

Improving India's
Education System through
Information Technology



International Business Machines India Ltd.

Subramanya Arcade, No.12, Bannerghatta Main Road, Bangalore - 560 029, India.





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OVERVIEW

The future of India will be fashioned in her classrooms. While India has made great strides in improving her education system, much still remains to be done. The goal of this report is to outline how information technology (IT) can help create an education system that is based on the principles of helping teachers be effective in what they do; improving the quality and relevance of classroom instruction; and making quantifiable and measurable progress towards improving efficiency. All this is to be done with an understanding of the special social, cultural, political, infrastructural and economic factors prevalent in the country.

We have elected to focus on school-level education, simply because that is where the foundations for learning are laid and it is where the most daunting challenges lie. However, most of our recommendations could also extend to college-level education.

Our findings suggest that IT can help address three important challenges facing school education in India:

1. Improving performance. Less than a tenth of those who enter the school system qualify for a collegiate education. A majority of those who do qualify do so with very poor grades.
2. Improving teacher-training. There are large numbers of under-qualified teachers and many more who need further professional education and training as they work.
3. Improving the quality of instruction material. Text books are updated infrequently and often contain errors.

We have elected to focus on school education, as this is where the foundations for learning are laid.

India should look towards developing new models for designing curricula, and for helping teachers and students. These can be achieved using an Education Collaboration Network.

We believe that to address these challenges, we should look towards developing:

- **New models for designing relevant curricula:** We envisage a system that encourages the mass participation of experts, teachers, and students in shaping and updating curricula in a timely manner.
- **New models for authoring training material and teaching aids:** We envisage a system that allows teachers and students to comment and discuss sections of text books, link supplementary material for further study, share lectures, exercises, assignments, tests and so on. We also see the participatory development of training material for helping teachers and administrators update and enhance their skills.
- **New models for providing access to teaching aids:** We envisage a system in which every teacher is able to access and use teaching aids developed anywhere, and by anyone.
- **New models for teaching students:** We envisage a system that can provide flexible ways of teaching students, in the face of socio-economic pressures that make it difficult for students to attend regular classes, and systemic pressures that have resulted in a shortage of qualified teachers.

This report is about achieving these goals within the framework shown in Figure 1. At the core of this figure is an 'education collaboration network', or ECN, that has at least the following properties:

- It is highly distributed and capable of taking advantage of existing infrastructure in the country (like EDUSAT, Vidhya Vahini Labs and Teacher Centres);
- It makes provisions for dealing with different levels of IT maturity and multiple languages; and
- It is based on open standards for encoding and accessing content.

Here are some scenarios that we think will become a reality with such a network:

USAGE SCENARIOS

Ashok, Science teacher, Rural Madhya Pradesh

- Ashok wants to improve his understanding of Newton's laws for his lecture next week. Neither he nor the school he works in has a computer.
- He goes to a community portal in his village, which has been integrated into the ECN and begins his search using an easy-to-use graphical interface.
- He finds a ranked list of material matching his requirement (the ranking is based on past searches, access by and recommendations from other teachers).
- He also finds notes from Mandira Mukopadhyay, a teacher in Kolkata on how she taught Newton's laws (the original notes were in Bengali but were translated into Hindi by Nimish who lives in Allahabad). Ashok prints the notes using the free quota available to him for this purpose.
- There is also a video by Professor Goyal. He sees the video and makes some notes.
- Ashok also finds some problem sets and test questions provided by other teachers. He prints these support materials.
- Ashok's selections are recorded by ECN to refine the ranking of its content.

The Education Collaboration Network (ECN) will use existing IT infrastructure and account for different levels of IT maturity and multi-lingual content.

The ECN should enable distributed content creation and new forms of teaching. Teaching material can be corrected, accumulated and re-used.

Uma, a dedicated physics teacher in Kerala

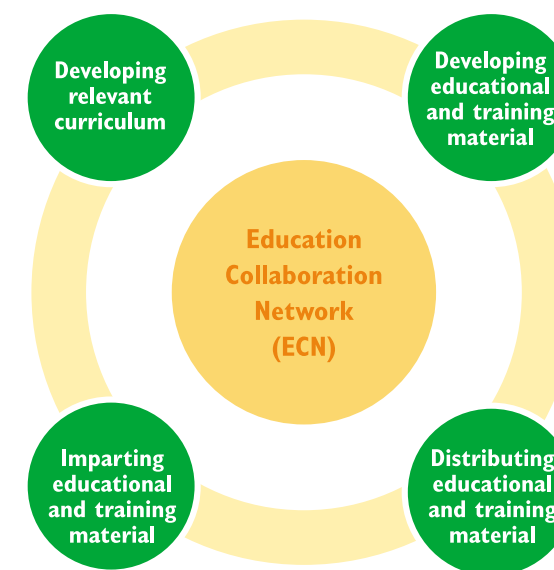
- Uma also wants to improve her understanding of Newton's laws for her lecture next week.
- However, unlike Ashok, she works in a school that has provided a computer in the faculty room and there is one TV and a (video) CD player per class room.
- Uma uses the Internet to get into the ECN and carry out her search and also finds the same material as Ashok (although probably not in the same order as Ashok, given his selection and those of other teachers).
- Uma 'burns' a CD of the Professor Goyal's video. Instead of lecturing herself, she replays the video recording. She takes on the role of the discussant, occasionally halting the lecture to add supplementary explanations from her experience or to answer questions.
- She creates a new problem set that combines ideas from the ones she found on the ECN and her own problem sets from the past and adds it to the ECN. She also adds comments about her use of Professor Goyal's lecture and how her students did on the new problem set. Her material now becomes available to other teachers using the ECN.

Ruhi, a social science teacher in Belgaum, Karnataka

- Ruhi teaches in a school near the Maharashtra border. She is using a textbook in the Marathi language. She has to lecture on India in world affairs. Her school has an EDUSAT terminal.
- She sees the map on page 107 in which China is in India, Pakistan is an island in the Arabian Sea and Tibet has moved to Bay of Bengal. It also shows SAARC members like Bhutan, Bangladesh, and Nepal as island-nations.¹
- Ruhi tells her students about this error and later goes to the EDUSAT terminal, connects to the ECN and records these errors.

1. These errors were reported recently in a national newspaper (*The Times of India*, 11th November, 2004). The report is from Karnataka, although the actual location is not mentioned.

FIGURE 1. Framework for a collaboration-based education system.



We are, of course, aware that technology alone cannot solve a complex problem such as providing universal, high-quality education to a country as large and diverse as India. Nevertheless, we believe that the approach advocated here can form the cornerstone for a modern education system that can serve us well into this century. Specifically, in the near-term we believe the ECN will allow:

- Teachers and students to work together to develop education and training materials, such as supplements to textbooks and teaching support materials.
- Teachers and administrators to work together to identify deficiencies in curricula and associated textbooks, and develop solutions for addressing the problems.
- Teachers and students to have access to education and training materials.
- Teachers and administrators to experiment with new methods of teaching and training.

In the long term, teachers will become better teachers, the material will improve and operational efficiency will increase.

In the long term the ECN will:

- Help teachers become better at what they do;
- Allow the development of better instructional material; and
- Improve operational efficiency by using information-based methods for planning and distribution of materials.

The rest of the report is devoted to our key findings, specific technology recommendations, a proof-of-concept system design for the ECN and a discussion of why we believe the ECN could revolutionise the education for all.

FINDINGS AND RECOMMENDATIONS

Our principal focus is on the use of IT to improve the state of Indian education. It is instructive to examine the backdrop against which this exercise is undertaken. Despite impressive achievements over the past 50 years, significant concerns remain. Focusing on school education (see Appendix I), the most important of these are:

- **Performance:** It is estimated that of 100 children enrolled in Standard I, only about six to eight complete school and qualify for collegiate education. For a majority of those who do qualify in the third division a special concern appears to be performance in English, the Sciences and Mathematics.² The DPEP Baseline Surveys³ also provide evidence of the poor performance of students. The data analysis shows that the extent of repetition in Grade I in some states is about 30-40 percent. The sixth All India Educational Survey conducted by NCERT in 1993 reported a repetition rate in the range of five to seven percent in each grade.⁴ A number of reasons have been put forward, including poor quality of schooling and management, lack of school's facilities, distance of schools, too few teachers or poorly qualified teachers, lack of female teachers, expense of schooling and the demand for child labour.⁵
- **Teacher training:** There are large numbers of under-qualified teachers and many more who need further professional education and training as they work. Estimates suggest that 51 percent of the teachers are higher secondary qualified or below (24 percent secondary, 4 percent below secondary), 31 percent are graduates, 10 percent are post graduates and only 44 percent have received in-service training.⁶

2. M. Mukhopadhyay, 'Indian Education: Overview, Issues, and IT intervention', IBM Internal Report, 2004.

3. The DPEP, or District Primary Education Programme, was launched in 1994 with assistance from international organisations (like the World Bank) to supplement governmental efforts to provide primary education for all children.

4. Y. Aggarwal, 'Regaining Lost Ground: The Malaise of School Inefficiency', National Institute of Educational Planning and Administration (NIEPA), 2002.

5. An extensive compilation of these for primary education is available in 'Public Report on Basic Education' (PROBE), Oxford University Press, 1999. We will henceforth refer to this as 'the PROBE report'.

6. Source: Mukhopadhyay (2004)

Despite impressive achievements over the past 50 years, significant concerns remain about the education system.

We have elected to focus on areas in which we believe IT can make a significant difference.

- **Teacher-student ratios:** The teacher-student ratios in primary grades are the worst. The current ratios for Primary, Secondary and Higher Secondary Education stand at 1:43, 1:34 and 1:34 respectively. 1.4 percent of the Primary Schools have no teacher while 19 percent have a single teacher and 43 percent have two teachers. 0.9 percent of primary schools have a teacher-student ratio of worse than 1:100 and another 26 percent have a ratio of worse than 1:60.⁷
- **Quality of material:** Text books are updated infrequently, and often contain errors. The process of updating text books and curricula does not appear to have any collaborative feedback mechanism for gathering inputs from teachers and students.⁸

A further concern, of an operational nature, is this:

- **Data:** While there is now a good mechanism for collecting some kinds of data at the primary level⁹, there are no corresponding mechanisms for other levels of education making it difficult to plan effectively for these levels. Education statistics, where available can result in biased estimates of performance or efficiency of individual schools.¹⁰

A greater reliance on IT can provide more effective means to address some of the problems underlying these concerns. We have elected to focus on areas in which we believe that IT can make a significant difference. For each such area, we will present our principal findings and enumerate some solutions, restricting ourselves in the former to problems that we believe can be addressed by the use of information technology; and in the latter to IT-based solutions.

7. *District Information System for Education Report for 2003 (DISE 2003)*. See <http://www.dpepmis.org/>

8. *Source: Mukhopadhyay (2004)*.

9. *The DISE project (<http://www.dpepmis.org/>) maintains data on primary school facilities in almost all Indian districts.*

10. *Source: Aggarwal (2002)*

In developing our recommendations, we could have adopted one of the two approaches: either propose specific solutions for one or more of the problems considered; or concentrate on the IT requirements common to all the problems. We have elected to do the latter. Consequently, our immediately actionable recommendation concerns the IT infrastructure for enabling mass collaboration of educationists, teachers, administrators and students. Solutions for specific problems can be built utilising this infrastructure. In later sections we provide a technical design for such a collaborative network and some illustrative examples of its use.

Our immediately actionable recommendations concern the IT infrastructure for enabling mass collaboration of educationists, teachers, administrators and students.

Part I
findings

Our findings suggest that there are three areas in which the imaginative use of IT can significantly alter the current landscape. In order of decreasing priority, these are¹¹:

1. Helping teachers become better at what they do, by enabling collaborative development of teaching material and making this material accessible to all.
2. Improving the quality of instruction by enabling mass participation in developing curricula, monitoring text books and creating supplementary material.
3. Improving operational efficiency, by enabling the collection of disaggregated data, and the use of information-based methods to procure and distribute materials.

CONCERNING TEACHERS AND TEACHING

The principal concerns regarding teachers and the teaching profession are as listed below:

- **High work-loads:** The teacher-student ratio has changed unfavourably over the decades. This is especially the case with primary education (nearly 20 percent of primary schools have just one teacher) and matters are expected to get worse.¹²
- **Lack of support material:** Teachers are largely dependent upon conventional tools like chalk boards for teaching and have almost no access to other supportive material (like lesson plans and supplementary material to text books) or any means to share and re-use resources.
- **Lack of training:** A majority of teachers have themselves not studied beyond the higher secondary level and less than 50 percent have received any form of in-service training.¹³ The result is that teachers do not benefit from new advances and continue to teach outdated material.

11. See Appendix II for details of our fact-finding process.

12. The current ratio is 1:43 for primary education. The PROBE report estimates that if all children who should be in school do indeed go to school, then this ratio may be much lower.

13. Source: Mukhopadhyay (2004).

Helping teachers become better at what they do is an immediate concern.

- **Lack of motivation:** Teacher motivation has long been identified as a key issue that needs strengthening, in order to significantly raise educational standards.¹⁴ A direct indicator of teacher motivation is the significant absenteeism of teachers in schools. A recent study presents findings that place India next to last in the prevalence of teacher absenteeism in a study of eight countries.¹⁵

IT-based solutions could be developed to address some of these concerns. The collaborative development of teaching support material is possible, which could then be made accessible to teachers anywhere in the country; teachers and students could participate in discussions and comment on textbooks or lectures; for those schools with a cheap playback device, 'virtual' teaching with flexible class hours is possible; and training material could be developed to help train teachers and administrators.¹⁶ All these solutions require a platform for developing content by collaboration and mechanisms for making this content available to anyone.

14. As far back as 1986, *The National Programme on Education in its programme of action* refers to the crucial link between teacher motivation and the quality of education.

15. See: M. Kremer, K. Muralidharan, N. Chaudhry, J. Hammer and F. Halsey Rogers, "Teacher Absence in India: A Snapshot", World Bank Research Working Paper, June 2004 (available at <http://econ.worldbank.org/view.php?id=36660>). The report finds absenteeism ranges from 15% to 42% (depending on the state).

16. On the face of it, while none of the solutions appear to address directly the motivation problem, they may still have a beneficial effect: Kremer et al. (2004) report that teacher absence is correlated not with pay, but with incentives to attend work. It is possible that being in a position to participate in the development of education and training material and to acquire new training at any time could provide such incentives.

CONCERNING WHAT IS TAUGHT

Shortcomings on what is taught in classrooms fall largely into two main categories

- **Concerns about the curriculum:** There do not appear to be mechanisms in place to ensure that the curriculum keeps pace with developments in the fields being taught. In addition, some educationists express the view that the material taught is too theoretical and places an undue emphasis on learning by rote.¹⁷ Finally, vocational aspects are not adequately covered.
- **Concerns about the education material:** There does not appear to be any established principle on the timely revision of textbooks; textbooks can contain factual errors; students find it difficult to relate examples and illustrations¹⁸ and there is often a significant difference between textbooks and teaching material used by private and government schools.

Relevant IT-solutions that address these shortcomings are:

- Tools that allow experts, teachers and students to provide feedback on the updates needed in the curricula;
- Tools that allow sources to create, in a timely manner, high quality instruction material (including texts and workbooks) and supplementary material (like corrections to textbooks and updates on new developments); and
- Mechanisms for sharing instruction material amongst schools.

Once again, the principal requirement for these solutions is an infrastructure for collaborating and sharing information.

17. Source: Mukhopadhyay (2004).

18. This point is brought out forcefully in the PROBE report.

Concerns about what is taught in classrooms centre on the curriculum and the quality of education material.

CONCERNING OPERATIONAL EFFICIENCY

Improving operational efficiency is an important consideration in a sector where almost 90 percent of current costs are salary-related. We find shortcomings on three fronts:

- **Estimates of supply and demand:** Currently, data on school facilities are only available for primary education (through the DISE project). There is also no clear picture on the education requirements of the population by geographic location, socio-cultural groups and so on.
- **Estimates of performance:** The performances of individual schools along some standardised scales are usually not available.
- **Procurement, distribution and production:** Textbooks must be physically transported to sales outlets, and delays in the process mean that schools do not always have the latest available edition. Consequently, students often continue to use earlier editions, fail examinations and eventually are forced to drop-out.¹⁹ Although the cost of governmental textbooks are kept as low as possible, up to 30 percent of the costs of production remain non-paper related.

The following are examples of IT-based solutions for these problems:

- Constructing and maintaining a nationwide registry of facilities and performance statistics, collected at a level of detail that could be used in planning and management;
- The use, wherever possible, of supply-chain management techniques for procuring and distributing materials efficiently; and
- By retaining content in electronic form to delay commitment to paper form to as late in the distribution process as possible.

In all the cases, primary requirements of IT-based solutions consist of the following:

- **Data collection and storage:** Depending on the purpose, data would be collected across the nation for tasks like monitoring or facility mapping. The collection and storage mechanism would need to make provisions for dealing with multiple data formats, languages, input devices, levels of reliability and 'IT-readiness.' In addition, there will also have to be in place 'information life management' methods and associated policies for managing the data collected.
- **Data analysis:** This will involve using computational tools that calculate optimal or near-optimal solutions for specific problems being addressed (like facility planning or performance assessment). Good solutions will require the data used for computations to be up-to-date, of high quality and available at any location.

Part II
recommendations

Our findings in the previous section suggest that there are two requirements for IT-based solutions:

1. Hardware and software infrastructure for enabling the collaborative development of content and making this content available across the nation. The resulting solutions are intended to assist teachers, educationists and students and to improve the quality of classroom instruction.
2. Hardware and software infrastructure for collecting and analysing data from sources across the nation. The resulting solutions are intended to help administrators improve operational efficiency.

Our findings suggest further that it is the first of these that is an immediate priority for the country (see Appendix II). Consequently we do not propose to elaborate on the latter requirements, except to note that they entail infrastructure for anytime, anywhere access to integrated (sometimes called federated) views of the data, using whatever means of data communication exist.

Turning to enabling the collaborative development of content, we recommend, as a priority, the building of an Education Collaboration Network (ECN). The ECN should achieve the following:

- **New models for designing relevant curricula:** Teachers, students and other experts should be able to participate in shaping and updating the curricula in a timely manner.
- **New models for creating training material and teaching aids:** Teachers and students should be able to comment on and discuss sections of textbooks; link supplementary material for further study; share lectures, exercises, assignments, tests, and so on. It should also be possible to develop training material for helping teachers and administrators update and enhance their skills.

An immediate priority is the hardware and software for enabling collaborative content development and making this content available across the nation.

The ECN will handle different levels of IT maturity and multiple languages. It will benefit from existing IT infrastructure in the country and will be based on open standards.

- **New models for providing access to teaching aids:** While contributors to the creation of teaching aids are likely to be fewer, every teacher should be able to access and use them.
- **New models for teaching students:** The network should allow flexible ways of educating students, in the face of socio-economic pressures that make it difficult for students to attend regular classes, and systemic pressures that have resulted in a shortage of qualified teachers.

The principal requirements of the ECN are the following:

- It should be capable of handling different levels of IT maturity and multiple languages.
 - Highly distributed and able to capitalise on existing IT infrastructure (for example, like EDUSAT and Vidya Vahini).
 - Based on open standards for encoding and accessing content.
- Appendix III describes some successful existing efforts, in other fields, of mass collaboration based on open standards.

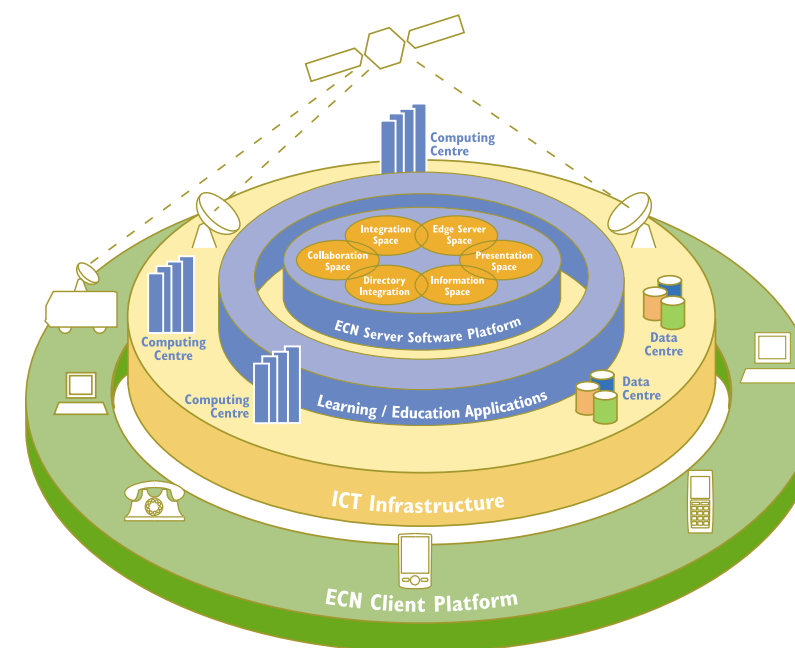
In the next section we elaborate on one possible system design of the ECN.

BUILDING THE EDUCATION COLLABORATION NETWORK

There are a number of IT-based initiatives that have already been started by government and non-governmental organisations. It is only appropriate that any architecture for the ECN should benefit from them. The specific architecture we propose is a Web services oriented one²⁰, based on open standards. Everything that is proposed can be implemented immediately, using commercially available components.

The architecture proposed – a physical picture is shown in Figure 2 – is principally composed of two parts: a ‘client platform’ and a ‘server platform.’

FIGURE 2. A physical view of the ECN.



20. Web services are a new kind of Web application. Web services are self-contained, self-describing, modular applications that can be published, located, and invoked (by other applications) across the Web (see <http://www.w3.org/2002/ws/>).

CLIENTS AND SERVERS

The client-server architecture is a widely accepted way of building a distributed system in which software is split between computer processes called 'server' tasks and 'client' tasks. A client process sends requests to a server process, according to some protocol, for information or action, and the server responds.

For the ECN, the client side of the architecture consists of facilities for offline content access, content authoring and collaboration capabilities depending upon the infrastructural support. The activities of a user will result in client processes that send and receive information from one or more servers. There is no requirement that clients (or servers, for that matter) have to use the same operating system or hardware and we expect the ECN will be able to support the kinds of clients shown in Table 1.

TABLE 1. Examples of the kinds of clients to be supported by the ECN

Client type	Example operating environments	Example devices
Thick client	Windows platform, Linux	PCs, Simputers, high-end personal digital assistants (PDAs), Internet-enabled appliances.
Thin client	Internet browser running on Windows platform, Linux	PCs, Simputers, high-end PDAs, kiosks
Low-memory client	Internet browser running on Windows platform, Palm Operating System	Low-end PDA, Wireless Application Protocol (WAP), General Packet Radio Service (GPRS) enabled mobile phones
Non-computing device	–	Televisions, telephones

Of these, thick clients will enable a user to access content online and offline, create multimedia content, collaborate with others at different levels such as mail, chat, projects and so on. Thin clients provide a Web browser-based infrastructure with limited storage facility. This category of clients will primarily allow content access and support simple content creation. Low-memory devices and non-computing clients are adequate for users that only require content access (the former will also allow electronic mail and 'chat'). Taken together, the clients will be able to support different levels of IT maturity, ranging from settings that have high-speed connectivity and a high awareness amongst the users, to settings with limited connectivity provided by community centres to a populace with very rudimentary knowledge of IT capabilities.

Servers provide back-end support for the different clients. The 'services' that we expect to be offered by a server in the ECN are shown in Table 2.

TABLE 2. Examples of the services offered by servers in the ECN.

Service	Function
Presentation	Enables users to access domain-specific content. Supports all client types.
Infrastructure	Basic infrastructure level services that would be required by applications (like system management, lifecycle management, workload management, storage management and security).
Information	Handle content organisation, lifecycle, storage, distribution, authoring, search and so on.

There is more to the client-server architecture than the client devices in Table 1 and the services in Table 2. Without going into detail, this would include support for clients to communicate to the server; the flexible addition of applications to a client platform based on open standards

(applications here refer to tools for authoring, access, multimedia manipulation and so on); application services that can be provided by the server; the integration services provided by the server, and so on. Logical views of the client and the server platforms are shown in Figures 3 and 4.

Figure 3. A logical view of the components comprising the client platform.

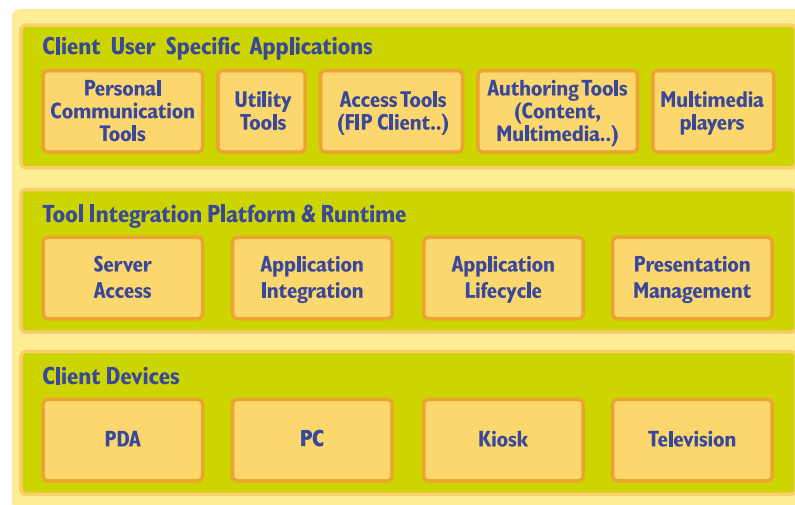
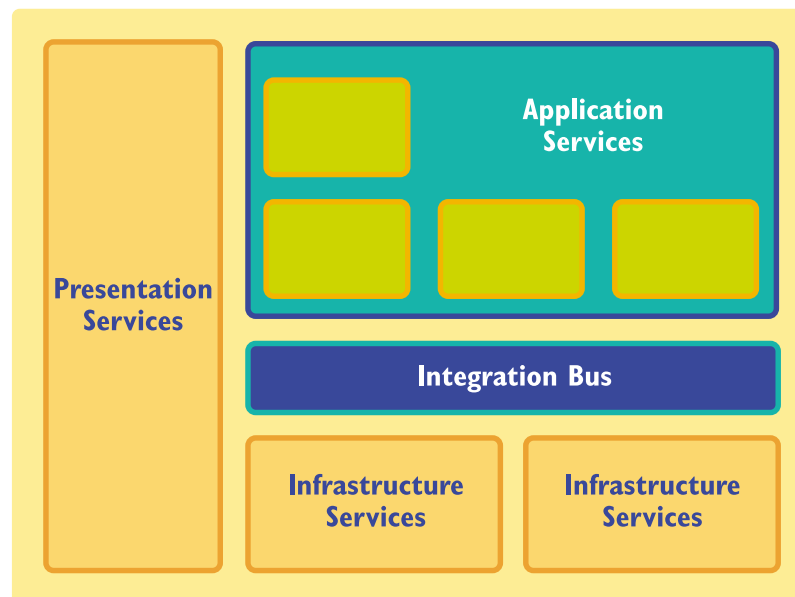


Figure 4. A logical view of the components comprising the server platform.

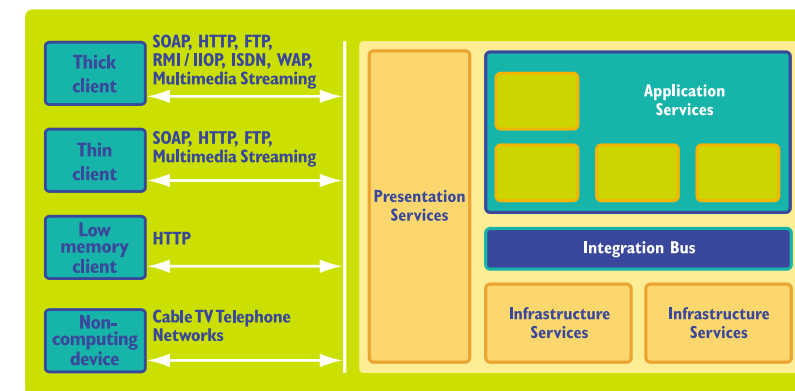


To support the interactions envisaged between clients and servers in the ECN, the presentation services of the server needs to support the following methods of communication:

- SOAP²¹ for simple message querying and retrieval with and without attachments.
- HTTP²² requests and responses.
- FTP²³ for transferring multimedia files.
- WAP²⁴ for mobile access of information and status updates.
- Cable networks for client devices with non-computing abilities for simple audio and video streaming

Figure 5 depicts a logical view of the interaction between clients and a server.

FIGURE 5. A logical view of client-server interaction.



21. SOAP (Simple Object Access Protocol) is a way for a program running in one kind of operating system to communicate with a program in the same or another kind of an operating system (see <http://www.w3.org/TR/soap/>).

22. HTTP (Hypertext Transfer Protocol) is a way of transferring information between servers and Web browsers.

23. FTP (File Transfer Protocol) is a way of copying files from one computer system to another.

24. WAP (Wireless Application Protocol) is a way of allowing communication between wireless devices. It allows, for example, a mobile telephone to access the Internet.

We do not commit here to any particular arrangement of client and server nodes (the network's 'topology'). We expect this will evolve as the use of the ECN becomes widespread. Nevertheless, given the economic and infrastructural realities in India at present, we would expect server nodes to be hosted – initially at least – by state or regional authorities, district educational centres or urban schools. We would also expect that, reflecting infrastructural constraints, server platforms would run on a 'virtualised environment'. This would enable them to utilise processing and storage resources already available to the ECN, thus reducing significantly the initial expenditure of setting up a node in the ECN.

Finally, although we do not intend to comment here on usage, it is nevertheless instructive to point out how the infrastructure we have proposed actually addresses some issues that arise naturally in India:

- The different types of clients (thick, thin, low-memory and non-computing) allow for users with a wide range of IT facilities and awareness.
- Access to material and collaboration can be achieved using communication technology ranging from the Internet (using, for example, PCs, Personal Digital Assistants or smart phones) to the telephone network.
- The infrastructure allows for both automatic translation of content from one language to another and distributed translations by multi-lingual users. Since the latter are more likely to be done for texts found to be beneficial, the system should eventually benefit from translations of the best in a language.
- As it builds on existing IT initiatives, the cost of developing the ECN should be relatively low. Further, rather than commissioning content, it attempts to make use of the country's large educated population. Regulation, although possible, is not mandatory. It is replaced instead by a form of self-regulation arising from collective wisdom and

usage-based ranking. Other attempts at collaborative content development (see Appendix III) suggest this approach scales better, due largely to a kind of 'network effect', in which a fairly small number of well-meaning (and skilled) individuals produce very high quality content.

As it builds on existing IT initiatives, the cost of developing the ECN should be low.

DISCUSSION

India's school education system in the 21st century faces some fundamental questions: "How do we reduce the poor performance of students? How do we improve the quality of teachers? How do we improve the quality of curricula and teaching materials?"

In many cases, the teacher is at the centre of the solutions proposed.²⁵ This is not surprising and, in one sense, quite heartening. Every one of us can probably recall at least one teacher who inspired us, impressed us through his or her dedication to teaching, helped us to understand a difficult subject through some unique and insightful explanation, made learning fun and enjoyable; and one whose class time we looked forward to during the entire school week. These are the individuals who exemplify the quality and dedication that can make the difference to any education system. If only we could amplify their efforts, many of the questions above can be addressed very effectively. With today's information technology we have an opportunity to do just that and our proposed collaboration infrastructure – the Education Collaboration Network – enables the entire education system to benefit from the work of dedicated teachers. The infrastructure provides the facilities needed for teachers to create teaching material, share them on a wide scale, draw upon the experience and learning of others and impart the best learning to their students. Thus:

- A physics teacher in Bangalore who has an effective method for teaching Newton's Laws can gather his teaching methodology, notes and exercises, and share it with a wider audience of teachers nationwide.
- A teacher in Delhi in a school that has a dedicated Internet connectivity can download material contributed by another teacher, augment it with a video presentation from another school and make an effective multi-media presentation for her class.

25. This is also in agreement with our own experience in the use of information technology in education, gained from the long-running 'Reinventing Education' initiative. Some relevant projects within this initiative are summarised in Appendix IV.

- Teachers in rural Kerala can download material through a community portal, and print out notes and exercises to be used in their classes.

These are just a few of the possibilities enabled by the ECN. As more teachers and educators become part of the network we can expect to see unusual patterns of usage emerge. In a manner similar to other collaborative efforts – like the World Wide Web – we would expect that even with a smaller number of initial users the benefits of the ECN should become apparent enough to ensure wider participation. Indeed, we would expect this medium, in due course, to become an essential part of many schools.

Some may be concerned about quality. There have been ample demonstrations that quality of content can be self-regulated in a community portal. A working example of this is the Wiki project (described in Appendix III). We can expect a similar self-regulating mechanism, driven by the review and feedback of the users of the material, to ensure that good quality content emerges. However, the infrastructure itself can use other methods of monitoring and ensuring quality (like the involvement of a regulatory body, if needed).

The ECN will eventually require a well-trained set of teachers, educationists and students to make the best use of the functionality provided by the network. There are many initiatives currently under way that are addressing this issue. States are setting up computer laboratories in schools, teachers are being trained in the use of computers; and community portals are being set up in many rural areas.

Once the teachers know how to use the computers, what next?

The material in this report provides one answer to this – they will now be able to use the ECN to contribute to the improvement of education at a national level.

Teachers have long held a hallowed spot in the Indian consciousness.²⁶ With the ECN, we will be ensuring that they will continue to shape the thoughts of Indians living in what will probably be the pre-eminent information-driven nation of the 21st century.

APPENDIX I: WHY FOCUS ON SCHOOLS?

There has been a massive expansion of schooling facilities since 1947.

The number of primary schools has increased from about 200,000 in 1950-51 to about 660,000 in 2001-02 (Table 3). The upper primary schools increased from 13,596 in 1950-51 to about 220,000 in 2001-02. There are now estimated to be more than 133,000 secondary and senior secondary schools in India (Figure 6). The growth rate of secondary schools during 1986 and 1993 was 25 percent and of senior secondary schools 52 percent, compared to about an 8 percent growth rate of primary schools during the same period. This provides some indication of the pressures that the system is likely to face.²⁷

TABLE 3. Growth of recognised educational institutions.

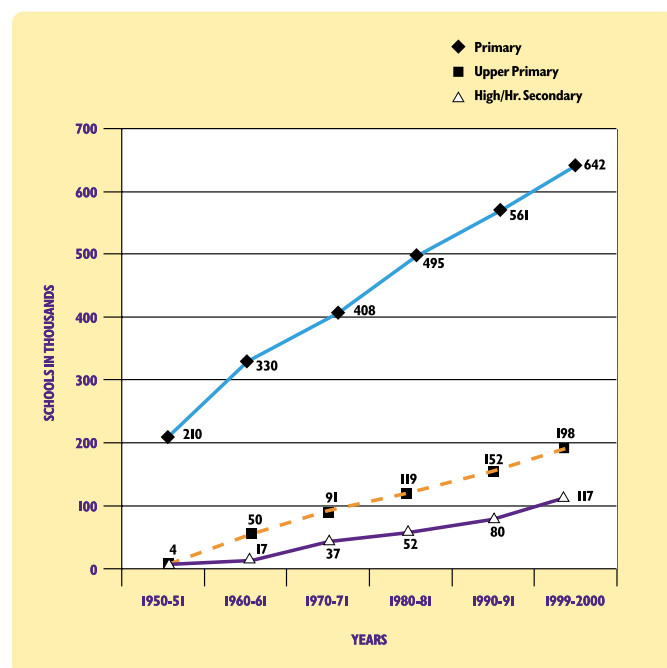
Year	Primary	Upper Primary	High/Hr. Sec./Inter/Pre. Jr. College
1950-51	209671	13596	7416
1960-61	330399	49663	17329
1970-71	408378	90621	27051
1980-81	494503	118555	51573
1990-91	560935	151456	79796
2000-2001*	638738	206269	126047
2001-2002'	664041	219626	133492

*Provisional.

26. Recall: "Let thy teacher be to thee like unto a God!", *Taittiriya Upanishad, First Valli, Eleventh Anuvaka* (a full translation is available at: http://wikisource.org/wiki/Taittiriya_Upanishad).

27. Source: National Council of Educational Research and Training (1996 figures). Wherever not referenced, statistics in this section are from Mukhopadhyay (2004).

FIGURE 6. Growth of schools since 1951



(Source: Selected Educational Statistics, 1999-2000)

Primary schools accommodate about 113.9 million children (about 122 million in 2002-03). Enrolment in the middle or upper primary stage is about 44.8 million; that in the high and senior secondary stages is about 30.5 million (see Table 4). Thus, the Indian school network accommodates about 197 million students (see Figure 7).

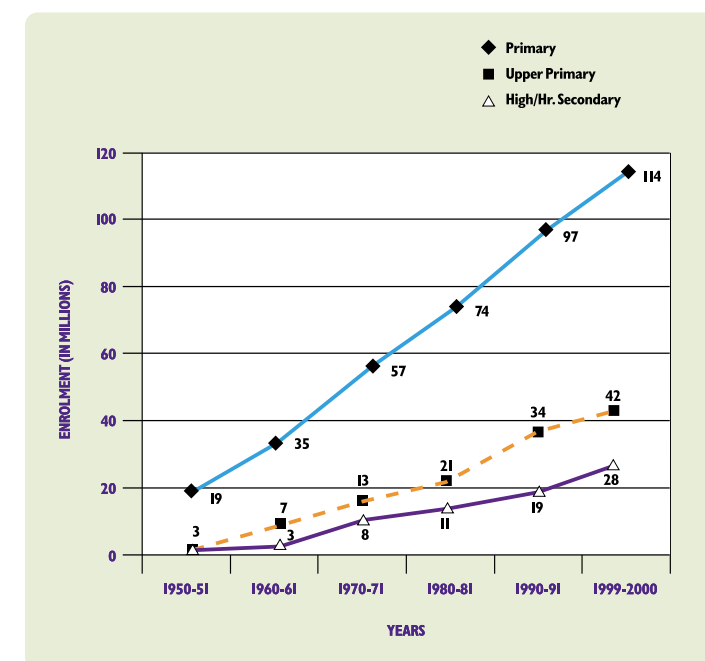
According to the best available estimates, more than 70 percent of children in the age group 6 to 14 years are enrolled in schools. According to National Family Health Survey, this enrolment is 79 percent. The Gross Enrolment Ratio (GER) is still at 94.9 percent. However, according to estimates provided by the Ministry of Human Resource Development, the gross enrolment ratio in primary grades is 96.3; 105.3 for boys and 86.9 for the girls (see Table 5). There is a sudden decline in the GER at the upper primary level – 60.2 percent for both boys and girls, registering a decline of more than 30 percent. Also, there is an enrolment gap between boys and girls (although this gap is steadily declining: see Table 6).

TABLE 4. Enrolment by stages from 1950-1951 to 2001-2002 (in millions)

Year	Primary (I-V)			Middle/Upper Primary (VI-VIII)			High/Hr. Sec./Inter/Pre-Degree (IX-XII)		
	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls	Total
1950-51	13.8	5.4	19.2	2.6	0.5	3.1	1.3	0.2	1.5
1960-61	23.6	11.4	35.0	5.1	1.6	6.7	2.7	0.7	3.4
1970-71	35.7	21.3	57.0	9.4	3.9	13.3	5.7	1.9	7.6
1980-81	45.3	28.5	73.8	13.9	6.8	20.7	7.6	3.4	11.0
1990-91	57.0	40.4	97.4	21.5	12.5	34.0	12.8	6.3	19.1
2000-2001*	64.0	49.8	113.8	25.3	17.5	42.8	16.9	10.7	27.6
2001-2002*	63.6	50.3	113.9	26.1	18.7	44.8	18.4	12.1	30.5

* Provisional

FIGURE 7. Growth of enrolment in schools



(Source: Selected Educational Statistics, 1999-2000)

TABLE 5. Percentage of Girls Enrolment to Total Enrolment by Stages

Year	Primary (I-V)	Middle (VI-VIII)	Sec./Hr. Sec./ Intermediate (IX-XII)	Hr. Education (Degree & above level)
1950-51	28.1	16.1	13.3	10.0
1960-61	32.6	23.9	20.5	16.0
1970-71	37.4	29.3	25.0	20.0
1980-81	38.6	32.9	29.6	26.7
1990-91	41.5	36.7	32.9	33.3
2000-2001*	43.7	40.9	38.6	39.4
2001-2002*	44.1	41.8	39.5	39.9

*Provisional

TABLE 6. The Gross Enrolment Ratio (GER)

Year	Primary (I-V)			Upper Primary (VI-VIII)			Elementary (I-VIII)		
	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls	Total
1950-51	60.6	24.8	42.6	20.6	4.6	12.7	46.4	17.7	32.1
1960-61	82.6	41.4	62.4	33.2	11.3	22.5	65.2	30.9	48.7
1970-71	95.5	60.5	78.6	46.5	20.8	33.4	75.5	44.4	61.9
1980-81	95.8	64.1	80.5	54.3	28.6	41.9	82.2	52.1	67.5
1990-91	114.0	85.5	100.1	76.6	47.0	62.1	100.0	70.8	86.0
2000-2001*	104.9	85.9	95.7	66.7	49.9	58.6	90.3	72.4	81.6
2001-2002*	105.3	86.9	96.3	67.8	52.1	60.2	90.7	73.6	82.4

*Provisional

The participation of girls in primary education increased from 28.1 percent in 1950-51 to 44.1 percent in 2001-02. The gain has been significant in the elementary grades: from 16.1 percent in 1950-51 to 41.8 percent in 2001-2002. Gains are equally large in the secondary, senior secondary and the degree level education. This increasing participation of girls in education has contributed significantly to the improvement in the gender parity index. Table 7 shows that this has improved from 0.38 in 1951 to 0.81 in 2001-02. It is perhaps noteworthy that the index has remained steady at around 0.80 since 1995. This achievement in enrolment is however largely neutralised by a high drop-out rate. According to available data (from 2001-02), 39.01 percent children drop out of the primary grade (standards I to V). The drop-out rate between I-VIII is 54.65 percent. Drop-out rates in 1970-71 in primary grades and elementary grades were 67 percent and 77.9 percent, respectively. In addition, there are more than 30.58 million children in the 6 to 11 years age group who are still out-of-school (see Table 8).

TABLE 7. The Gender Parity Index

Year	Gender Parity Index		
	Primary (I-V)	Upper Primary (VI-VIII)	Elementary (I-VIII)
1950-51	0.41	0.22	0.38
1960-61	0.50	0.34	0.47
1970-71	0.63	0.45	0.59
1980-81	0.67	0.53	0.63
1990-91	0.75	0.61	0.71
1995-96	0.82	0.73	0.80
1998-99*	0.82	0.75	0.81
1999-2000*	0.82	0.74	0.80
2000-2001*	0.82	0.75	0.80
2001-2002*	0.83	0.77	0.81

*Provisional

TABLE 8. Drop-out rates at primary, elementary and secondary stages

	1960-61	1970-71	1980-81	1990-91	1992-93	1999-2000	2001-2002
Class I-V							
Boys	61.7	64.5	56.2	40.1	43.8	38.7	38.4
Girls	70.9	70.9	62.5	46.0	46.7	42.3	39.9
Total	64.9	67.0	58.7	42.6	45.0	40.3	39.0
Class I-VIII							
Boys	75.0	74.6	68.0	59.1	58.2	52.0	52.9
Girls	85.0	83.4	79.4	65.1	65.2	58.0	56.9
Total	78.3	77.9	72.7	60.9	61.1	54.5	54.6
Class I-X							
Boys	N.A.	N.A.	79.8	67.5	70.0	66.6	64.2
Girls	N.A.	N.A.	86.6	76.9	77.3	70.6	68.6
Total	N.A.	N.A.	82.5	71.3	72.9	68.3	66.0

A potentially more worrying problem in primary schooling concerns actual performance. On an average, children take 7.5 years to graduate the five-year primary schooling, implying an average of 2.5 years of additional schooling.²⁸ Despite the high drop-out rate and poor performance, the transition rate from primary to upper primary is as high as 93.37, but the actual competency of the students reaching this stage can be quite variable.

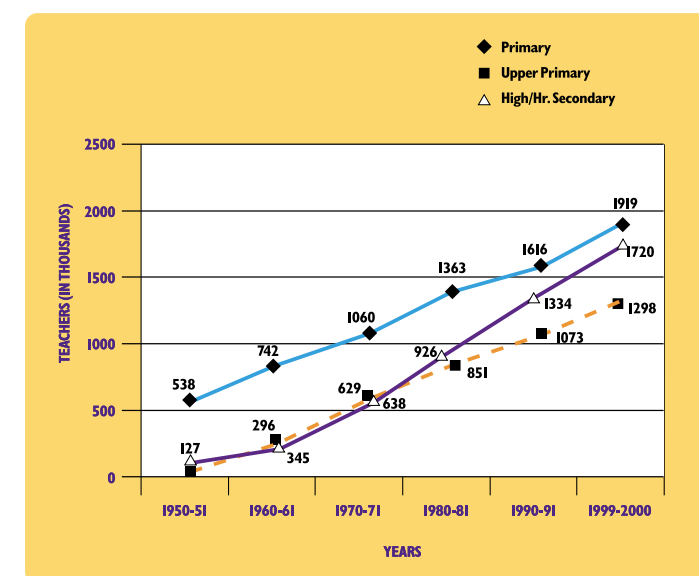
The Sarva Shiksha Abhiyan (SSA) initiative headed by the Prime Minister and the 93rd Constitution Amendment makes education for 6 to 14 years a fundamental right and the State is now committed to education for all with an acceptable level of quality. The challenge is thus of providing an additional 36.75 million children with a quality education.

28. This does not include poor learning outcome as measurable on any standard achievement tests for such grades.

According to the 2001 census, the total number of secondary school age children (14 to 17 years) is 91.7 million. This is 27.8 million over the population of the same age group in 1991. By 2011, the size of the secondary school age group population is expected to reduce marginally to 89.2 million.²⁹ By 2011, the current enrolment of 20.05 million in secondary education and 12.1 million in the senior secondary stage may rise to 35.6 million and 14.7 million respectively. With improved efficiency and accelerated rate of growth, enrolment may actually close to 35.6 million.

Along with the growth of schools, there has been substantial growth of teachers (Figure 8 and Table 9). It is estimated that there are about 1.93 million teachers in primary grades and about another 1.47 million in upper primary grades. The number of teachers in secondary and senior secondary grades and those in higher education are 1.78 million and 0.42 million, respectively.³⁰

FIGURE 8. Growth of teachers



(Source: Selected Educational Statistics, 1999-2000)

29. Source: Selected Educational Statistics, MHRD, 2001-02.

30. Source: Selected Educational Statistics, MHRD, 2002-03.

TABLE 9. Teachers by Type of Schools (in 000')

Year	Primary			Upper Primary			High/Hr. Secondary/ Intermediate		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
1950-51	456	82	538	73	13	86	107	20	127
1960-61	615	127	742	262	83	345	234	62	296
1970-71	835	225	1060	463	175	638	474	155	629
1980-81	1021	342	1363	598	253	851	669	257	926
1990-91	1143	473	1616	717	356	1073	917	417	1334
2000-01'	1221	675	1896	820	506	1326	1184	577	1761
2001-02'	1213	715	1928	921	547	1468	1157	620	1777

*Provisional

The student-teacher ratio is an important determiner of quality of education. As the educational system has grown, there is a definite and steady unfavourable change in the student-teacher ratio at all levels (Table 10).

TABLE 10. Pupil Teacher Ratios (PTRs)

Year	Primary	Upper Primary	High/Hr. Secondary
1950-51	20	20	21
1960-61	36	31	25
1970-71	39	32	25
1980-81	38	33	27
1990-91	43	37	31
1995-96	43	37	32
1996-97	43	37	32
1998-99'	42	37	31
1999-2000'	43	38	32
2000-2001'	43	38	32
2001-2002'	43	34	34

*Provisional

Finally, we present some statistics on the educational 'mortality' rate.

Of the 100 children enrolled in grade I, not more than 26 reach grade X (revised estimates suggest this number may be 34). With pass percentage in board examinations being 50 percent, 13 percent (or 17 percent, according to revised estimates) qualify for higher secondary education. According to the available data, only 11 (16 by revised estimates) join higher secondary classes; and about 50 percent succeed in the grade XII exam. Thus, about six to eight of those who began their journey at grade I qualify for collegiate education (see Table 11).

TABLE 11. Trends in school enrolment

Grades	Enrolment in Millions	As Percentage of Enrolment	As percentage (Out of 100 admitted in Grade I)
I	29.7	15.68	100
II	23.9	12.62	73
III	21.7	11.46	66
IV	19.7	10.40	57
V	18.9	9.98	53
VI	16.9	8.92	47
VII	14.8	7.81	41
VIII	13.2	6.97	38
IX	10.7	5.65	30
X	9.4	4.96	26
XI	5.4	2.85	13
XII	5.1	2.69	11
Total	189.4	99.99 or 100	

APPENDIX II: FACT-FINDING PROCESS

The goals to be achieved by the fact-finding process were as listed below:

1. To identify a small number of needs in Indian education that would benefit significantly from the deployment of information technology.
2. To identify necessary requirements on any information system designs that can achieve sustainable solutions to the needs identified in (1).
3. To identify specific IT-based solutions to address some high-priority needs.

The following materials were available for reference:

- a) Reports prepared by government departments and independent bodies on the state of education in India.
- b) Expert opinion on education in India.
- c) IBM internal reports on hardware and software for the deployment of large-scale solutions for education related sector.
- d) IBM technical expertise on solutions for large-scale problems.

The following method was adopted:

1. From reports and expert opinion collect a set of education needs.
2. For the set of needs in (1), identify a subset for which it is evident that substantial information technology is required for a sustainable solution.
3. For the subset of needs in (2), identify a necessary set of requirements on any IT-based solution.
4. From expert opinion, obtain an ordering (if any) of the subset of needs based on priority.
5. Develop an IT solution that satisfactorily addresses a high-priority need.

Opinions of experts in the field were obtained using the results of a questionnaire and interviews. The identification of the subset of needs for which IT was deemed to be necessary (Step 2 above), the subsequent identification of requirements (Step 3 above) and the IT solution developed (Step 5 above) were all done using IBM technical expertise.

The results obtained were as follows.

A. We identified a list of needs to be addressed. Following the Department of Educationist categorisation³¹, this list consisted of topics relevant to the following eight different areas:

1. Elementary education
2. Secondary education
3. Higher education
4. Technical education
5. Adult and continuing education
6. Teacher training
7. Vocational training
8. Language development

B. The needs expected to necessarily require IT intervention cluster into the following categories:

- 1. Helping teachers become better teachers:** This includes collaborative development of lectures, assignments and tests; mass participation of teachers and students to comment or discuss sections of textbooks or lectures; development of training materials for helping teachers and administrators enhance their skills and enable access to model lectures, aids created by other teachers.
- 2. Quality and relevance of classroom instructions:** This includes mass participation of experts, teachers (and even students) in the development of curricula; tools for the timely creation of supplementary material and provide new models for imparting education to enable flexible class hours and compensating for low teacher-student ratios.

3. Operational efficiency: This includes nation-wide data collection of facilities and statistics to facilitate planning; supply-chain management techniques for improving operational efficiency e.g. textbook production.

C. Expert opinion (from responses to questionnaires) suggests that the first two topics in (B) above (i.e. helping teachers and improving quality of instruction) are of higher priority than the third (operational efficiency).

APPENDIX III: SOME MASS COLLABORATION EFFORTS

Three of the most successful IT efforts in the use of mass collaboration to develop content in the recent past are described here.

WIKI

Wiki refers to server software that allows users to create and edit Web content using any browser. To edit a Wiki web page (sometimes simply called 'a wiki'), the user does not need to know Web markup languages like HTML. Instead wikis have their own explanatory code that makes it simple for everyone to contribute to or edit a page.

One very successful wiki is Wikipedia, a free encyclopaedia.

This collaborative encyclopaedia has accumulated substantial information from all over the globe. It recently topped one million articles. Its English language version alone has 350,000 pages - three times as many as the online version of Encyclopaedia Britannica. More than 25,000 contributors have written or edited at least 10 articles. There are many other wikis: cookbooks, dictionaries and collections of quotations. Teachers have used wikis to stimulate discussion.

LINUX

Linux is a computer operating system that was initially created in 1991 by a student at the University of Helsinki in Finland. The kernel, or the heart of all Linux systems, is developed and released under the GNU General Public License and its source code is freely available to everyone. There are now several hundred companies and organisations and an equal number of individuals that have released their own versions of operating systems based on the Linux kernel.

Apart from the fact that it's freely distributed, Linux's functionality, adaptability and robustness, has made it the main alternative for proprietary Unix and Microsoft operating systems. In just a decade after its initial release, Linux is being adopted worldwide as a server platform, although its use as a home and office desktop operating system is also on the rise.

A study conducted in 2000 of a popular version of Linux (Red Hat Linux 7.1), found that this particular distribution contained 30 million lines of computer code. The study estimated that this distribution required about eight thousand person-years of development time. Had all this software been developed by conventional proprietary means, it would have cost 1.08 billion US dollars to develop. In a later study, the same analysis was performed for a different version (Debian GNU/Linux version 2.2). This distribution was found to contain over fifty-five million lines of code and was estimated to cost 1.9 billion US dollars to develop by conventional means.

OPEN DIRECTORY

The Open Directory Project (or ODP) is the largest, most comprehensive human-edited directory of the Web. It is constructed and maintained by a vast global community of volunteer editors.

Instead of fighting the explosive growth of the Internet, the Open Directory provides the means for the Internet to organise itself. As the Internet grows, so will the number of 'net-citizens', who can each organise a small portion of the Web and present it back to the rest of the population, culling out the bad and useless and keeping only the best content.

The Open Directory Project is a tree-like, human-collected thematic directory of resources in the Internet. Each branch of this tree, called a category, represents a topic and contains links to resources in the Internet that relate to this topic. Every link added to the ODP must be accompanied by a short description (25-30 words) of a resource it points to. The Open Directory now has more than half a million sites, over 11,000 editors and nearly 90,000 categories.

APPENDIX IV: THE 'REINVENTING EDUCATION' INITIATIVE

IBM's Reinventing Education (RE) is a global program spanning 25 sites in 11 countries. The initiative encompasses about 65,000 teachers and 2 million students. Participants in the initiative have used IT-based tools to address issues like how teaching skills can be developed over a career; how information is to be shared and used; and how learning is to be measured. All projects are evaluated independently to examine if they have had a measurable impact on student performance. After over a decade the RE initiative was launched in 1994—the emerging consensus from project evaluations is that IT can have a systematic effect on public education and classrooms, provided teachers are involved.³² In this section, we describe RE efforts in three countries that are relevant to the contents of this report.³³

TEACHER AND STUDENT COLLABORATION IN AUSTRALIA

Using innovative collaborative software students and teachers in the RE programme developed in Australia participate in structured open-ended learning projects. This provides an opportunity to publish their own work and engage with their peers in online discussion and collaboration.

Over 500 students in the Australian RE network of schools have participated in a range of online projects that have extended and enhanced the school curriculum. The projects also appear to have motivated students to collaborate with their peers utilising a broad range of information and communication technology skills. Australian schools have also taken the opportunity to engage in collaboration with international RE sites. Some examples are:

- A group of principals and teachers participated in a video conference

³² A summary of some of the results is available in 'The Reinventing Education Initiative From an Evaluation Perspective: The Role of Technology Partnerships in Addressing Significant Challenges to Education Improvement', Centre for Children and Technology Research Report, April 2004 (available at http://www2.edc.org/CCT/publications_report_summary.asp?num PubId=164).

³³ We do not suggest here that these efforts can be replicated in India. Indeed, each RE initiative is usually custom-designed to meet the needs of the participants involved. Nevertheless, they include sufficiently many aspects that are of interest here.

and online communication session with their counterparts in Philadelphia. The ensuing discussion assisted in the defining of Australian RE model, which has re-used elements of the RE programme in Philadelphia.

- Australian teachers and their students have participated in online interactive video conference sessions with Japanese teachers and students. The software used gave students and teachers the opportunity to speak in the other's language and a window into each other's culture and way of life.
- Australian teachers and students have engaged students in the United States in a 'Fantasy Football' project. Aussie kids have explained the finer points of Australian Rules football to their US counterparts and have participated in a tightly contested football statistics competition online involving the selection of key players, their game statistics and the assignment of points. This project immersed students in an array of curriculum areas including maths, the arts, English and social studies.
- Students participating in an RE programme in China have discussed religion, geography, flora, fauna and culture with a group of Australian students living in a rural country town.

CHANGING CLASSROOM INSTRUCTION AND TEACHER'S PROFESSIONAL DEVELOPMENT IN VIETNAM

Education in Vietnam is centralised and schools use a unique textbook system that complies with the education standards set by the Ministry of Education and Training (MoET). An RE project was initiated in 1998 as public-private partnership between the MoET and IBM, involving schools and a teacher training college. The main objectives of the project were:

1. To change the ways of teaching and learning in schools by integrating technology into school curricula; and
2. To create a new environment for the professional development of teachers based on a peer coaching model.

The initial program was implemented at Trung Nhi Secondary School and the Hanoi Teacher Training College. RE teachers nominated from this school were trained in teaching methods (jointly by IBM and the teacher training college) that incorporated the effective use of technology into their teaching programs. The RE school teachers then applied the new methods in four Math and English classes with technical support provided by the RE college teachers. During this period, 20 teachers, about 200 school students, and 70 student teachers were involved in the program.

Once the initial group of teachers had mastered the new instructional methods, additional teachers from other training colleges and schools were included. By the end of the partnership in 2001, the programme was implemented in schools in the cities of Ho Chi Minh and Da Nang; and the provinces of Ba Ria Vung Tau and Nghe An. Since 2002, the MoET has continued funding expansion of the programme to more cities. The initiative has contributed to the MoET's strategic educational policies, including new textbooks for standards I to VI and a plan to equip schools with computer laboratories and Internet access.

TEACHER TRAINING IN CHINA

A joint effort between the Ministry of Education of the People's Republic of China and IBM was launched in 2004. A key feature of this effort is the utilisation of educationists and practitioners within China and abroad to share innovative teaching methods and skills with Chinese teachers. So far, 24 leading Chinese teachers from 12 schools from four regions of China have participated in skills-transfer sessions led by leading Australian education experts benefiting about 3,200 students. It is estimated that as the program expands over the next two years, 1,200 teachers will be trained, benefiting about 60,000 students. While it is too early at this stage to obtain an accurate assessment of benefit, early reaction from teachers appears to be uniformly positive. Children being taught by RE teachers appear to be proactive; and to have developed good exploratory learning skills and communication skills. There also appears to be some initial evidence of improvement in classroom performance.

APPENDIX V: ACKNOWLEDGEMENTS

This report benefited greatly from the input of several individuals and organisations. We are extremely grateful to all of them. The report was undertaken in association with the Confederation of Indian Industry (CII). We are specially thankful for the guidance provided by Mr N. Srinivasan (Director General, CII) and Mr Y.S. Rajan (Principal Advisor, CII).