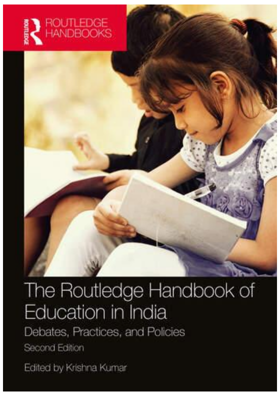

The Routledge Handbook of Education in India Debates, Practices, and Policies

Krishna Kumar

Science and mathematics teaching in schools and colleges

Publication details
https://www.routledgehandbooks.com/doi/10.4324/9781003030362-9

Shobhit Mahajan

Published online on: 30 Sep 2021

6
Science and mathematics teaching in schools and colleges

Shobhit Mahajan

> The dominating feature of the contemporary world is the intense cultivation of science on a large scale, and its application to meet a country's requirements. It is this, which, for the first time in man's history, has given to the common man in countries advanced in science, a standard of living and social and cultural amenities, which were once confined to a very small privileged minority of the population. Science has led to the growth and diffusion of culture to an extent never possible before. It has not only radically altered man's material environment, but, what is of still deeper significance, it has provided new tools of thought and has extended man's mental horizon. It has thus influenced even the basic values of life, and given to civilisation a new vitality and a new dynamism.
>
> *(Government of India 1958)*

These words, written in 1958, sum up the attitude to science that prevailed in the early decades after India's Independence. This was the time when the policy-makers were convinced that science and technology (S&T) would be important in pulling up India from centuries of underdevelopment. S&T were thought of not just as a panacea for our underdevelopment, they were also seen, as the Resolution above makes clear, as important in themselves for civilisation. Scientific temper, a term associated with Pt Jawaharlal Nehru (Nehru 1946: 512) though possibly influenced by Bertrand Russell (Arnold 2013: 360–367), was an important part of the making of a 'modern' India. The harnessing of S&T for development, as well as a rational outlook towards the world, was an essential part of the narrative of nation building in the first couple of decades of independent India.

The central role of S&T as envisaged by the policy-makers meant that a large infrastructure of research, training, and teaching would need to be created virtually from scratch. Thus, the early decades after Independence saw the establishment of laboratories, research institutes, universities, and technology institutions. The network of research laboratories, under the Council of Scientific & Industrial Research (CSIR) and the Indian Council for Agricultural Research (ICAR), as well as the Departments of Atomic Energy and Space, were set up not just as ivory towers engaged in scientific research but indeed to meet the challenges of rapid economic development.

DOI: 10.4324/9781003030362-9

The education sector too witnessed an unprecedented expansion in this period and indeed in the subsequent decades. The total expenditure on education, as a percentage of GDP, went up from a little over 0.6 per cent in 1950–51 to around 3.8 per cent in 2010–11 (University Grants Commission (UGC) 2013). Technical and professional institutions like the Indian Institutes of Technology (IITs) and engineering colleges were set up to provide human resources to the industrialising economy. The growth in the number of primary and secondary schools, colleges, polytechnics, universities, and professional colleges has also been very impressive, though obviously from a very low base. Thus, for instance, the number of universities has grown from 30 in 1950–51 to over 700 in 2012–13 (ibid.) The expansion was not just in higher education – the number of schools, including primary, upper primary, secondary, and senior secondary schools went up from around 225,000 to more than 1,425,000 between 1950–51 and 2013–14 (Kumar *et al.* 2008; Ministry of Human Resource Development (MHRD) 2014).

Though the disaggregated data for the number of high schools or colleges where science is taught are not available, it is reasonable to assume that given the large numbers of institutions, there are a fairly large number (in absolute terms) of them where science is offered.

There is no doubt that we have made impressive quantitative gains, as the numbers above testify. It can, of course, be argued that there is still a lot of pent-up demand for both schools and institutions of higher learning and we need to expand the sector at an ever-increasing pace. For instance, the National Knowledge Commission (NKC) recommended setting up at least 1,500 universities as well as 50 national universities in the country to 'provide education of the highest standard' (NKC 2006).

However, to look at education purely as a matter of providing more schools and colleges is missing the important issue of quality. Herein lies the problem as even the NKC, in a surprisingly forthright manner, has pointed out:

> [T]here is, in fact, a quiet crisis in higher education in India that runs deep. It is not yet discernible simply because there are pockets of excellence, an enormous reservoir of talented young people, and an intense competition in the admissions process.
>
> *(Ibid.)*

The problem is not just limited to higher education, but is in fact much more serious in schools. The two are of course linked, as we shall examine below. As the Kothari Commission noted in 1966, 'Indian education needs a drastic reconstruction, almost a revolution' (Kothari Commission 1966). Sadly, this is even truer today than half a century ago.

Statistics and numbers

The UGC was set up in 1945 as a result of the recommendations of the Sargent Report (Sargent Report 1945). However, it was only in 1956 that the UGC was established as a statutory body for coordination, determination, and maintenance of standards in university education. This regulatory body sits at the apex of the landscape for non-technical education and thus, *inter alia*, for higher education in the sciences. In addition, in an odd conflict of interest, the UGC is the regulator as well as the funding agency for all central universities.

The higher education sector comprises central universities, state universities (both private and public), deemed universities, Open universities, institutions of national importance, and finally the bedrock of the higher education system, undergraduate colleges. Their respective numbers are given in Table 6.1 (MHRD 2014). Table 6.2 (ibid.) gives the statistics for schools at different levels.

Table 6.1 Number of institutions of higher education

Universities	Central university	42
	State public university	310
	Deemed university	127
	State private university	143
	Central Open university	1
	State Open university	13
	Institution of national importance	68
	Institutions under State Legislature Act	5
	Others	3
	Total	**712**
Colleges		**36,671**
Stand-alone institutions	Diploma level technical	3541
	PGDM	392
	Diploma level nursing	2674
	Diploma level teacher training	4706
	Institute under ministries	132
	Total	**11,445**

Source: MHRD 2014.

Table 6.2 Number of schools

Type	*Number*
Primary	790,640
Upper primary	401,079
Secondary	131,287
Senior secondary	102,558
Total	**1,425,564**

Source: MHRD 2014.

The massive increase in both institutions of higher learning and at the school level that has been mentioned already has led to impressive strides in the gross enrolment ratio (GER) at almost all levels. Table 6.3 (ibid.) shows the latest available statistics, while Figure 6.1 (UGC 2013) depicts the GER for higher education over time.

Though we see that higher education enrolment has increased substantially, the disaggregated figures for various disciplines shows that in 2011–12, the percentage of students in the sciences was around 13 per cent of the total, as shown in Table 6.4 (MHRD 2014). The figures might understate the total number of students in science and mathematics since in several universities mathematics is a separate faculty and the degrees given are bachelors or masters of arts.

The total enrolment numbers for higher education combines all levels – undergraduate, postgraduate, and research. If one looks at the disaggregated figures for the various courses, one finds that enrolment is the highest at the undergraduate levels and falls substantially as one goes up, though in the case of sciences this fall is not as sharp as in other disciplines.

Some figures are available for enrolment in various streams at the senior secondary level, though they are not very comprehensive. Thus, in 2002 the number of students appearing in

Table 6.3 Gross enrolment ratio at various levels

Level	All: Boys	All: Girls	All: Total	Scheduled Castes: Boys	Scheduled Castes: Girls	Scheduled Castes: Total	Scheduled Tribes: Boys	Scheduled Tribes: Girls	Scheduled Tribes: Total
Primary (I–V)	98.1	100.6	99.3	110.8	112.2	111.5	111.5	108.8	110.2
Upper primary (VI–VIII)	84.9	90.3	87.4	93.2	96.5	94.8	86.5	85.7	86.1
Elementary (I–VIII)	93.3	96.9	95.0	104.2	109.4	102.8	102.5	100.5	101.5
Secondary (IX–X)	73.5	73.7	73.6	76.0	76.2	76.1	67.5	66.7	67.1
I–X	89.4	92.4	90.8	98.6	103.0	97.6	95.9	94.2	95.1
Senior secondary (XI–XII)	49.1	49.1	49.1	48.1	49.7	48.8	35.5	33.2	34.4
I–XII	83.3	85.9	84.6	91.1	93.3	92.2	87.5	86.0	86.8
Higher Education	22.3	19.8	21.1	16	14.2	15.1	12.4	9.7	11

Source: MHRD 2014.

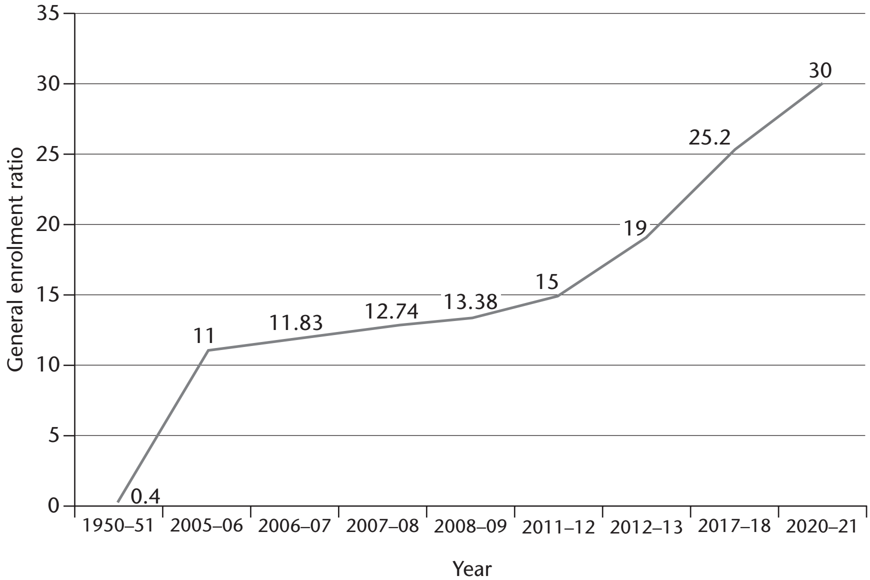

Figure 6.1 Change in GER for higher education with time.

Source: 'Higher Education in India at a Glance June, 2013', www.ugc.ac.in/pdfnews/6805988_HEglance 2013.pdf.

economics in CBSE and ICSE Boards combined was 158,548, while those appearing in physics was 162,175 and those in mathematics was 173,919. The numbers appearing in chemistry were similar to those in physics, while for biology the figure was 75,369 (Garg and Gupta 2003). These numbers, though suggestive, are obviously not very comprehensive since they leave out all the State Boards where the total enrolment is much higher. Nevertheless, taking these figures

Table 6.4 Percentage enrolment in various courses

Programme	*Male*	*Female*	*Total*
BA – Bachelor of Arts	28.22	37.84	32.55
BCom – Bachelor of Commerce	11.51	11.30	11.42
BSc – Bachelor of Science	10.41	12.09	11.17
BTech – Bachelor of Technology	9.10	4.46	7.01
BE – Bachelor of Engineering	8.07	4.06	6.26
BEd – Bachelor of Education	1.34	2.84	2.01
LLB – Bachelor of Law or Laws	0.86	0.48	0.69
MA – Master of Arts	3.45	5.42	4.34
MSc – Master of Science	1.59	2.31	1.91
MBA – Master of Business	2.25	1.44	1.88
MCom – Master of Commerce	0.77	1.16	0.94
MCA – Master of Computer Applications	0.92	0.75	0.84
MBBS – Bachelor of Medicine and Bachelor of Surgery	0.46	0.52	0.49
MTech – Master of Technology	0.61	0.39	0.51
ME – Master of Engineering	0.25	0.22	0.24
Other	20.20	14.72	17.73

Source: MHRD 2014.

as representative of the overall trend, it seems clear that the fraction of students opting for science and mathematics at the senior secondary level is higher than those opting for these subjects at the undergraduate level.

Since the bulk of undergraduate training takes place at the college level, it seems obvious that for any meaningful analysis of higher education in science and mathematics, one has to consider the undergraduate college as the unit of analysis. Of course, since only a handful of colleges are degree-granting institutions, the linkages of the colleges to the degree-awarding universities will also need to be considered. Furthermore, in matters academic as well as administrative, there is almost no autonomy for the colleges and so it is imperative to look at the functioning of the universities too, to gain any insight into the state of education at the undergraduate level.

While undergraduate colleges may be the loci for teaching science, research is almost always a preserve of universities in India. This complete separation of research and teaching at the undergraduate and to an extent at the postgraduate level has profound implications for the teaching of science, as we shall see.

Issues and analysis

The various issues which impact education in the specific cases of undergraduate and postgraduate education in general and in science in particular include the curriculum, the assessment or examination system, human resources, infrastructure, and access. We shall consider each of these in the following.

However, to look at science and mathematics education at the undergraduate level, it is important to have some understanding of how science teaching is done at the secondary level in schools. This is crucial because, to a large extent, the pedagogical issues faced at the undergraduate level are a result of the quality of school teaching. And this is particularly true in the sciences.

However, there is a problem when we try to analyse the teaching of science in schools – and it stems from the enormous heterogeneity in the school system in the country. For instance, 25 per cent of all schools in India are private schools, while 54 per cent are managed by central/state governments and 21 per cent by local bodies. Again, 96 per cent of schools are affiliated to their respective state boards and 1 per cent to the CBSE (E&Y 2014). Non-uniformity is, of course, also a feature of undergraduate education, though to a lesser extent. Thus, though the differences between teaching in a well-funded college of a central university and a small *moffusil* college affiliated to a state university might be large, a great number of colleges do populate the middle of the distribution. For schools, this problem is more severe.

Nevertheless, we can still try to find commonalities in pedagogy across schools which transcend the differences. First, a large majority of the schools still have poor infrastructure. Physical infrastructure in terms of laboratories, libraries, and computers, as well as broadband connectivity, is nowhere near what is required for efficient and effective teaching of science. In fact, a survey of over 240,000 secondary and senior secondary schools conducted by the Unified District Information System on Education (UDISE) and data analysed by the Delhi-based National University for Educational Planning and Administration (NUEPA) found that around 75 per cent of them lacked fully equipped and functional science laboratories (*Times of India* 2014). Even this dismal statistic hides wide divergences – thus, for instance, even in a relatively prosperous state like Karnataka, only 6 per cent of the schools have fully equipped labs at the senior secondary level (ibid.).

The paucity or poor quality of infrastructure extends to human resources as well; the teachers, who might technically be qualified to teach science, are in general not terribly inclined to communicate the excitement of doing science. The lack of good, inspiring, and effective teachers proves to be a major stumbling block in the students' engagement with the subject.

The indifferent quality of teaching is, of course, not restricted to the sciences, but it certainly does result in a large number of students being put off the subject for the rest of their lives – whereas an exposure to the sciences, if done in an engaging and exciting way, can prove to be of immense help in shaping a general culture of science and scientific temper. Invariably, the lack of good teaching makes students apprehensive of the subject. The same is true, even more acutely so, for mathematics. A majority of the population with school and college education still suffer from a phobia of mathematics due to uninspired teaching at the school level. In fact, there are now websites claiming to assist schools to overcome this (MB 2016)!

There is also the issue of the curriculum and its stress on a passive dissemination of facts. Despite numerous attempts to make science interesting, relevant, and ultimately a joy to learn, the actual situation is that it is usually taught as a collection of facts and theories that need to be memorised. In fact, the National Focus Group on Teaching of Science brings out the issues very clearly: 'science education, even at its best, develops competence but does not encourage inventiveness and creativity' (NCERT 2006).

Teaching science in a way in which learning is done primarily by doing and supplemented by constructing theories and hypotheses is significantly more challenging for teachers and hence is usually neglected. In fact, an important lacuna in the curriculum and its implementation is the almost complete neglect of experimentation. And this is not just because a majority of the schools lack the resources and infrastructure – the same is also true for the so-called elite schools which are otherwise very well equipped.

The issue of curriculum in schools is an important one – it is an important link in the development of scientific literacy.

> From the beginning of modern science in the 1600s, there has been an interest in how to link academic science with the life world of the student. This requires a lived curriculum and a range of thinking skills related to the proper utilisation of science/technology

> information. The extent to which students acquire these cognitive competencies determines whether or not they are scientifically literate. The supporting science curriculum must be culturally-based and in harmony with the contemporary ethos and practice of science.
>
> *(Hurd 1997: 407–416)*

There have been several experiments in various parts of the country to change the way science is taught. The Hoshangabad Science Teaching Programme is an example of a well-designed and competently implemented programme to address the above issues. Learning by doing, keeping the quantum of 'facts' to a minimum, extensive teacher training, and a commitment by the state were some of the key elements responsible for its success. However, the replication of this and similar experiments across the country has not been very successful (Eklavya 2007).

The National Focus Group on Teaching of Science seized on the importance of the problem and recommended

> that science education in India must undergo a paradigm shift. Rote learning should be discouraged. Inquiry skills should be supported and strengthened by language, design and quantitative skills. Schools should give much greater emphasis on co-curricular and extra-curricular elements aimed at stimulating investigative ability, inventiveness and creativity.
>
> *(NCERT 2006)*

The nature of assessment, as we shall also see later, has a major impact on the quality and quantity of science teaching at the school level. In fact, the above-mentioned position paper of the National Focus Group on Teaching of Science recognises this and adds that 'the overpowering examination system is basic to most, if not all, the fundamental problems of science education' (ibid.). The recommendations of the National Focus Group on Teaching of Science are radical: 'we recommend nothing short of declaring examination reform as a National Mission (like other critical missions of the country), supported by funding and high quality human resources that such a mission demands' (ibid.).

Coming to higher education, the basic institution for imparting science education at the tertiary level is the undergraduate, affiliated college. A typical university might have affiliated to it tens of colleges spread over a large geographical area. This situation, which might have been appropriate when it was introduced more than 50 years ago, is now one of the major impediments in improving the quality of science education.

Typically, the affiliated or constituent college has no academic autonomy. The curriculum, the academic calendar, and the examinations are all centralised with the affiliating university. Colleges just happen to be the locations for teaching. The disjunction of the actual site of learning and that of decision making has proved to be disastrous. We will look at each of the issues mentioned above in some detail now.

Curriculum

The undergraduate science curriculum of most universities is decided by the science departments in the university. Though there are various institutional mechanisms whereby the college teachers, the people who actually have to teach, are consulted, in practice curriculum framing becomes an exercise carried out almost exclusively by the faculty members of the affiliating university.

This is unfortunate since the college teacher is the fulcrum around which science education at the tertiary level revolves. This is not only because she is the person most informed about the actual reality on the ground, but also because she is the only person who has the potential to excite her students about the subject. Having had no say in the framing of the curriculum has a major impact on the quality of teaching since there is no sense of ownership.

The curricula themselves are mostly outdated, uninspiring, and usually err on the side of including too much. Even where syllabus revision takes place frequently, there is little connection with reality in terms of capabilities of teachers to teach the syllabus, the infrastructure required to teach, and, most importantly, the level of the students. For instance, introducing new experiments in laboratories without adequate preparation in terms of equipment and personnel makes it impossible for the colleges to actually undertake them. Or, introducing new subjects (like microprocessors, computer programming, genetic engineering etc.) without training the faculty members (who may not be familiar with them) leads to their teaching becoming a farce.

The curriculum is mostly designed in such a way that it encourages passive reception of knowledge. The need for the student to investigate, develop problem-solving abilities, and work in teams is neither required nor encouraged. This has the effect of science being taught in a way that is contrary to its basic principles – discovery, comprehension, and application to different situations.

Laboratory work, which is seen as integral to any serious scientific teaching, is mostly done as a matter of routine. It is important for students to be aware of experimental techniques, data processing, and analysis, as well as to be familiar with the equipment used. Most institutions lack the infrastructure to effectively carry out this exercise. The laboratory curriculum itself consists of experiments that are outdated and have little pedagogical value. In short, there is nothing in the laboratory that could inspire or excite the student.

Frequently, there is also a project component in the curriculum. The spirit behind this is admirable, but the actual implementation has destroyed it. The project is supposed to train the student to formulate a problem, investigate it, collect data, and prepare a detailed report. This would be useful in developing skills in a variety of areas like literature search, technical writing, data analysis, and experimental techniques. However, in most cases, what actually happens is that the project is bought off-the-shelf – there being shops which specialise in preparing projects!

Research seems to confirm what has been known to science educators for some time – students who are given more freedom to think and less instruction in laboratory classes seem to perform much better than those who are given a 'cookbook' approach to the class (*The Hindu* 22 February 2007). Unfortunately, the laboratory curriculum in our colleges and universities is a classic example of the cookbook approach in which students are provided step-by-step instructions to carry out the experiments, resulting in almost no innovation or understanding.

Thus we see that both at the school and college level, the curriculum and the methodology of teaching leads to science being taught as a collection of facts that need to be memorised. Lack of infrastructure and demotivated teachers also contribute to the student not experiencing science as an exciting method to learn about and analyse the world around her. An important factor which reinforces this malaise is the assessment system.

Assessment

The examination or assessment system prevalent in most undergraduate institutions is highly centralised, where no distinction is made between the immense variations among the colleges. It is a system which is not conducive to innovation or initiative.

The nature of the examinations is detrimental to any assessment of genuine learning. Most examinations do not test anything more than memory. This is very damaging in all subjects, particularly the sciences, where no training is given for problem-solving or application of concepts. Commenting on the dismal state of the examination system, the Knowledge Commission has noted that:

> The nature of annual examinations at universities in India often stifles the teaching–learning process because they reward selective and uncritical learning. There is an acute need to reform this examination system so that it tests understanding rather than memory. Analytical abilities and creative thinking should be at a premium. Learning by rote should be at a discount. Such reform would become more feasible with decentralised examination and smaller universities.
>
> *(NKC 2006)*

All this is disastrous for science education – not just because the marks obtained at the end of the course are no indicator of the quality of the student, but more importantly because it has a negative feedback effect on the teaching per se. There is no incentive for the teacher to be innovative in the class. The student also takes the path of least resistance and is not interested in doing anything more than what is required for getting good grades in the examinations.

Decentralisation of the examination system will certainly help since motivated teachers could devise ways and means to encourage students to develop critical skills. One way to do this would be to incorporate some form of an Internal Assessment system which allows continuous assessment rather than an end-of-year assessment. This will also have the advantage of the teacher who is teaching the course being able to frame an assessment method which is suitable to the course and the students.

A common objection against decentralised assessment is grade inflation. While this is undoubtedly true to an extent, there can be several solutions to this. Thus, for instance, one can think of a relative grading where a student is only placed relative to his/her peers in the class rather than across institutions. Then the assessment will gauge a student's true ranking in his/her class. The relative placement of students across institutions can be done by standardised tests at some point.

In the sciences, there is also an additional examination for laboratory work. This by and large is a farce, since the methodology of testing the students does not test their experimental abilities or skills. And since here, too, everyone gets good grades, this examination serves no purpose as an assessment since it does not differentiate.

Human resources

The most important element in any educational system is the teacher. Competent, qualified, and motivated teachers are essential in maintaining the quality of education.

Contrary to popular perception, teaching is not very high on the list of attractive professions for good students. Even among teachers, teaching science is not a preferred option for many students. There are of course many reasons why science as a career is not high on the priority list. The job opportunities for professional degree holders are better and there is a lot of parental and peer pressure to secure a good future by becoming a professional. But one of the main reasons for a lot of students getting turned away from science is the dismal state of teaching at the school level.

Science teaching in even the best and most well-endowed schools does not inspire the student. As noted earlier, the syllabus and the pattern of assessment at the secondary level are such that most students are turned off. The whole philosophy behind science, one of discovery, problem-solving, and critical questioning, is discouraged and rote learning is encouraged and rewarded.

The quality of teachers is also poor, given that the best students opt for other careers and it is those who are left with no option that pursue a career in school teaching. Thus a typical student who enters college is already disillusioned with science, having never experienced the joy of learning and discovery. This is not just a problem in India – declining interest in science among school students has been noticed globally. The reasons given are many, though an important one is that 'students reject a school science that is disconnected from their own lives, a depersonalised science, where there is no space for themselves and their ideas' (UNESCO 2010).

The lack of motivation on the part of the students has a negative feedback effect on the teaching process, with the teacher not delivering her best to a class of disinterested students. This is a very serious problem and though no numbers are available, anecdotal evidence suggests that in the University of Delhi, even in good colleges, the percentage of students who want to pursue a degree in science out of choice is no more than 15 per cent.

The teaching profession has little charm for a bright and motivated student. This has disastrous consequences for science education since it creates a vicious circle. Students who go through their course with bad teachers lose interest and become demotivated teachers themselves, producing disinterested students, and so on.

This problem has been highlighted eloquently by the Indian Academy of Sciences *Report on Higher Education, 1994*. Bemoaning the lack of interest in science as a career, the report points out,

> In contrast to the situation a few decades ago, students, parents and indeed society as a whole do not presently view a career in science as rewarding or challenging, or even as offering a satisfying professional life. Career opportunities in science are perceived as limited, and as being not at all comparable materially with other professions. Intimately related to these negative impressions is the fact that faculty positions in colleges and universities appear lacking in prestige and respect.
>
> *(IAS 1994)*

The issue is not just one of quality, but also of quantity. The number of teachers with the requisite qualifications and competence is woefully inadequate, especially in the sciences. This is evident in the number of vacant teaching positions in most institutions, including the new ones (IITs, Indian Institutes of Science Engineering and Research, central universities). The administrators of these institutions have repeatedly pointed out that the paucity of qualified and competent teachers is their biggest challenge (*Economic Times* 2015).

Physical infrastructure

We have already indicated the dismal state of physical infrastructure for science teaching in secondary schools. Many schools operate from makeshift buildings and without the bare minimum of facilities in the classroom. Libraries are mostly defunct or barely functional; laboratories, which are anyway skeletally equipped, are not used for most of the year and opened only at the time of the Board examination. It is a dismal state of affairs that in seven states more than 80 per cent of the schools are without toilets (*The Indian Express* 2015).

The situation at the undergraduate level is hardly any better. Barring a few extremely well-funded institutions (the IITs and the recently established IISERs), the physical infrastructure in most of our higher education institutions is simply not good enough. Physical infrastructure includes classrooms with at least elementary teaching aids, tutorial rooms, and rooms for faculty members, well-stocked libraries, computers, internet connectivity, and laboratories, as well as recreational areas, toilets, etc.

In most colleges, there is a paucity of classrooms and tutorial rooms for discussions. Classrooms are in most cases non-functional. This environment is certainly not conducive to learning and exploration. In a situation where even functional blackboards are hard to find, there is little point in talking about high-technology teaching aids like projectors and display screens.

A well-stocked library with ample sitting space is an essential part of any educational institution. Unfortunately, most colleges have libraries that are not functional in any real sense. The maintenance is shambolic and there is little budget for increasing the holdings or even maintaining subscriptions in view of the ever-increasing costs of journals and books. This is disastrous since, given the high cost of books, the majority of students are dependent on the libraries for access to them.

Information technology can play a very important and enabling role in education. However, a majority of the colleges in the country have limited resources to provide computers for student use. There is also a lack of infrastructure in terms of uninterrupted power supply in most colleges; therefore, laboratories and computer resource centres function sub-optimally, leading to tremendous loss of time and efficiency.

Undergraduate teaching laboratories are in a pathetic state. The rising cost of equipment and spare parts has meant that the measly resources available for the laboratories are grossly insufficient to even maintain the labs, leave alone introduce new experiments.

Surprisingly, the Education Commission in 1948 had similar observations on the state of teaching laboratories:

> There is no doubt that modern teaching and research in scientific subjects require adequate and even costly equipment. Modern scientific research is largely a matter of evolving new techniques, the apparatus for which is costly and can only be provided by making adequate capital and recurring grants.
>
> *(Education Commission 1948)*

The gross neglect of undergraduate teaching laboratories has disastrous consequences for science education. As one commentator has noted:

> A major area of investment in Chinese universities is the upgrading of undergraduate teaching labs. We spend almost nothing on this front even as we stuff up a few 'prestige' institutes with costly equipment. But there will be a real pay-off only if we invest in training young people in the universities well. This is where China is correctly placing its money, and this is where we are totally off track.
>
> *(Desiraju 2007)*

Equality of access

J.P. Naik, in a seminal article, spoke of equality, quantity, and quality comprising the elusive triangle in Indian education (Naik 1979). This is the aspect of education which, though critical, is usually not considered in most discussions on education. Access, defined in a very broad way, implies real opportunities for everyone for a high-quality, meaningful education at affordable rates.

The first and the most obvious fact is that there are simply not enough vacancies for all the interested school-leaving students to get into colleges. Even though our GER for higher education is now a fairly respectable 20 per cent or so, it is clear that there is still a large unmet demand for education. This is evident from the large number of applicants for the limited number of college seats across the country. For instance, in 2015 Delhi University received around 320,000 applications for 54,000 seats (*India Today* 2016).

For those who do manage to secure a position at a college or a university, there are several barriers to a meaningful education. These barriers range from language skills, lack of textbooks and reference material in their native language, and a very heterogeneous school education leading to a huge gap in informational and conceptual training, etc.

In many parts of the country, the medium of instruction at the college level, especially in the sciences, is English. This automatically places a large number of students who have had their school education in vernacular languages at a disadvantage. The challenge of understanding the language has to be first overcome before even attempting to meaningfully engage with the subject.

The availability of high-quality and affordable books is another problem faced by most students. Even in English, the number of locally produced books which are of good quality is very small. The books that are normally used in most universities are of very poor quality, since in most institutions books written by foreign authors are either not prescribed or not used in practice by the students. The reasons are many – the cost of these good-quality, though foreign, books is much higher; the engagement demanded on the part of the student while using the book is much higher than locally produced books; and finally, the language used is frequently difficult for students who are not comfortable with it. Instead, what we get are locally written clones of these standard books, which in trying to make the subject and language more accessible, often end up being glorified guidebooks. It is ironic that with the third or maybe fourth largest manpower base in S&T in the world, one cannot point to more than a handful of good textbooks written in India which are of a global standard. Unlike, say, China or the post-revolution Soviet Union, where the best scientists wrote textbooks, some of which became classics in their subjects, our scientists don't seem to be inclined towards this enterprise (Wikipedia 2016).

A related issue is obviously the availability of books in languages other than English. In the sciences, there are almost no good-quality textbooks available in any of our languages at the college level. The non-existence of good reading material in the vernacular was recognised by the NKC, which recommended the setting-up of a Translation Mission to translate material into Indian languages (NKC 2006).

Finally, we have a huge gap in what we expect our undergraduates to know and the skills that they ought to possess and what the reality is. The entering student is supposed to possess skills and have a level of awareness and information which is presumed to have been acquired either at home or at the secondary level. However, because of the huge variation in the standards of secondary education which exists in our country, there is a concomitant range of capabilities of the students entering the tertiary level.

Furthermore, the policies of affirmative action and reservation have resulted in a number of students from less privileged backgrounds entering colleges and universities. In fact, some of them are first-generation learners. However, it would be a fallacy to think that lack of preparation to handle the rigours of college education is restricted to those who have gained access owing to reservations. It is far more general and widespread.

The solution, of course, is not to dilute the academic standards and thereby make a mockery of the whole system, but rather to provide the deficient students opportunities to catch up. After all, how does one expect them to cope with the huge demands that our system puts on their comprehension and informational capabilities given their deficient training? Is it fair on the students to be admitted (because of reservation or otherwise) and then be left to their own devices to compete in this harsh, alien ecosystem? Or should there be institutional mechanisms to empower and train these students? These could range from remedial classes in the afternoon or evenings, extensive preparatory classes during vacations, or some other methods to bring the ill-equipped students up to speed.

University of Delhi: a case study

We can consider the case of a large central university like the University of Delhi (DU) as illustrative of the above-mentioned malaise. DU is one of the largest institutions of higher education in the country. There are more than 80 constituent colleges where undergraduate teaching takes place. Postgraduate teaching is almost entirely done in the 80-odd departments of the DU, which are grouped into 14 faculties. The total student enrolment, including the distance education programme, is upwards of 500,000 (DU 2016).

The science subjects are aggregated into two faculties – science and interdisciplinary sciences – while mathematics has a separate faculty. Undergraduate teaching shifted to the colleges at various times in the past; for instance, in the case of physics it was only in 1971 that undergraduate Honours course teaching moved to some of the colleges. Prior to this, all teaching was in the Department of Physics.

There have been several curriculum revisions in the sciences course over the last few decades. Let us focus on the Honours course in physics.

The Honours course in physics underwent at least three revisions prior to 2010. The process of curriculum revision, though in principle a fairly democratic one, in practice has some of the teachers in the postgraduate department in consultation with a small cohort of undergraduate teachers deciding what is to be taught and when. Genuine widespread consultations are not the norm and even if they take place, the suggestions are often overlooked.

Nevertheless, it must be said that the curriculum in the physics Honours course has, until recently, always been more or less comparable to the best in the world. Thus, for instance, what is usually considered the core for an undergraduate degree in physics – namely mechanics, electricity and magnetism, heat and thermodynamics, modern physics, and waves and oscillations – were all covered in some detail in the course. The topics covered in these subjects were comprehensive and essentially followed the standard treatment of these subjects as in well-known textbooks. In addition, one of the notable features of the physics Honours course was its stress on training in mathematical physics. This emphasis on mathematical physics, with one paper in each year, was something that was not practised in most universities in India or even abroad. A strong grounding in mathematics, the language of physics, means the student is given ample training in the techniques of problem-solving, at least at the theoretical level.

The course, as we noted, was extremely well designed and of high quality. Nevertheless, the quality and quantity of what is supposed to be taught is crucially dependent on how it is taught. Here the problems of centralisation of decision making in curriculum framing becomes obvious – the colleges in the DU are very uneven in terms of human and physical infrastructure. Thus, for instance, there are colleges where there are not enough teachers to teach all the subjects in the curriculum. The colleges then have to engage guest lecturers who, because of their limited engagement, are of limited efficacy. Even in colleges which are adequately staffed, the absence of any meaningful training and refresher courses means that most of the teachers are not equipped to teach some of the newer subjects. For instance, in the 1990s, when the Honours curriculum was revised for physics, several new subjects like microprocessors and digital electronics were introduced. Most teachers had never been exposed to these subjects and were therefore unable to teach them effectively. Furthermore, most of the colleges did not have proper equipment for the laboratory courses that went with these subjects. In such a scenario, the high quality of the curriculum itself becomes meaningless.

The curriculum, though otherwise of very high quality, has always had a major lacuna in terms of laboratory work. The choice of experiments and the structure of the lab courses is woefully inadequate to prepare the undergraduate student to develop any appreciation, let alone training of experimental physics. This is further exacerbated by the extremely poor infrastructure available in most colleges and even the postgraduate department. The funding available to the laboratories is pitiful. For instance, the total capital expense on laboratories in physics in 2012–13 at a premier college in the DU was around Rs. 16,000 – not even enough to buy a decent oscilloscope, an essential piece of equipment nowadays. It is pertinent to note that the number of students using the labs would be upwards of a couple of hundred (Ramjas 2013).

All this changed with the latest set of changes in the DU. In the last five years, the poor undergraduate has had to get used to the introduction of the semester system, then an abortive attempt to introduce a four-year undergraduate programme (FYUP), and finally a new avatar of the FYUP, the current Choice-Based Credit System (CBCS).

Whatever the theoretical merits and demerits of these revolutionary changes introduced in a blitzkrieg fashion (and with no discussion or debate), their effect on the curriculum has been disastrous. The changes in the curriculum to fit the new models have made a mockery of a perfectly good course of study. How else can one characterise the process through which the annual course of study was simply arbitrarily cut into two to fit the semester mode? In some of the subjects, this meant the load on the students increased since it was not possible to distribute the content evenly over two semesters. Worse, sometimes the two halves of the course were not even taught in successive semesters thereby making it all the more difficult for the teacher and the taught to maintain continuity in the development of the subject.

The mayhem caused by the FYUP and its new mutation, the CBCS, was even worse. Now we had the discipline courses slashed to make room for the so-called minors and foundation courses. This may not be such a bad idea per se, had it been done in the proper way with widespread discussion and adequate preparation. However, what actually happened was that the curriculum and structure of the foundation and minor courses made a mess of any meaningful pedagogy. The foundation courses, in particular, were designed it seems by someone like Rip Van Winkle – someone who had missed the developments of the last few years. How else does one explain a compulsory course for all undergraduates which in this day and age teaches students how to send an email or how to search for something on the internet (Mahajan 2013)?

Even though the curriculum till recently, with all the limitations of its implementation, remained of high quality, the assessment system was not conducive to any meaningful pedagogy. Examinations were held at the end of the year and assessment was centralised without any distinction between the hugely disparate academic standards of the colleges. Furthermore, the examinations tested nothing more than the ability to recall. In a subject like physics, an assessment that totally ignores the problem-solving abilities of the students and instead rewards memory recall of standard textbook material is disastrous. This, of course, had a feedback effect on the teaching, with both the student and the teacher adopting a path of least resistance towards attaining high grades, irrespective of any real understanding. The situation in the laboratories, where, as we have seen, even the curriculum was outdated, was worse since there was no real assessment. Almost everyone got very high grades with or without any experiments being performed.

Things changed somewhat around 2003, when a system of partial internal assessment was introduced (University of Delhi 2003). Some percentage of the overall mark was assigned to internal assessment done by the teacher running the course. This at least meant that there was some element of continuity as well as decentralisation in assessment. However, this was a chimera – the propensity of the teachers to inflate grades and the fetish of 'objectivity' in grading led the university to adopt a 'moderation' of the grades which made the whole exercise meaningless. Worse, the moderation process was shrouded in secrecy and could not be subjected to elementary tests of fairness or rigour.

The introduction of the semester system and the subsequent changes also had a dramatic effect on the quality of assessment. The DU, in an attempt to make the hugely unpopular system more likeable, resorted to large-scale grade inflation in some subjects. Thus, while previously it was rare for even the best students to achieve marks of more than 85 per cent in the physics Honours course, scores in the 90+ per cent range were now common. It was not just the highest marks which were inflated – the median score also jumped to an unprecedented level (Mahajan 2012).

In terms of human resources, the situation is extremely bleak. There are more than 4,000 vacant teaching positions in the DU. Although the number of these positions in the sciences is not available, if one takes the number of students as an indicator of the number of positions and assumes the vacant positions are evenly distributed across subjects, the estimate for the sciences would be close to 1,000. This is alarming to say the least (Mahajan 2016a).

The situation is actually much worse – governance issues in the DU, especially in the last few years, have meant that these vacant positions are actually staffed by 'ad hoc' teachers. These contractual teachers have no security of tenure, are made to take a disproportionately high teaching load and are therefore a demotivated lot. It would be too much to expect such a demotivated teacher to actually inspire students towards the subject.

The quality issues in teaching are also something that need to be addressed – with changes in curriculum and the introduction of new subjects, the teachers need to be offered high-quality in-service training and refresher courses. No systematic policy has been framed to address this crucial issue.

The DU is one of the best funded universities in the country. And yet, the physical infrastructure of most colleges as well as large parts of the campus leave a lot to be desired. Laboratories with outdated or, worse, non-functioning equipment, libraries which serve as little more than a lending library for textbooks and examination guides, and a paucity of classrooms and recreational spaces are common across the university. Poor maintenance of existing infrastructure, a fairly widespread malaise in our nation, is also evident.

Of course, lack of resources is the primary reason for this situation. Resource allocation has not kept pace with the increase in enrolment. However, there is certainly an element of misguided priorities where libraries, classrooms and laboratories always seem to have a lower priority in a resource-scarce environment.

Finally, the issue of equality of access has recently become of great importance even in the DU. For a long time, the university has attracted students from across the country and thus the student body has always been fairly heterogeneous. However, despite this heterogeneity, there were only a very small percentage of students in the sciences who had not had their school education in English.

With the recent increase in enrolment due to a constitutional amendment which also mandated a reservation for certain classes of students, a fair number of students from disadvantaged backgrounds are now entering the university.

These students, many of them from rural backgrounds, have not had the opportunities that their urban, middle-class fellow classmates have had. The schools they have gone to were of poor quality and, worse, their exposure to English as a medium of instruction is nil. Indeed, some of them are the first in their families to reach college. Thus, for instance, in the entering class for MSc in physics in 2015, more than 40 per cent of students' parents had never studied beyond Class XII (Mahajan 2016b).

This is a huge problem especially in the sciences, since all the instruction in the DU is in English. Thus, these students from modest backgrounds face a double whammy – a deficit in their exposure to the subject as well as the medium of instruction. It doesn't help that there are no appropriate textbooks available at the undergraduate level in the vernacular. This huge disadvantage was brought home to me when a postgraduate student of mine asked me for some clarifications in a textbook that I had written. When he showed me the relevant page, I noticed that the margins were filled with translations of the sentences in Hindi. When I asked him about it, he sheepishly confessed that he didn't follow the language and so had asked a friend to translate it into Hindi, which he had transcribed.

This is not to argue that these students are inherently any worse than others. It is just that the opportunities that they have had have been limited and therefore for their university education to be truly meaningful, they require a degree of assistance. Sadly, neither the administrators in the DU, nor the policy-makers in the government are interested in this matter.

Although the scenario we have discussed is for a particular course in a particular subject, the situation in all the other science subjects in the DU is fairly similar. It is indeed noteworthy that this is the situation in an old, well-known, and well-funded institution like the DU. One can only imagine the state of poorly funded state universities and *moffusil* colleges where sometimes even a proper building is missing.

Conclusions and outlook

Science education at all levels is not in a particularly good shape as things stand. Although our enrolment ratios have increased dramatically because of an enormous increase in public expenditure on education, the results have not been very encouraging.

At the school level the situation is more alarming than at the higher levels. This is because to a large extent, the fundamental approach to learning gets imbibed by the student at that formative stage. Poor infrastructure, lack of qualified and, more importantly, inspiring teachers, and standardisation imposed across states and the country leads to dismal results. Grade inflation, which is rampant in almost all school boards, masks the actual state of affairs, with a large number of students scoring in the high 90+ per cent range and a majority of them scoring reasonably well. That such a kind of assessment loses its meaning as assessment is, of course, a cause for concern, but possibly more important is the impact on the actual learning by the student.

Learning science for a vast majority of the students becomes basically a question of memorising some facts and information without processing it. Problem-solving, analytical thinking, and working out what-if scenarios, which are the hallmarks of training in science, are completely ignored.

The situation in higher education is not much different. Although we might be producing a fairly large number of graduates and postgraduates in the sciences (see Table 6.3), it is now widely acknowledged that these graduates do not possess the requisite skills. A good measure of how our science training compares with others is the research output. Leaving aside the advanced industrialised economies, our research output in the sciences is lagging behind similar countries. Thus, for instance, China was lagging behind India in the number of scientific publications and citations till 1996, when it outpaced India and is now far ahead in both the quantity and quality of research (Kademani *et al.* 2014).

In this dismal landscape, there are several initiatives which are laudable and could produce positive results over time. Several schemes to encourage students to take up science have been initiated in the last several years. These include the Innovation in Science Pursuit for Inspired Research (INSPIRE) programme and the Kishore Vaigyanik Protsahan Yojana (KVPY), which aim to identify bright students with an aptitude for science at a young age and then provide them with scholarships (DST 2015). The INSPIRE programme also has a component of various scientists visiting schools and colleges to deliver talks and seminars. The impact on the students, especially in schools in rural and remote areas, of this exposure to the excitement of science should not be underestimated. The Homi Bhabha Centre for Science Education has been organising programmes based on the Science and Mathematics Olympiads across the nation, and these have certainly inspired some of the brighter school students. The Indian Academy of Science has a summer programme in which interested students get assigned to a mentor for a summer project (IAS 2015).

The Rashtriya Avishkar Abhiyan (RAA), another initiative of the MHRD, 'while emphasising the primacy of the schools and classroom transactions, aims to leverage the potential for Science, Mathematics and Technology learning in non-classroom settings' (RAA 2015). This too should yield positive results in the quality of learning outcomes for school students over time.

For improving the quality of human resources in our institutions, there are several in-service refresher courses which are mandatory for promotions. This requirement has unfortunately made these courses somewhat unattractive. Nevertheless, these courses can provide a valuable resource for teachers to get up to speed with some of the latest developments in the subject as well as in pedagogical methods.

In all of the above, we have not discussed the role of research, and have focused on teaching at the universities and colleges. This is because for a majority of our college faculty, continuing with research is an almost impossible task. Lack of facilities, paucity of time, and the overall inertia make it almost impossible for anyone but the most motivated teacher to continue with research. This, of course, has major consequences for teaching since it has been widely acknowledged that research work actually leads to an improvement in teaching quality (Prince *et al.* 2007).

The infrastructure needed for scientific research, namely laboratories and access to journals, etc., is an area where some welcome steps have been taken in the last few decades. The development of central facilities by the UGC is a very welcome step. These inter-university centres cater to the college teachers who can avail of them, especially during vacation time. This provides teachers with an opportunity to use expensive and hard-to-obtain equipment to facilitate their research. Similarly, the expansion of initiatives like INFLIBNET will provide electronic access to journals to colleges, thus improving access to information and research for students and teachers there.

Both the school and higher education system in the country need a drastic and urgent overhaul. At the school level, there is an urgent need to rethink and experiment with new curricula, as well as pedagogical tools, while improving the physical infrastructure. For higher education, a massive expansion and qualitative improvement is required in such institutions to improve their access to all our citizens. This is imperative if we want to compete in an increasingly globalised world where knowledge plays a role as important as capital, labour, and natural resources.

Of course, improving the quality of and access to schools and universities requires enormous resources. But one should be careful in recognising that though this might be a necessary condition, it is by no means a sufficient one. What are really needed are a judicious use of resources, change in mindsets, improved systems of governance, and a proper use of incentives and disincentives. We must also realise that given our tremendous diversity, there is no single magic formula which will guarantee success.

Finally, apart from the institutional framework, it is also important to consider the broader social milieu if one wants to understand the issues facing science education in the country. Science as a vocation has been hugely downgraded in our society. This is a big change from the situation prevailing in the 1950s and 1960s, when science was seen as the career of choice for the best and brightest. People like Vikram Sarabhai and Homi Bhabha, the pioneers of scientific institution building in post-Independence India, were idolised by a generation of students. In the decade of the 1970s and 1980s, this changed drastically. Research and/or teaching as a profession was downgraded and presumed as unattractive for students. It was not just about monetary rewards of alternative careers – social recognition started playing a major part in career choices.

Education is not just about increasing the enrolment numbers by fiat. It is about providing genuine opportunities to students from diverse backgrounds to enlarge their mental and cognitive capabilities. Of course, there are challenges – financial, institutional, and human-resource related. These challenges are especially acute in the sciences because of the nature of the disciplines. However, education is such an important area of human activity – an enabler not just in the economic sense but also in a civilisational one – that the challenges are worth taking up.

References

Arnold, David. 2013. 'Nehruvian Science and Postcolonial India', *ISIS*, 104(2): 360–370.

Desiraju, Gautam. 2007. 'China shows the way in science education'. *The Hindu*, 19 February.

DST. 2015. *'INSPIRE'*. www.inspire-dst.gov.in; www.kvpy.org.in/main (accessed on 23 March 2015).

DU. 2016. 'Academics'. http://du.ac.in/du/index.php?page=study (accessed on 12 June 2016).

E&Y. 2014. 'Private sector's contribution to K-12 education in India: current impact, challenges & way forward'. www.ey.com/IN/en/Industries/India-sectors/Education/EY-role-of-private-sector-on-K-12-education-in-India.

Economic Times, 2015. 'IITs facing faculty shortage by up to 40%; beefing up compensation packages to attract talents'. http://economictimes.indiatimes.com/jobs/iits-facing-faculty-shortage-by-up-to-40-beefing-up-compensation-packages-to-attract-talents/articleshow/47636795.cms (accessed on 10 June 2016).

Education Commission. 1948. *Report of the Education Commission, 1948*. www.teindia.nic.in (accessed on 20 March 2015).

Eklavya. 2007. 'Thirty years of Hoshangabad Science Teaching Programme: 1972–2002: a review'. www.eklavya.in/pdfs/HSTP/HSTP%2030%20years%20Review%201-3-2007.pdf (accessed on 23 March 2015).

Garg, K.C. and Gupta, B.M. 2003. 'Decline in science education in India: a case study of +2 and undergraduate level', *Current Science*, 84(9): 1198–1201.

Government of India. 1958. *Science Policy Resolution*. http://dst.gov.in/stsysindia/spr1958.htm (accessed on 23 March 2015).

The Hindu. 2007. 'Scientific literacy among students'. *The Hindu*, 22 February. www.thehindu.com/todays-paper/tp-features/tp-sci-tech-and-agri/scientific-literacy-among-students/article2267358.ece (accessed on 23 March 2015).

Hurd, P.D. 1997. 'Scientific literacy: new minds for a changing world', *Science Education*, 82: 407–416.

IAS (Indian Academy of Sciences). 1994. *Report on higher education*. www.ias.ac.in/initiat/sci_ed/report.html (accessed on 20 March 2015).

IAS. 2015. 'Indian Academy of Science'. www.ias.ac.in/index.html (accessed on 23 March 2015).

India Today. 2016. 'Delhi University admissions 2016: over 1 lakh applications received in two days'. http://indiatoday.intoday.in/education/story/delhi-university-admission-process-began-2016/1/683174.html (accessed on 8 June 2016).

The Indian Express. 2015. 'Modi promised total sanitation in schools, but it might be difficult to achieve. Here is why'. 24 February.

Kademani, B.S., Sagar, Anil, and Kumar, Vijai. 2014. 'Indian science & technology research: a scientometric mapping based on Science Citation Index'. http://eprints.rclis.org/8398 (accessed on 15 March 2015).

Kothari Commission. 1966. *Report of the Education Commission 1964–1966*. Delhi: Government of India Press.

Kumar, N., Kumar, Vipan, and Kumar, Neelam. 2008. 'Educational infrastructure in India'. In *India S&T Report, 2008* (pp. 13–15). New Delhi: National Institute of Science, Technology and Development Studies (NISTADS).

Mahajan, S. 2012. 'Compounding the error – marks inflation at Delhi University'. https://kafila.org/2012/02/08/compounding-the-error-marks-inflation-at-delhi-university-shobhit-mahajan.

Mahajan, S. 2013. 'Weak foundations'. *Social Scientist*, 41(7/8): 35–38.

Mahajan, S. 2016a. 'Things to DU'. *The Indian Express*, 20 February 2016.

Mahajan, S. 2016b. 'Survey of M.Sc. (Physics) students at Delhi University'. Unpublished.

MB. 2016. 'Eradicate math phobia in schools'. www.slideshare.net/MathBuster/eradicate-math-phobia-in-schools (accessed on 9 June 2016).

MHRD (Ministry of Human Resource Development). 2014. *Educational Statistics at a Glance*. New Delhi: MHRD.

Naik, J.P. 1979. 'Equality, quantity and quality: the elusive triangle in Indian education', *International Review of Education*, 25(2–3): 167–185.

NCERT. 2006. 'Position paper: National Focus Group on Teaching of Science'. https://ideas.repec.org/s/ess/wpaper.html.

Nehru, Jawaharlal. 1946. *The Discovery of India*. Oxford: Oxford University Press.

NKC (National Knowledge Commission). 2006. 'Report to the Nation'. http://knowledgecommission-archive.nic.in/reports/report09.asp.

PrinceM.J., Felder R.M., and Brent R. 2007. 'Does faculty research improve undergraduate teaching? An analysis of existing and potential synergies', *Journal of Engineering Education*, 96(4): 283–294.

RAA. 2015. 'Order of RAA guidelines'. http://mhrd.gov.in/rashtriya-avishkar-abhiyan (accessed on 10 June 2016).

Ramjas. 2013. 'Balance sheet as on 31st March 2013'. http://ramjascollege.edu/pdf/141095338473398661183.pdf (accessed on 13 June 2016).

Sargent Report. 1945. *Sargent Report on Education, 1944*. www.kkhsou.in/main/education/sargent_report.html (accessed on 25 February 2015).

Times of India. 2014. '75% of schools lack decent science labs'. *Times of India*, 19 August.

UGC (University Grants Commission). 2013. 'Higher education in India at a glance, June, 2013'. www.ugc.ac.in/pdfnews/6805988_HEglance2013.pdf (accessed on 10 March 2015).

UNESCO. 2010. 'Current challenges in basic science education'. http://unesdoc.unesco.org/images/0019/001914/191425e.pdf (accessed on 13 June 2016).

University of Delhi. 2003. *Ordinance*. http://dcac.du.ac.in/documents/ordinance.pdf.

Wikipedia. 2016. 'Course of theoretical physics'. https://en.wikipedia.org/wiki/Course_of_Theoretical_Physics.