after for education. This trend is likely to remain so in future, as research skills become a necessary component of outcomes of even undergraduate programmes.

In this chapter we discuss some important aspects of providing high-quality education. The discussion in this chapter is largely for undergraduate programmes, though many of the ideas can be applied to master's programmes also. (We consider PhD as a research training programme and discuss it in a separate chapter.) In the chapter we discuss aspects of programme design, including programme outcomes, course design and learning outcomes, interdisciplinary programmes, etc., as well as feedback systems for ensuring high-quality education and learning. But before that, we discuss the special role of research universities in higher education.

3.1 EDUCATION IN A RESEARCH UNIVERSITY

What are the purposes of higher education? What is it supposed to do to the students undergoing it? These are a philosophical questions and answers can vary from developing responsible citizens and critical thinkers, to professional development for lifelong employment, to spiritual development. However, if we look at the impact higher education has on students, two key goals stand out—professional development and self-growth or self-development. This aligns with the framework of the European Union (EU), which states sustainable employment, personal development and active citizenship as three dimensions of relevant higher education (Vossensteyn et al. 2018), if we consider citizenship as part of self-growth. It is also similar to the framework discussed in Bridgstock (2009), which groups graduate attributes into two types—those pertaining to the capacity for citizenship and those pertaining to work productively.

Most students undertaking higher education, and often paying significant tuition fees, clearly expect higher education to provide them knowledge and skills which will help them in their professional career in life (which could be employment or self-employment). Hence, professional development is clearly the basic goal of higher education. The years a person spends in a university are perhaps the most defining ones in a person's life. For most students this period has a significant impact on their personality, interests, thinking, relationships, values, etc. All these we consider as part of self-development. For high-quality education, a university should provide development of the student in both these dimensions.

Most research universities take their education seriously and indeed are often the most sought-after for their education programmes also. While the education mission of a research university is similar to that of a teaching-focused university, the flavour and style of education in research universities is often quite different, and research universities often view education somewhat differently and as synergistic with research. Indeed, the

objective of education in research universities can be argued to be somewhat different than that in teaching-focused institutions.

The number of students who will get their education in these research universities will be a small fraction of the total students. Given that these research universities, due to their high-quality faculty and prestige and other reasons, are also highly sought after, admission to these is highly competitive. In the Ivy League colleges in USA, it is often in single-digit percentages. In IITs in India, the acceptance is still just about 2 per cent of those seeking admission. Given that the intake in these universities is highly selective and the best minds join them, clearly, the goals of educating this cohort should be different than those of educating a general cohort. Let us start the discussion by looking at some special aspects of education in a research university.

3.1.1 Teaching–Research Nexus

Many have argued that there is a nexus between research and teaching, and that these two missions are not in conflict and can be synergistic. A considerable body of work exists on examining the teaching–research nexus. An example of how this nexus is supported in one university is discussed in Gibbons (1998), and a few types of connections between teaching and research are discussed in Neuman (1992). Though the debate about the nexus is not settled, it is possible to actively plan and support this nexus, and different approaches can be applied for this (Healey 2005)

Teaching benefits from research are generally quite evident. A teacher who is an active researcher will be well-versed with the latest developments in a subject, and hence while teaching that subject will be able to include the latest developments. There is also a qualitative difference in the teaching of a course when taught by a researcher in the field. With research faculty, advanced courses can be taught, which, besides covering the latest developments, may also provide students an opportunity to do some research. Moreover, such faculty will often offer projects, either as part of the courses or as capstone or final year projects,

which are research-oriented—this can provide the students a deeper understanding of some areas and develop limited research capability. Overall, it is easy to see how teaching can benefit when the faculty are research-active.

However, it is not very evident how the research of a faculty or department can benefit from teaching. At the faculty level, conflicts can arise, since in pursuit of research faculty members may want to prioritize research over teaching for their time allocation and may view teaching as consuming valuable research time. Let us discuss some aspects of how teaching can support research.

At the most basic level, teaching helps solidify the depth of knowledge about a subject. As is acknowledged and experienced by many academicians, the process of explaining is one of the best ways to clarify things to yourself, and doing so to a class of bright students has the extra benefit of students potentially challenging the ideas or explanations or requiring further clarifications—which inevitably helps the faculty member in deepening his/her own understanding of the subject matter. As research universities tend to have top students and the ethos of such places encourages questioning and critical thinking, teaching in such universities undoubtedly helps the teacher also in further mastery of the subject.

Research universities are often at the forefront of introducing courses on emerging technologies and areas. Such courses are often intricately tied to current research and developments in the subject and may often start as 'special topics' or 'seminar' or 'advanced course'—with time, they may become standard courses. These courses are inevitably initiated by faculty working in the area and often start without a textbook in the area, with research papers as the primary source for the course. The format of the course is also often far more interactive, with students participating actively in researching on different topics in the subject, as well as often developing new ideas as part of their semester project or report. These types of courses further the research agenda of the faculty member in multiple ways.

First, it helps the faculty master the related work in different sub-areas of the subject and helps him/her conceptualize a suitable framework for structuring the knowledge—something that is often needed for a course. This directly furthers the research agenda of the faculty member. In academic circles, it is well-known that if a faculty member wants to get into a new area, he/she often prefers to teach a course on that area, with an important goal of developing mastery and depth in it.

Second, often offering such courses results in direct research outcomes. This can take the form of identifying important research problems to work on—something that a detailed survey and a deep understanding of the state of the field facilitate. These research projects can then be developed later. Sometimes, in these courses, students working on course projects or reports come up with interesting issues and solutions, which may then result in research publications and direct contribution to knowledge creation. Many faculty members have benefitted from this potential, and there are many research publications that have come out of such courses.

Third, such courses provide the students with an opportunity to go deeper into an area, and so if a student finds it interesting, he/she may choose to work in the area. The natural choice of selection of supervisor will then be the instructor of the course. In other words, such courses also provide a platform to attract good students to do their research work or thesis in the area and under the instructor, and their performance in the course also provides the faculty a better understanding of the students' capability and interest in the area. As faculty members in research universities are always keen to attract good students to do their research or thesis with them, such a course aligns almost directly with their research agenda.

In fact, such courses can be treated almost as a research activity. It is not surprising that there is generally a strong contention among faculty members to get an opportunity to teach such courses. Many departments have policies regarding how such

courses are allocated. There are different ways in which the teaching–research nexus can be actively supported, and there are multiple ways in which such advanced courses which embed research can be organized (Healey 2005). A policy that directly recognizes the value of such courses and the teaching–research nexus, which is followed in IIIT-Delhi, is as follows. The standard teaching load of faculty is three courses in an academic year. Of these, while two courses are expected to be standard courses, the third course may be a special topic or advanced course directly aligned with the faculty members' research. This policy has helped institutionalize research as part of education—not only for students but also for faculty members—and explicitly recognizes the teaching-research nexus.

The benefits of research on teaching and those of teaching on research are widely acknowledged. The importance of faculty engaging in research to educate is widely acknowledged, and lack of research in many of the HEIs in India has been recognized as one of the causes of the poor quality of education (Chandra 2017). The NEP also recognizes and supports this connection and urges a strong research culture to be built in universities and a culture of research to be developed in all students.

3.1.2 Leadership in Programme, Curriculum and Course Design

All universities have a range of education programmes. For each programme, a curriculum in terms of courses a student may take in that programme is specified (along with other constraints and requirements). For each course, a syllabus is defined to ensure learning by the students in the subjects of the course. None of these three are static—new programmes and courses are often introduced, and syllabi for courses are often enhanced. Research universities are expected to take leadership in all these three.

New programmes are sometimes started by universities—while the starting of new programmes is not too frequent, it is a standard mechanism used by universities to respond to changing

demands. New programmes are started generally in response to the changing needs of the society and industry and the consequent potential demand from students. The design of a programme is often a long process involving inputs from a range of sources, in particular from the industry or other potential employers. Often, data about the demand may not exist (as the programme does not exist). To create a programme that would produce manpower 4 years later which would be highly valued by society is an act of academic leadership, and the leading research universities are naturally expected to take this initiative. They are also well placed to undertake it as, besides having the leading subject matter experts in their faculty, they often also have strong linkages with the industry and other stakeholders to evolve a better understanding of the skills and capabilities that need to be developed by such a programme.

The curriculum for the programmes evolves over time, and all universities have mechanisms to review their curriculum and revise it as needed. As part of any revision exercise, it is common that universities will look at the curriculum of other leading universities. Generally, the curriculum of leading universities in the field inevitably influence the design. In other words, often, improvement in the larger education system may originate in what is being done in the leading universities. Given this, research universities play a leadership role in curriculum development—their curriculum can impact many other universities. These universities should be cognizant of this role which, even if they did not actively seek it, has been assigned to them.

Most universities will regularly add new courses on subjects of importance or include in the current education recent developments and advancements in knowledge. These leading-edge courses are often driven by the state of the knowledge. Since the research faculty in these research universities are often the leaders in their fields and are instrumental in the development of the fields and the furthering of knowledge, they are in the best position to design such courses and refine them based on their offering them to their own students. Such courses can then be taken up

by other universities. Introduction of new courses, particularly in emerging areas, is a key role research universities have—not only for offering it to their students who have high expectations from their education, but also for helping introduce such courses in other institutions.

Another area in which research universities are expected to take leadership is research on education itself. Given the research capability and culture of research universities, and the fact that there always are open questions about education, it is natural for research universities to undertake research on higher education itself. Higher education has been a subject of research, and will continue to be so, as technological and societal changes require higher education to respond appropriately with changes in curriculum, support for learning, use of appropriate technology, etc. While all research universities are not expected to conduct research on education, some of them must do so. These universities are the most suitable hosts for doing this research. Not only do they have the research capability and culture and environment, but the university itself offers a platform to study higher education and conduct experiments where needed.

There are two key dimensions to research on higher education. One involves the higher education system itself and the related structures, frameworks, processes, etc. The other involves pedagogy-related issues in higher education (which are often different from the pedagogy issues of children or school students). There is a need to do research on both these aspects of higher education.

3.1.3 High-Quality Learning Experience

Given the highly selective intake, it is expected that research universities will provide a high-quality learning experience to their students through innovative and sound education practices. Indeed, given the selective intake, it is incumbent upon these universities that the learning environment and education practices are the best.

One of the aspects of education in these universities is that research is part of the education. While most undergraduate programmes generally focus on developing attributes that will develop the students for professional careers, one of the careers research universities must develop their students for is a career in research. Given their focus on research, and the research faculty that exists in these universities, this goal is natural. Some percentage of their graduates are expected to take up research careers.

Even otherwise, research capability is fast becoming a skill needed for most professional careers, given the pace of innovation and new-knowledge creation. Innovation rests often on the scholarship and research capability of the person—how well equipped the person is in reading and understanding research papers on the latest developments, in seeing the potential value of new developments for his/her work, to aid further development to make research results more suitable for the current job, etc. Research universities can develop these capabilities in their graduates by making research available even to undergraduate students.

Most research universities indeed have mechanisms for allowing undergraduate students to participate in research. These could be allowing some academic credits for undergraduate research, doing research for their UG project, research internships in labs and with faculty members, etc. This is often a unique offering of research universities—one that aligns well with its education goals as well as with the aspirations of its students.

High-quality learning experience, besides having the best curriculum, should also support learning opportunities outside the formal coursework and classroom. Experience indicates that while students learn in the courses which are taught by faculty, they also learn a lot outside the classroom and formal coursework. Many will argue that, in fact, it is the learning from peers that is the strongest in the best universities, as they have the highest quality peers. In other words, learning does not only take place in the formal coursework, but a lot of it also happens from the environment the university provides. Therefore, for high-quality

learning experience, research universities need to provide such an environment.

The formal education programme, or the curricular aspects, usually focuses on professional development with some elements for self-growth. Much of the self-growth dimension is left to the informal processes that take place in corridors, hostels, student clubs and extracurricular activities, student–student interaction, student–faculty interaction, etc. These informal processes also support the professional development goals—for example, students learn a great deal from each other.

Generally, so much emphasis is placed on formal teaching that learning and growth that happen outside the formal curriculum have not been studied or understood well. The faculty and the universities like to believe the self-servicing view that what is taught in the programmes by the faculty is all that matters in education. Thankfully, universities have evolved as open and liberal communities which naturally provide a rich environment for significant informal learning and self-growth. A great university is one that provides a facilitating environment and strong support for development in both these key goals.

One way to encourage students to engage in such activities is to identify some activities and provide limited credits for these. Many universities follow this. For example, in IIIT-Delhi, students are required to earn two credits of 'self-growth' and two credits of 'community work' for graduation. These allow students to develop their interests outside the profession and learn to contribute to society. Both these have received tremendous feedback from the students on their learning and growth. (The community work credits were used effectively for conducting a summer camp for school children from poor neighbourhoods—discussed further in the chapter on the third mission [Chapter 5].)

3.2 CURRICULUM DESIGN

We now discuss the design of a curriculum for a degree programme. (Programmes are called courses in many contexts;

however, we use the term course to refer to units in a programme.) In this section our discussion will be around undergraduate programmes, though the same concepts apply for master's programmes also.

The design of a programme starts with what types of careers or roles it is trying to prepare its students for. We will refer to these as objectives of the programme. Often, these objectives may be common for a class of similar programmes—for example, BTech programmes may have similar objectives, while BA programmes (in social science and humanities) may have different objectives. These objectives may be stated in terms of what careers a graduate may be pursuing a few years after graduation, and are generally influenced by the mission and vision of the university.

As an example, let us consider the BTech programmes in IIIT-Delhi. The institute has stated that its programmes are preparing the students for careers in: Engineering, Research and Entrepreneurship. Stating the education objectives as specific careers has some clear implications on the programme design. A traditional programme is often designed for engineering careers and hence may focus mostly on developing engineering skills and foundations. With research and entrepreneurship careers also as the education objectives necessarily requires that all programmes should have opportunities for students to develop capabilities for these careers also in the programme. That is, there need to be courses, projects, industry interaction opportunities, etc. to support these. Also, stating these as education objectives does not mean that students cannot choose to later go into other careers like finance or management (e.g., by doing an MBA)—it only states that the education programmes will be designed to support these stated objectives.

With the overall objectives, specific outcomes for each programme are defined. These are the attributes of the graduates at the time of completion of the programme, or statements about the student's capabilities at the time of graduation, and are called programme outcomes or graduate attributes. Clearly, these should align with the objectives of the programme.

The programme outcomes are finally delivered though courses that are taught by faculty in semesters over the duration of the programme. Each course has to be designed to ensure some learning, such that together the courses can deliver the learning stated in the programme outcomes.

In the rest of this section, we discuss these aspects of the programme design. The designed programme translates to courses in the programme, which are the unit of teaching in a university. We will also discuss the effective design of courses. Following this discussion, we will discuss the design of interdisciplinary programmes and the use of open courseware. In the next section, we will discuss how the designed programme and courses can be delivered for effective learning.

3.2.1 Graduate Attributes (Programme Outcomes)

A degree programme can be specified in terms of what capabilities a student will have at the time of completing the programme, that is, the attributes graduates of the programme are expected to have. These are called programme outcomes or graduate attributes (sometimes, these terms are used with subtle differences; in our discussion here, we consider both of them as specifying the same thing). These outcomes should be aligned with the stated education objectives.

Clearly, programme outcomes will depend on the programme—so a BS in psychology will have different outcomes than a BTech in computer science. However, universities aim to develop some common attributes or capabilities in all their programmes, so graduates across different disciplines are expected to have some attributes that are common. These are sometimes called generic graduate attributes. These are skills and capabilities of graduates which are beyond disciplinary knowledge and often aim to develop the individual for being a responsible member of the society and develop skills that are transferable to different contexts (for a discussion on generic attributes, see Barrie [2006, 2007] and Bridgstock [2009]).

With general graduate attributes, programme outcomes can be divided into two groups: a general set of outcomes that apply to a family of programmes and a specific set of outcomes, one for each programme. For many professional fields, professional bodies also specify graduate attributes, which they expect the degree programmes to support. Often, having these attributes may be necessary for accreditation of the programmes. As can be expected, these graduates' attributes should be such that they will help in achieving the education objectives established by the university.

One common method of specifying the general attributes is to enumerate them as assertions about the graduates of the programmes. For example, in IIIT-Delhi, the general attributes for BTech programmes are:

- Ability to function effectively in teams to accomplish a common goal;
- An understanding of professional and ethical responsibility;
- Ability to communicate effectively with a wide range of audience;
- Ability to self-learn and engage in lifelong learning;
- Ability to undertake small research tasks and projects;
- Ability to take an idea and develop it into a business plan for an entrepreneurial venture; and
- Understanding of the impact of solutions in the economic, societal and environmental context;

The general outcomes play an important role in the holistic development of the student. Due to their wider and foundational importance, most good universities give careful attention to these outcomes. In India, often, the education is too narrow, with early specialization, thereby allowing students to graduate without the strong general attributes needed for a good citizen (Chandra 2017). The new National Education Policy (NEP) of the government of India has articulated the importance of education programmes moving from narrow, discipline-based education to one that is based on broader, more liberal education. The NEP envisages

broad-based and multidisciplinary foundations to be provided beyond the disciplinary knowledge to develop well-rounded students who have good values and cultural literacy and general capabilities like critical thinking, problem solving, data analysis, communication, teamwork, social responsibility, etc. (NEP 2019).

While the general attributes are largely aligned with the broad goals of education, for a programme in a discipline, a fundamental goal is to develop competencies related to the discipline which can lead to gaining productive employment. Typically, these are evolved by experts in the discipline, with inputs from the end employers/users of the graduates. Most universities that explicitly state the programme outcomes will state these on their websites. For example, the goals of the Computer Science programme in IIIT-Delhi are to develop the following attributes in students (in addition to the general attributes mentioned earlier):

- Understanding of theoretical foundations and limits of computing;
- Understanding of computing at different levels of abstraction, including circuits and computer architecture, operating systems, algorithms and applications;
- Ability to adapt established models, techniques, algorithms, data structures, etc., for efficiently solving new problems;
- Ability to design, implement and evaluate computer-based systems or applications to meet the desired needs using modern tools and methodologies; and
- Understanding of and ability to use advanced techniques and tools in different areas of computing.

As can be seen, these outcomes are stated mostly in terms of the discipline, and so are different for different disciplines.

3.2.2 Programme Design

Once the programme outcomes are specified, the overall programme has to be designed for a degree programme. This is a

challenging exercise, as for many practical and educational reasons, each programme is not designed in a stand-alone manner. Most programmes are designed within some overall constraints imposed by the university, which are influenced by the mission, vision and values of the university, as well as the constraints of the college or the school to which the programme belongs, which will generally require some common features in all the programmes. Within the constraints, programme design often comes down to decisions regarding:

- **General requirements**. These are courses that all students in all programmes need to take. These are largely driven by the general graduate attributes. They may be grouped into different subcategories and may even be divided among university-wide and school-wide general requirements. However, the essence of these requirements is that they provide a common foundation to all students, based on which students can essentially do any programme (and so programme switching is easier), and they also help develop some of the general attributes.
- **Programme-specific requirements**. These are what the specific programmes, which are mostly discipline-based, require. Some of the courses in these are mandatory for students enrolled in the programme, whose goal is to deliver the core or foundational knowledge about the discipline which forms the basis for advanced topics in the discipline. These are often called the programme's compulsory or core courses. Other courses are programme electives, that is, the student chooses courses on advanced topics in the discipline from the set of courses being offered (subject to the satisfaction of the prerequisites for the course). These courses may also be grouped into different buckets with some requirements that students must take some number of courses from some number of buckets. Collectively, the programme requirements of core course credits and elective credits aim to deliver the programme-specific learning outcomes.
- **Open credits**. These credits allow the student an opportunity to take any (with some restrictions sometimes on some of the

credits) of the courses in the university. This allows him/her to gain a deeper understanding of topics of interest which may not fall within the discipline of his/her programme. It also encourages a broader development of the student, providing him/her with a breadth that disciplines, by definition, do not provide. Moreover, in limited ways, it allows a student to customize parts of his/her programme as he/she wishes. These credits are often used for doing a minor in another discipline or doing another major. Due to these credits and discipline electives, most students will graduate with a transcript different from others, depending on the set of courses they have done.

There are generally some constraints on the programme design. First are the total credits for a programme and credits a student can enrol for in a semester. Let us take a typical undergraduate programme, which can be completed by a full-time student in 4 years or eight semesters. During a semester, a full-time student can be expected to spend a total of about 40 hours per week. This total effort puts a limit on the total number of credits a student can earn in a semester, which, in turn, puts a limit on the total number of credits in a programme.

While often no clear definition of credit is provided by universities, broadly, credits are understood to have a relationship with the total effort the student is expected to spend. In other words, one credit should translate to some overall effort, including the time spent in lectures, as well as tutorials and labs. This effort may be thought of as average in a week, or total in a semester, but should include all efforts a student is required to put, including efforts outside the class, which in many ways are more important for learning than the time spent on course lectures. Many universities have a standard credit for regular courses, with an understanding of the total hours and lectures per week that are expected in a course. For example, most regular semester courses in many US universities are of three credits (four credits in IIIT-Delhi). Such courses are expected to have 3 lecture hours every

week and an average total workload of 8–10 hours per week. This means that a full-time student can effectively take four to six such courses.

The above discussion indicates the maximum credit or load that a student can take in a semester. Programmes often assume that most students, if they study full-time, have the learning capability to finish an undergraduate programme in eight semesters. However, it is well-known that the academic preparedness and learning abilities of students who enrol in a university in a programme may be quite different. While many students can handle this load, there are others who may find this level of full-time load hard to handle at the pace required for it. The approach in many countries, particularly in the West, for addressing this is to allow the student to take more than 4 years to graduate and take a load that he/she may be comfortable with.

This approach, however, is unacceptable in countries like India where there is a strong desire to finish the academic programme in the stipulated period. In such situations, having a fixed number of credits for graduation is tantamount to having a one-size-fits-all approach. Such a model can indirectly encourage the university to pitch its courses at a lower level so all students can complete, or have to face the problem of large number of backlogs, which pose another set of problems. Once a student is admitted to a university and a programme, it is somewhat the responsibility of the university to help the student graduate and achieve the learning outcomes. Hence, some flexibility in credits can be desirable, without violating the integrity or value of the degree.

One approach, which is used by IIIT-Delhi, is to pitch the main programme for the regular students admitted to the institute and provide a 'honours' option to those who are more motivated and can pursue higher levels of learning in their time in the programme. With this approach, the credit requirement is such that for a couple of semesters a student can work with a slightly reduced load, which also allows a student to make up for some courses he/she may not cleared earlier and still graduate

in the desired 4 years. At the same time, the 'honours' student is required to do a few more courses and a thesis and must have a graduating cumulative grade point average (CGPA) above a respectable threshold. Given the CGPA requirement, the option is made available to only those who have shown through their performance in first few years that they can cope with the course load and are ready to take up more learning challenges.

Within these overall parameters, the programme for a degree in a university has to be designed. There are no rules for how many credits should be provided in each of the course categories or which courses should be included where. This is generally achieved through a process of discussion and iteration—often, programme design (or programme refinement) may take over a year, with different committees spending a considerable amount of time discussing and thinking and examining the programmes of other universities. Often, workshops may be held, in which external experts from other universities, as well as from the relevant industry, may also be invited to give inputs. Finally, the main academic body of the university discusses and approves the programme.

A broad principle that is being followed in many universities for their programmes now is to keep the compulsory portion of the programme as small as possible and allow a student more choices. This generally implies fewer credits for general requirements and fewer credits for the core courses of a discipline, with more credits left for discipline electives and open electives. It should also be pointed out that with more room for credits in the elective and open categories, the possibility of providing for minors and second majors increases, as often these credits are utilized to complete the requirements of a minor or a second major.

How do we know that the programme design is sound? The main test of the soundness of a programme design is that it should, at a minimum, achieve the programme outcomes and that the graduates should have the graduate attributes in them at the completion of the programme. As the programme outcomes are qualitative statements on what the student has learned in

the programme and what capabilities he/she has developed, the assessment that the programme delivers to them also has to be done qualitatively. Generally, given the learning outcomes of each of the courses (discussed below) and the network of courses a student has to do in a programme, it can be demonstrated that achieving the learning outcomes of each course the student takes will lead to the student achieving the programme outcomes. Indeed, the course design is often influenced by the programme outcomes in that the learning outcomes of a course are decided upon so as to contribute towards the programme outcomes. How the network of courses satisfies the programme outcomes may be shown in terms of tables showing which course contributes to which of the learning outcomes, and how collectively the set of courses deliver a programme outcome.

3.2.3 Course Design and Learning Outcomes

Course design is a widely discussed topic in teaching and learning literature, as finally education for a programme boils down to teaching in courses, as a course is the basic unit for learning in an academic programme. Teaching of courses is also what teachers do—hence, for improving education, the focus is often on the teaching of courses. Due to the importance of courses in teaching, most books on effective teaching (e.g., Ambrose et al. 2010; Fink 2013) place strong emphasis on course design, as without a good course design high-quality teaching and learning are not likely to take place in the course. Often, a course is designed by enumerating a list of topics that should be covered in the course, generally called the course syllabus. This is a very teaching-focused approach, as the list of courses is often selected by the instructors based on their judgement regarding the importance of the topics. It is widely agreed that this approach, which is still quite prevalent, is not a sound approach for the design of courses. To help ensure good learning in a course, the course design should be learning-driven, first articulating the learning outcomes of the course and then designing the syllabus and its teaching. Besides the learning objectives and teaching plan to

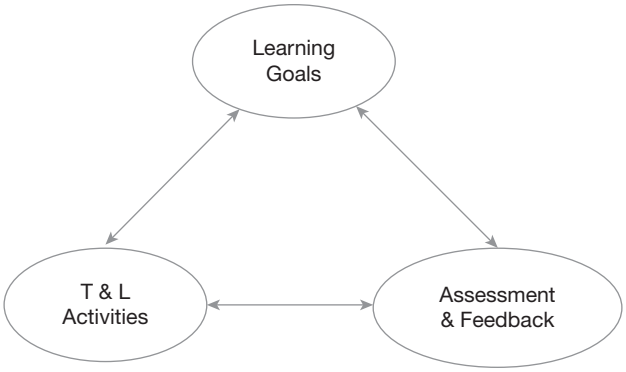

Figure 3.1 *The Three Elements of Course Design and Their Dependence on Each Other*

Source: Dee Fink (2013).

achieve them, another basic aspect of course design is assessment planning, without which the level of learning cannot be ascertained. An integrated course design then has three main elements, as shown in Figure 3.1.

These three elements are strongly dependent on each other and reinforce each other. Weakness in one will compromise the eventual goal of the course—to ensure that the learning outcomes are satisfied by most of the students. For example, if the course delivery plan is not aligned with the learning outcomes (for example, it does not cover all the necessary topics), then the student cannot achieve the stated learning outcomes. If the assessment plan is such that it focuses on assessing what can be assessed easily rather than on what are stated as the learning outcomes, then the students will align their learning towards the assessment rather than the learning outcomes, and the grades given to the student will not accurately represent the learning with respect to the learning outcomes. This again results in compromising the goal of teaching and learning in a course.

The design of a course, therefore, starts from stating its learning outcomes. Learning outcomes are statements about

the knowledge and capabilities of a student who has successfully completed the course, that is, statements that assert what the student at the end of the course should know and what he/she will be able to do. The learning outcomes are critical in the design of courses, as from these it can be determined if the overall programme outcomes and graduate attributes are being delivered by the programme or not. As mentioned above, the programme is finally a network of courses that a student undertakes. The learning outcomes of the set of courses that a student undertakes in a programme should together ensure that the outcomes of the programme are satisfied. Hence, learning outcomes are not just what the instructor of a course decides for the course; they have to be aligned with the programme outcomes, particularly for the compulsory or core courses.

The type of knowledge acquired can be classified in many ways, and Bloom's taxonomy is the best-known technique for doing so (Krathwohl 2002). As per the revised Bloom's taxonomy, knowledge can be classified into six levels: remember, understand, apply, analyse, evaluate and create. Using the taxonomy, the statements about learning outcomes can be stated in terms of learning at different levels. However, for university courses, often the lowest level of knowledge are not the goals (unlikely to see learning outcomes for college courses state that a student shall 'remember x, y, z'). Generally, in courses in universities, especially in those in research universities, which are often pitched even higher, the learning outcomes are oriented more towards the higher levels of the taxonomy.

A simpler way to view the learning objectives is to focus on what the students will understand at the end of the course (conceptual knowledge) and what the students can do (skills). Using this simpler formulation, learning outcomes are statements of the type: At the end of the course, the student shall understand x, or be able to do y. It is desirable that most courses should have some learning outcomes of each of these—develop a better understanding of some systems, the world, people, how something works,

phenomenon, etc. and develop some capabilities in the students to do something (e.g., critically analyse, write code, write a technical note or a critique, evaluate a system, create a design, integrate some technologies, etc.).

The second aspect of the course design is the planning of teaching and learning activities in the course. For this, a principle to be kept in mind is the quote by Herbert A. Simon: 'learning results from what the student does and thinks and only from what the student does and thinks. The teacher can advance learning only by influencing what the student does to learn'. In other words, the goal of any activity in the course, including lectures, should be to ensure that the student has something to think about or do—the only way a student can learn. Generally, the most visible aspect of this plan is the schedule of topics covered in lectures. While this schedule of topics is sufficient to ensure that appropriate topics are covered for the learning outcomes, it is an incomplete plan for ensuring the achievement of learning outcomes. For that, activities outside the lecture must also be included in the plan. As discussed above, typically, in a course, for each hour of lecture, the student is expected to put in a few hours of effort outside the lectures, in reading (lecture notes or text), doing assignments, doing lab activities, writing reports, etc. While lectures can form the nucleus of knowledge for learning in a course, most of the learning by students happens in the activities they have to perform outside the lecture. Hence, these must be included in the instruction plan for a course.

Finally, there must be a good assessment plan in a course. Assessment is an important and difficult aspect of teaching, and one that is often not enjoyed by teachers, as it is also generally cumbersome and time-consuming. However, it is an essential aspect of teaching and learning. Without a proper assessment plan, the effectiveness of teaching cannot really be judged, and learning levels achieved will depend only on the student's motivation and drive. Note that assessment does not mean only exams or tests—assignments, report writing, etc. can all be, and generally are, components of assessment. In fact, an assessment based only

on formal tests/exams will be limiting in scope—it may not be able to test some of the learning objectives (e.g., the ability to set up an experiment), and it also encourages students to spend most of their effort on learning around the exams. Hence, assessment plans often use multiple instruments that are spread throughout the duration of the course. The final goal of assessment is to determine the level of learning achieved by the student, which is often captured in terms of the grade the student receives. In the current context, there is an increased interest in assessment and how automation and other approaches can be used. As delivery of lectures can now be done at a large scale through sophisticated tools on the Internet, assessments, which for many subjects have to rely on human effort for evaluating the students' learning, has become one of the key bottlenecks in scaling education through the Internet. Even otherwise, assessment is a challenging aspect, and books have been written on it (e.g., Angelo and Cross 1993).

3.2.4 Interdisciplinary Education and CS + X Programmes

Most degree programmes are aligned with disciplines—you get a bachelor's or a master's in some discipline like computer science, electrical engineering, economics, mathematics, etc. As discussed earlier, the overall curriculum of a UG programme generally ensures some amount of breadth and general foundations for the development of general attributes, while the bulk of the programme focuses on building competencies and knowledge in the discipline of study. Hence, a mathematics programme will have a lot of maths courses but also some general courses on communication, writing, sciences, etc., and an electrical engineering programme will have many courses in the various sub-areas of the discipline and also general courses in maths, computing, sciences, communication, etc.

This focus on discipline has emerged as a response to the increase in the breadth and complexity of knowledge. It simply is not possible for a student to acquire a decent understanding and knowledge of multiple disciplines. However, over the years,

the expertise has tended to become too narrow, and the understanding and appreciation of related disciplines, which is needed for effectively working in multidisciplinary teams, has declined. While research and development problems in each discipline remain, the big problems that face societies, nations and the world clearly do not align with discipline boundaries, and their addressal needs expertise from multiple disciplines. To address these problems and, in general, work on innovations and complex problems that rarely fall within discipline boundaries, there is a need for developing manpower that has multidisciplinary capabilities. (Though the terms multidisciplinary and interdisciplinary have different technical meanings, we use these terms interchangeably, as they often are interchangeable.)

One standard approach to allowing students to develop multidisciplinary capabilities is to allow the students the option of doing a minor in another discipline. A minor requires the student to do a small number of courses in the minor discipline, which the students can often do using their open elective credits for them. A minor provides a decent understanding and capabilities in the minor discipline, as well as a basic vocabulary of the discipline. It is a common way to allow students to develop some capabilities in another discipline, without their having to spend extra time in the education programme. Most universities provide for minors.

Another standard approach is to allow students the option for a second major. Generally, requirements for both the majors will have to be satisfied. Usually, credits for a course can be counted towards the requirements for both majors, if the course is permitted in both the majors. As there may be many common requirements, or courses that can be included in both majors, the number of additional credits required to complete the second major might not be too high, particularly if the two majors have many courses in common. Hence, generally, second major will require the student to earn only some additional credits to complete the requirements for the second major.

These two are flexible approaches which leave it entirely to the student to decide what type of interdisciplinarity he/she wishes

to pursue. Another way to approach interdisciplinary education can be to provide actual interdisciplinary programmes that are designed as such. In this approach, the programmes are designed and curated properly, and a student may choose to enrol in them; so, philosophically, this approach is quite different from the concept of a double major or a minor. Interdisciplinary programmes have been increasing in the recent past in universities (Knight et al. 2013).

The big challenge in having multidisciplinary programmes is, of course, that the size and duration of such a programme might become too large if a simplistic view that such a programme should be a combination of two majors is taken. If the design of this interdisciplinary programme has to fit in the overall credit requirements of programmes (as discussed above), then the key challenge is to balance the need to complete the programme in the defined time (or credits) and provide multidisciplinary capability, without diluting the capabilities of the disciplines. There are many different types of interdisciplinary programmes possible, depending on how the curriculum is structured and taught (Knight et al. 2013). Here, we discuss the approach taken at IIIT-Delhi.

Clearly, for such programmes, the disciplines being combined have to be chosen carefully. When considering which two disciplines to combine for such a programme (more than two is clearly not feasible), the disciplines should be chosen such that they develop complementary skill sets that collectively will be more valuable and sought after than only the skills of one discipline, for a range of jobs and careers. Further, the disciplines should also not be so 'vast' that combining them into one programme is simply not feasible. At least one discipline should be such that even with a small set of courses, reasonable skills and knowledge can be developed, which can help in improving the capabilities of other discipline also. Few disciplines will satisfy this—computing is one of them.

Computer science (CS) is a young discipline. However, with the easy and cheap availability of computing power, its use has become ubiquitous—there is hardly any discipline or any sphere

of life which is not directly affected by information technology (IT). That is why computing is sometimes considered as the 'new physics'—it is useful in all disciplines, and its basic knowledge is essential. Today, in every discipline, knowledge of computing is an asset, and there is a demand for professionals in various disciplines who also have decent knowledge of computing.

CS is in some ways a simpler discipline. It is fundamentally about algorithms, software and systems. Hence, education programmes in CS focus on these: for software, there are courses like programming, data structures, software engineering, etc; for algorithms, there are courses on data structures, algorithm design, theory of these, etc; and for systems, there are courses like architecture, operating systems, networks, etc. Generally, a subset of these topics forms the core (or compulsory) part of an undergraduate programme, allowing for a relatively small CS core. These core courses, along with a few specialized courses, can provide strong knowledge and skills to students for them to apply computational techniques.

This ability to have a small core to develop useful skills and knowledge, renders CS for interdisciplinary programmes which combine CS basics with knowledge of other disciplines. Given the need for knowledge of computing in many disciplines, having an interdisciplinary programme with computing makes a lot of sense, particularly since further progress in many disciplines is highly dependent on the application of computing. A good example is biology; earlier, it was considered an experimental discipline, but now, without the use of computing, many aspects simply cannot be done (e.g., anything to do with genomics requires huge amounts of computing).

In fact, many senior computing academics have argued that while computing as a discipline must evolve, computing must be more tightly integrated with some disciplines for it to have more impact on society and on other sciences. This is another reason for having interdisciplinary programmes with CS. So, there are interdisciplinary programmes being launched with CS and

other disciplines—these are sometimes called 'CS+X Programs'. IIIT-Delhi has launched a series of such programmes. UIUC and Stanford have their own such programmes. The discussion here is based on the thinking and experience of IIIT-Delhi.

One such programme is CS and Applied Maths. The basic motivation behind this programme is that for solving problems for complex systems as well as for big data, both mathematics and computing tools and techniques need to be applied. Hence, an engineer with training in both will be better prepared to handle such problems. Another programme is CS and Design, which aims to develop graduates who are not only well-versed with computing approaches, tools and technologies but are also experienced with design approaches and new media technologies and uses; it prepares students to work in the IT industry as well as in the digital media industry like gaming, animation, virtual/augmented reality, etc. CS and Social Sciences is another programme which aims to develop IT engineers with a strong understanding of relevant social science disciplines, as well as their methodologies. There is also the programme in CS and Biosciences—the need for this is easier to establish, as there are many master's and PhD programmes already in the field of computational biology and the need for combined knowledge of the two disciplines for solving problems in biosciences is well-established.

There are some guiding principles while designing such programmes. First, the set of core courses for the disciplines chosen for the interdisciplinary programme should be minimal, that is, the core should be as small as possible. Interestingly, it is possible to do so, since what constitutes a core is subjective, and when the programme is not for one discipline but tied to another, the core can be reduced considerably. Second, for electives for this programme, courses from both the disciplines should be permitted, and a balance should be achieved. Third, some of the courses taught in the programme should be interdisciplinary in nature.

Typically, in IIIT-Delhi, in any such interdisciplinary programme, a student will do the basic foundation courses in the

first year, most of which are common for all programmes. These include courses on communication, critical thinking, programming, mathematics, systems, etc. Then, in the next few semesters, the student will do a small set of (about six) core or compulsory courses in each of the two disciplines, which will provide the grounding in the two disciplines. In the last few semesters, the student will choose a few electives (four to six) from either discipline. Broadly, such an interdisciplinary programme can satisfy the requirements of a BTech in CS, as well as the requirements of a 3-year BA/BSc programme in the second discipline.

Such programmes allow a student to pursue an exciting career at the intersection of the two disciplines and also prepare them to pursue higher studies and a career in one of the two disciplines, as decent knowledge of both disciplines is provided in these programmes. Many thinkers believe that interdisciplinary approaches for problem-solving is where the future lies, as siloed approaches of individual disciplines are limiting and often unable to take a broader view of a problem and its context. Such interdisciplinary programmes should help develop manpower that has the capabilities of at least two disciplines for problem-solving. The NEP also encourages interdisciplinary programmes and explicitly allows programmes to have a common core for general attributes and have one or two areas of specialization, thereby allowing disciplinary programmes as well as interdisciplinary programmes (NEP 2019).

3.2.5 Use of Online Courses

Over the last decade or so, there has been a lot of excitement on Internet-based delivery of courses, in particular, massive online open courses (MOOCs). The power of new technologies and the Internet has enabled the MOOC model. In its early years, there was an expectation that MOOCs may disrupt the established HE systems through the delivery anywhere-anytime courses by leading experts to masses of student at potentially a fraction of the cost of regular courses offered in physical universities.

The disruptive potential of MOOCs has so far not been realized, but the technology and methodology are now being widely used for teaching and learning, including delivering certificate or degree programmes. Many leading research universities have used the platform to offer their courses to students across the world. Many universities are involved in MOOC, and there are a host of reasons why universities are offering MOOC courses—main among them are to extend the reach of the institution, build the brand, improve the economics and improve education, innovation and research in teaching (Hollands and Tirthali, 2014). Experience indicates that most universities are producers or both producers and consumers, with a few being only consumers of MOOC. Platforms like Coursera and EdX offer a way to universities to host MOOC courses and for students to enrol in and take them.

We discuss here the use of MOOC and other such courses to enhance the education programmes, without being a producer of MOOC. In this form, the university is the consumer of the MOOC or open courseware. Surprisingly, using MOOC/open courseware within existing programmes in universities has turned out to be more challenging than expected. Most universities that use MOOC courses for credit employ some type of blended approach where a local instructor is present, and there may be some sort of assessment within the university (Sandeen, 2013). Here, we discuss an approach that was followed by IIIT-Delhi, as an example of how a research university may use these courses for its own education programmes.

First, let us clarify the objective of using MOOC courses. The institute took a view that it should leverage the top-class content being offered by globally renowned professors through online platforms like EdX and Coursera and Swayam (an Indian platform) for its education programmes. The goal was to augment the elective offerings of the institute, thereby making a wider variety of choices available to students for their elective courses. In other words, the courses the institute offered remained, and additional courses on newer topics were offered through this mode. This goal

of augmenting the course offerings is somewhat different from what is commonly reported. There was a special keenness to make specialized courses available to students for which the institute did not have faculty to teach. To keep a control on this, the number of credits a student could earn thought this mode was limited.

For administering such courses, it was realized that it is easiest to 'offer' these courses as part of the course offerings in the institute. This not only simplifies their administration, registration, etc., but it is also easier for the students, as they are tuned to the semester rhythm. Consequently, only online courses that start and end within a semester are considered (though some relaxation is possible). To identify the courses, inputs from students are taken.

Once the courses are floated, an instructor is assigned for all the online courses being offered in the semester. For each online course, a teaching assistant (TA) is also assigned, who is required to enrol in the online course and take the course. The TA meets the students enrolled in the course once every 2–3 weeks to review the progress of students. Enrolled students may be required to submit suitable records to show that they are 'attending' lectures and doing the assignments. The TAs meet the instructor to brief about the progress of the courses.

As no formal assessment is done other than ensuring that the students are participating in all assessments of the online course, these courses are to be given only a pass/fail grade, so the problem is simplified somewhat. For giving the passing grade, the criteria are that the student has: listened to all the lectures, done all the assignments and taken all the exams and done well. When possible, the student should get a certificate of completion from the online course.

Generally, a few courses are offered each semester through this mode. The enrolment in these is not too heavy. However, the fraction of students who complete the course is almost 100 per cent, which is quite remarkable when compared to the completion rates generally published for such courses (less than 15%); even for paid courses/certificates, the completion rates are significantly

lesser. The student feedback in these courses was positive; a vast majority felt that the course was 'very useful', and most felt that the course gave them an experience similar to or better than a regular course.

Use of courses available on various MOOC platforms is an excellent way to leverage their potential to expand offerings, particularly when there is a shortage of faculty. These are high-quality courses generally offered by the top experts in an area. The main challenge is to integrate these courses into a regular academic programme. The NEP also envisages leveraging the potential of open learning and MOOC for improving access to quality education and enhancing the offerings, and proposes a larger role of MOOC courses; it explicitly recommends the recognition and accumulation of credits earned through MOOC platforms (NEP 2019).

3.3 SUPPORTING EFFECTIVE TEACHING AND LEARNING

In the preceding section, we discussed how programmes and courses within programmes can be designed to provide high-quality learning for students, leading to graduates with well-developed graduate attributes. While the design of education programmes, and the courses within the programmes, indeed forms the foundation of good-quality education, for their expectations to be realized, they must be executed properly. In other words, courses must be taught effectively leading to good learning by the students in the courses. Effective teaching leading to good learning requires extra care to be taken by teachers, and there need to be systems in the university to support and encourage effective teaching. Over the previous decades, there has been a sharper focus on effectiveness in teaching which leads to the desired learning. The NEP also suggests universities to give attention to the teaching–learning processes to improve the learning outcomes of students (NEP 2019).

Any system to deliver high-quality output requires not only the people involved in the execution to perform their tasks

as expected, but also needs feedback and quality systems to maintain and improve the quality—the law of entropy will ensure that if effort is not spent in properly administering the education delivery system, it is likely to decline in quality. There are a number of approaches universities can employ to improve the quality of teaching (Henard and Roseveare 2012). Focused efforts to orient teaching towards learning is known to improve the quality of teaching and student as well as faculty satisfaction (Kember 2009). Here, we discuss some approaches that universities can employ to help improve teaching, based on experience at IIIT-Delhi.

3.3.1 Training for Teaching

As stated in an earlier chapter, the faculty in a research university are recruited largely for their research potential. Such faculty are experts in their area, and their knowledge about their field is sound and deep. Earlier, the assumption was that if teachers had the required knowledge and understanding, they would be able to transmit their understanding to the students, resulting in good learning by the latter. This approach was adopted by almost all universities until a few decades ago—fresh faculty were assigned courses to teach with almost no training. This approach is no longer considered optimal. To ensure good learning in students, while subject matter expertise is necessary, it is recognized as not being sufficient. Teaching to ensure that students learn requires some effective teaching or pedagogical skills, besides knowledge about the subject matter.

Teaching and learning at the university level has been an active area of research for a few decades. Many traits and practices of excellent teachers (Sherman et al. 1987; Bain 2011) and of effective teaching (Devlin and Samarawickrema 2010) have been identified. While some people may naturally have the talent to be an effective teacher, it is now clear that there are some methodologies (e.g., active learning, project-based learning, etc.) that facilitate learning, which instructors can learn and apply. It is also

now clear that for a teacher to be effective, he/she must have a decent understanding of students' learning processes and styles and student motivation, besides understanding the principles of course design and the basics of teaching.

As the PhD is largely the enabling degree for eligibility for a faculty position in a research university, and as the PhD is focused around developing research capability (see the chapter on the PhD programme), a newly recruited faculty member generally might not have even the basic knowledge about the pedagogical aspects of effective teaching. Hence, it is essential that the faculty, who are recruited largely for their research capability and potential, be trained in methods and technologies for effective teaching. While a few decades ago this was not appreciated, this is now widely accepted, and most large universities have established teaching-and-learning or teaching excellence centres. These centres, besides doing research on effective teaching and learning, offer training programmes for faculty to become more effective teachers.

While it is widely accepted by university administrators that such training programmes are important for faculty, particularly the new faculty, ensuring that the existing faculty also undergo some such programmes has been a challenge due to the culture and autonomy that exist in universities. Also, some of the senior faculty might have perhaps evolved through experience their own methods of effective instruction and may feel that they do not really need any further help. Universities have evolved various approaches to teach teachers about effective teaching methods. These involve requiring incoming faculty to necessarily take some such modules (since for new faculty this can be easily enforced), providing support to faculty for undertaking such programmes, looking at teaching qualifications also during faculty promotion and appraisal, etc.

As the importance of high-quality teaching also increases and many universities value teachers who are recognized as good, certificates programmes on teaching have also evolved. Having such certification from a globally recognized and reputed agency

not only ensures that the teaching of the modules in a programme is effective, but it also helps motivate faculty to enrol in such programmes to obtain the additional qualifications that can make them more attractive for many universities. Faculty development programmes for improving teaching effectiveness have been generally found to be quite effective (Brawner et al. 2002; Hoyt and Howard 1978; Steinert et al. 2016).

3.3.2 Feedback Loops for Improving

Feedback loops are central to the improvement of any system—indeed, even maintaining the current level of quality requires feedback and continuous adjustment. For improving teaching, there need to be systematic feedback loops and actions taken based on the feedback for improving learning (Harvey 2003). There are multiple purposes for such feedbacks. For teachers teaching a course, feedback can help understand if they are proceeding as they had planned and if the teaching approach, speed, etc. are suitable for the current set of students. Feedback is also needed for the overall course, as course design cannot be static and its design cannot be assumed to be optimal—only with feedback can the design be improved—to either address deficiencies in design or accommodate newer developments. Even the design of a programme cannot be assumed to be optimal and should not be static; hence, feedback is needed on programmes. Finally, the teaching–learning methods being employed by faculty can always be improved, so feedback to understand the effectiveness of the approaches used by different teachers will help.

There are many feedback instruments that universities use; for example, end-of-the-course feedback from students is a standard in most universities. For different types of feedback, different approaches or questionnaires may be used (Harvey 2003; Richardson 2005). Here, we discuss the methods used in IIIT-Delhi for different purposes using structured questionnaires (with some open-ended questions)—they are likely to be similar in spirit and style to approaches used elsewhere.

- **Peer review of course design.** Most standard courses in a programme will have a design specifying the learning objectives, syllabus and assessment plan—the design would have been finalized through a process of discussion and review. However, it is desirable to provide some flexibility to instructors to adjust the topics covered, the assessment approach, etc., since even for a standard course some amount of evolution is desirable. If flexibility is provided to the instructor to modify the course design, it is desirable to ensure that the changes are appropriate and that the plan for course delivery by the instructor is sound in that it will deliver the learning outcomes and will assess them well. Given the autonomy and responsibility granted to the faculty for administering and running their courses—a freedom that is desirable and aligns with the faculty ethos—any approach for this has to be consistent with this ethos. Peer review of course plans is a feedback loop mechanism that attempts to achieve a balance. In peer review, the plan for a course by an instructor is reviewed by a peer (or a group of peers). The review comments are not meant to be on official record and are only given to the instructor. The institute only has to ensure that peer review has taken place, and so a record that it has been conducted is to be submitted. As it is a review by peers, it is a constructive exercise of improvement, with no threat of it becoming an assessment.
- **Mid-semester feedback.** The usual end-of-semester feedback on courses (discussed below), collected after the course has been finished, can only be used for improving the future offerings of the course and is of little value to the student enrolled in the course. To get feedback on the current course offering so any adjustments that might be needed can be made, an early mid-semester feedback instrument is employed—this is an online survey of students about a few key aspects of the course: the pace, the difficulty, their ability to understand and anything else the instructor may want to ask. The goal of this is to provide the instructor feedback on the current course teaching, so he/she can adjust it suitably, based on the inputs. This feedback is not an administrative instrument in

that the results are not recorded or used for assessment; it is meant exclusively for the instructor and to help him/her adjust the course. Hence, only the instructor receives the feedback, which he/she is expected to summarize to the class along with the actions he/she plans to take, if any.

- **End-of-semester feedback**. Most universities have end-of-semester feedback for courses. The main purpose of this feedback is to assess the quality of learning achieved by the student and the quality of teaching by the instructor (as perceived by the student), and obtain suggestions for improvement. Experience suggests that it is best to ask students precise questions that they can answer, rather than asking them summative questions (like: how good was the instructor, or how much learning did you acquire). Hence, it is desirable to have a set of questions regarding the teaching and a set of questions regarding the course and learning, and the student feedback on these can be combined into aggregate scores to assess the teaching and learning. Student evaluation of teaching has been found to be reliable and stable and useful for improving teaching effectiveness (Marsh and Roche 1997).

  For assessing the students' view on learning, if the feedback form is an online instrument (as is generally the case now), there is a possibility to tailor the feedback form for each course, rather than have only general questions. In the online form used at IIIT-Delhi for a course, the learning outcomes for that course are stated, and the students are asked to share their views on how well they achieved the stated outcome. The average feedback on all the learning outcomes can be considered as the students' view on their learning. The direct method of assessing the learning outcomes has been promulgated by many scholars for assessment. This feedback approach takes this idea further and asks students to share their views on their learning with respect to the learning outcomes. A side benefit of this approach is that it reinforces the importance of learning outcomes in students, which often gets lost in the details and activities of the course.

- **Course summary**. Student feedback, it is known, is not an accurate reflection of the level of learning or the quality of teaching. Students are often biased and let other factors colour their replies. As is the general wisdom, while student feedback is an important input, it has inherent limitations. To address this and gain a holistic view of the course, for each course a course summary is prepared by the instructor and the teaching assistants. This summary also provides information about any special efforts and initiatives employed by the instructor to improve learning, any tools used, any other special practice, etc. This short summary provides the instructor's views on teaching. The information in this summary, when combined with the student feedback, can provide better insights on the practices that might be helping in students' learning. This can be used to determine the 'good practices' and 'teaching innovations' that faculty colleagues employ that seem to make their teaching more effective. These can then be shared with other faculty as 'lessons learned'—these can help transmit the effective practices more widely.
- **Feedback from graduating students, alumni, recruiters**. To get a broader student perspective, feedback can be taken from students at graduation time. These students have a full perspective of the education programme and also have a sense of what helped them during their job interviews or their graduate study applications. The focus of this feedback is more on the overall programme and learning experience (as well as other aspects of student life) and what can be done to improve it. Unlike other feedbacks which focus on a course, this is a more comprehensive feedback and is taken once a year—inputs from this can help in deciding on changes in the overall programme.

  Another useful feedback is feedback from alumni a few years after they have graduated. This is focused mostly on the overall programme and the learning environment—which courses they feel were useful, which courses they feel did not provide much value to them, which courses they feel they would have liked to take, etc. Again, for these inputs, the context of the alumni

has to be kept in mind, as the views are inevitably determined by his/her experiences at his/her job—where he/she faced challenges and where his/her learning helped. While interpreting this, it has to be kept in mind that the education programme is designed for a range of job profiles and careers, and hence this feedback has to be interpreted suitably. Such feedback can also lead to a better empirical understanding of how the programme design supports the education objectives. However, getting such feedback is challenging—once students graduate, it is generally very hard to track them down and motivate them to participate in such studies.

In addition to these, feedback can be taken from recruiters on the strengths and weaknesses they observe in the students. These inputs provide valuable feedback from an employment perspective. However, it should be recognized that this perspective is often too narrow and focused on the objectives of the organization for which recruitment is being done, and that recruiters are unlikely to have a broad understanding of the education goals of the institute and the different career paths that the programmes prepare students for. Hence, such feedback cannot be taken literally, and any changes that may be suggested by this feedback must be supported by other needs and arguments.

3.3.3 Recognizing and Rewarding Teaching Excellence

Faculty members will often align their efforts towards what is perceived as valued by the institution and their profession. Though teaching and research are the two basic missions of a research university, in such universities, research performance is often what is most respected and what is most sought after by their faculty. In the quest for research excellence, the balance between teaching and research is sometimes lost in favour of research. There are some concerns that teaching has not been valued sufficiently by research universities, since in their own quest for prestige and rankings, they often send the message 'only research matters' to faculty. As mentioned earlier, teaching is the mission that society and governments value most and expect universities to excel in.

Therefore, there is a need to ensure that the message that teaching is important is communicated to the faculty (Efimenko et al. 2018). Along with it, a message needs to be sent to the students that teaching excellence is their right and not a favour by highly accomplished faculty.

There are methods established by professional bodies and societies to recognize and reward research excellence. There are prestigious awards, which often also have a financial incentive, to recognize great contributions in research. There are also prestigious fellowships established by professional bodies and societies which recognize research excellence. Additionally, of course, there are research funding schemes which provide grants for good research. Research contributions also get recognized through citations, invited seminars, keynotes, etc. Overall, there are many ways in which contribution to research is rewarded and recognized.

On the other hand, such channels are very few for teaching excellence. There is a fundamental challenge in this also—while research output is in public domain which the professional community of peers can assess and so can judge if the contributions over the years are worthy of recognition, such approaches are generally not possible for teaching excellence. Teaching is visible only within the university, and that too largely only to students (and indirectly, through their feedback and inputs, to others). Hence, it is hard for professional bodies to establish teaching excellence recognition and awards. Consequently, the university itself will have to identify and recognize teaching excellence—something it does not have to do for research excellence, for which it can rely on professional bodies. Recognizing teaching excellence through awards and prizes is now widely being practised in universities (Efimenko et al. 2018).

There will clearly be many ways to identify teaching excellence. Whatever method is employed, it must involve inputs from the students, as teaching is finally about the learning by students. Here, we briefly describe two schemes that are used in many universities, including IIIT-Delhi.

As hundreds of courses are taught each semester in a university and feedback is taken in each of these courses, one approach to recognizing good teaching is to recognize and reward instructors based exclusively on the student feedback on courses. Such recognition can be given to the 'top few' instructors in each discipline. For recognizing the top few, besides the feedback from students, other information can also be incorporated in the selection process—for example, size of the course, difficulty level of the course, innovations tried in the course (which are captured in course summaries), student comments, etc. This method has a drawback in that it relies too much on the student feedback, which is known to be not completely impartial.

A sounder approach can be to identify teaching excellence by taking inputs from graduating students and/or recent alumni. These groups of students have seen the entire programme and a range of teachers and hence are in a better position to identify those teachers whom they consider as having done the best job of helping them learn. These students would also not have any 'hidden agenda', as they would not be taking any more courses and would not be facing the faculty in the future. One approach for identifying recipients for teaching excellence awards as decided by the graduating batch (and/or alumni) is to have a process of nomination by the students, followed by subsequent voting. (This is the approach followed in IIIT-Delhi.) This method of recognizing teaching excellence has the drawback that as people tend to remember recent courses more, instructors of courses taught towards the end of the programme are likely to have an advantage. This can be alleviated by having separate categories for awards—some for the foundation courses, some for the core or compulsory courses, some for electives, etc.

Another way to respect and promote teaching excellence is to have workshops for sharing 'good practices' internally in the university. Recipients of teaching excellence awards, or those faculty who try some innovations in their teaching, can be invited to share their experiences and what they do with others. These workshops not only help in disseminate the good practices, they

also help message that teaching excellence matters, and that excellent teachers are recognized and appreciated. They also support bottom-up innovation in teaching, which has been argued as an appropriate way to motivate and improve teaching and learning, with the workshops providing the platform to connect and share effective innovations and strategies across different disciplines. These can also provide inputs for top-down policymaking regarding teaching excellence, as well as for refining the modules that teaching excellence centres offer to faculty.

3.4. SUMMARY

Education is the first mission of universities, and remains perhaps the most important and relevant mission, even for most research universities. While all universities are expected to provide good-quality education, there are additional expectations from research universities as they are expected to take leadership in higher education and be the agents of change and upgradation. The chapter started with a discussion on this aspect of education in a research university.

The education function of universities has evolved over the centuries and decades. While in the olden days educating students on the classics, science, mathematics, critical thinking, etc. might have sufficed, it is now expected and desired that there should be clear objectives for education, that is, what types of careers is the programme preparing the students for. The education programme should be designed suitably, imparting the desired graduate attributes and learning outcomes that fulfil the objectives. The chapter provided a brief discussion on how a programme is designed—establishing the programme outcomes, designing the programme structure and designing individual courses.

It also discussed some special and contemporary topics like interdisciplinary programmes, in particular CS+X programmes. It also discussed the use of MOOCs and open courseware in university education programmes. Examples from IIIT-Delhi have been shared.

Finally, we discussed some approaches for ensuring effective teaching. These include providing training for teachers on effective teaching techniques, establishing feedback loops to ensure that the programme, course design and their delivery are achieving their objectives, and establishing awards and recognition for effective teaching.

We have not discussed admission into undergraduate programmes in this chapter. While admissions are not directly related to the processes of education, they have an impact on learning, as the peer group is known to influence the level of learning by students. Admission policies that help diversity can also help in improving education (as well as research), as they bring diversity of thought, different perspectives, cultural backgrounds, etc. which help in the development of students. Admissions in India have, over the years, become very rigid and largely based on exams, which does not encourage diversity. A discussion of admission approaches in India can be found in Chandra (2017).

Regarding admissions, IIIT-Delhi has championed an innovation that is quite unique in India. Instead of having admissions based only on the results of the common entrance exam, which is the prevailing method in almost all engineering institutions, IIIT-Delhi uses the score of the exam as the basis but gives bonus marks for achievements in various spheres, including sports, culture, chess, Olympiads, programming contests, class XII board exams, etc. In other words, admission is based on a score that is the sum of the score in the entrance exam and the bonus marks. This is a transparent and fair process that encourages diversity and recognizes the importance of multidimensional criteria for admitting students. This innovation of allowing a range of other aspects to be included in the decision on admission has paid off too—the students who come with bonus marks have, on average, a higher CGPA at the end of the first year (by almost 1 point). If such an approach is followed by some of the major institutions in the country, it can have a revitalizing impact on school education and the development of young minds, which currently is very focused on exams for admission.

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