FUTURE ICT INFRASTRUCTURE FOR EDUCATION

K.R. Srivathsan, Director IIITM-K, Trivandrum
Email: director@iiitmk.ac.in

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1. INTRODUCTION

Presently Information-Communication Technologies, or ICT, is used in education mainly for Internet access, email and limited e-journals access facilities. In a limited way, some form of distance classroom options are used by IGNOU or a few elite institutions. Recently MHRD and some states have taken a few significant initiatives to make better uses of the capabilities provided by IT for education. Notable among these are the NPTEL, INDEST and the Infonet/AICTE/ERNET connectivity programs. The author is currently driving the Kerala Education Grid project that directly addresses effective methods to enhance the quality of higher education. This is briefly reviewed in the next section. The challenge that this paper addresses is how to leverage effectively upon IT and the opportunities provided by the launch of EduSat, emerging broadband connectivity and developments in Technology Enhanced Learning and Teaching [TELT] in ways that bring about far reaching and fundamental changes that are so desperately needed in our education systems at all levels.

This paper does not directly address specifically the technology, deployment or how much it will cost. The author feels that the investments that have to be made are of two kinds. One side is the technology and infrastructure related investments at the ground level that we have to make anyway. But this will not necessarily result in the quantum leap that we need to achieve in the quality and opportunities of education that we must provide to the students of our country at large. The other are the investments that we have make upon the services, programs and processes and building the associated competencies and capacity in the people to run such services and programs. To do the latter, we need (i) a vision driven approach, and (ii) identifying the kind of infrastructure and processes to achieve the intended objectives. This paper concentrates on this latter issues.

Here we develop an outline of the comprehensive and enabling approach that redefines the future [ICT] infrastructure and information systems requirements based upon the state-of-the-art emerging technologies, interaction, information and collaborative learning paradigms. We look at the whole gamut of technology facilitation of education in a holistic manner and present

the different component TELT environments that we can build. The approach presented when driven in the right spirit and alignment of the educational processes has the potential to make India a true world leader in the emerging knowledge driven era.

In recent years the Indian education system has somehow overcome to a good extent catering to numbers but unable to grapple with providing quality education. We are seeing mushrooming of colleges and even engineering seats are available to almost any qualified person who seeks admission. But the present Indian Education System has several deficiencies. Firstly, its emphasis is on too much on rote learning with a mechanical classroom – examination approach. Students do not get education that equips them to face real-world problems. Take the way most engineering or science subjects in the universities system. The students are taught mostly the rules and description of the subject content. Outdated syllabus that hardly keeps pace with changes is set up at one level – say by AICTE; the teachers in the colleges teach them with a mechanical chalk and talk and without being equipped to put the students through the minimum learning exercises; examination paper is set up by some empanelled person without capacity to evaluate the learning processes in ways that help the student to make quality learning efforts and finally the answer books are evaluated by a fourth set of people whose capabilities to carry out the same are limited at best. In the end we end up graduating 'Cricket Spectators' and not 'Cricket Players' with the result that most graduates become unemployable for no fault of theirs. Whatever system we are going to create must address the existing system being thoroughly reorganised to ensure that the teachers teach better, the students learn better and the system to manage so that we produce employable graduates, enhances the capacity of teachers

Current approach is not able to provide for universal elementary and secondary education to all. Significant number of people in the rural areas has inadequate access to educational resources and facilities. There is acute shortage of motivated and competent teachers. There are no systems in place to address these issues by which the local people themselves are empowered to address them. Available learning resources are grossly inadequate for students to learn from practice. Our aim should be to provide such learning environment and processes that enable our students to identify and address real-world problems. So we need to reinvent our educational systems from first principles based upon a far-sighted future vision that addresses the knowledge driven growth of the country and driven by a sharing and caring approach. Here we look at some of these issues in the light of the opportunities provided by the emerging ICT and the launch of the MHRD Educational Satellites.

1.1 PROPOSED VISION AND SYSTEMS DRIVEN APPROACH

Our vision will be to "***Enable, Educate and Empower Every Citizen Through Knowledge***". We shall do it in the spirit of "***Quality Education to All Independent of Geography***".

At every level of the education system and in every process behind it, the above vision shall inspire build such educational systems that equip our people with the ***capacity*** to apply knowledge in real life and participate in knowledge enabled wealth creation. At this stage, we may recall the following set of 'Education Criteria for Performance Excellence', published by the National Institute of Standards and Technology of USA that have universal value in the context of the emerging knowledge society. Each item thereof, besides the vision stated above is briefly described in the Indian context.

i) **Learning-Centred Education:** Our focus will be on enhancing our present classrooms and exams oriented system to one of ensuring that every child or student is provided with quality learning experience and building capacity into them to address and solve real-world problems.

ii) **Organizational and personal learning**: We need to build-in continuing research, analysis and evolution of teaching methods and cognitive aspects of learning (areas that are neglected in today's education) in every subject. New processes supported by e-courseware maintenance will ensure that educational institutions master the methods by which quality of education and instruction is enhanced year after year. Those who teach and/or part of the instruction design and management teams will also be oriented to understand such processes that produce quality education.

iii) **Valuing faculty, staff and partners**: Teachers will be equipped to assess themselves on their comfort in teaching, assessing and communicating the intricate and subtle concepts and methods in their respective subjects. Capable teachers will have opportunities to be assessed by experts and be given incentives to further their enthusiasm in the promotion of quality education. Support staff will have opportunities for innovations and continuing education. Inputs and competence from experts in industry and business will be solicited to make education relevant in addressing real-world needs. Such industry partnership will be formal and duly acknowledged. Teachers will have ample opportunities to enhance their qualifications through imbedded continuing education programs.

iv) **Agility**: Current outdated modes of curricula updates will be replaced by processes of knowledge collaboration over the educational network to ensure that empowering

education that is current, relevant and attuned to understand today's problems and needs. Teachers will be provided with asynchronously supported continuing education to ensure that they are well equipped and freely assisted to teach state-of-the-art developments.

v) **Focus on the future**: Existing educational bodies like the NCERT, CBSE and their state counterparts, DTEs, DCEs, etc. will have to be totally revamped. We shall support subject or area specific expert groups with members from relevant educational organisations, academia, industry and organizations. Such groups will manage and maintain subject specific study and research portals. This will enable knowledge collaboration between all teachers and scholars concerned. The expert group will be funded to ensure that teaching materials and content are developed such that what is taught is in tune with real world needs, emerging trends and future opportunities.

vi) **Managing for innovation**: A major need to sustain innovation is to foster interdisciplinary learning culture and systems thinking. New systems shall be in place to establish and run respective study and research portals in each subject maintained by the respective experts in the field. Discussion forums will be used to build case studies and challenges where lessons learnt are used to solve real-world problems or used in combination with related subjects to educate learners in building and managing complex systems. The proposed knowledge network approach is eminently suited to nurture such environment that encourages innovations.

vii) **Management by fact**: This requires a clear understanding of where our education system in any given subject is today, where we really need to go and understand the competency and knowledge gaps that need to be bridged. Then we set in place processes guided by appropriate metrics and deliverables related to student performance, available financial inputs and capacity of the organization to deliver. We need to set in place appropriate educational strategy groups in different areas to develop a plan of action following due consultative processes. A standing mechanism to implement such plans will be in place for effective implementation.

viii) **Public responsibility and citizenship**: A major responsibility of our universities and education system is to address the educational needs of the community around. A good example of this is the University of Birmingham that offers courses in diverse topics – outside of its formal studies – to the neighbourhood. The community must feel proud with a sense of ownership of the university system and seek its services (for a

price as necessary) and demand such courses or training as needed time-to-time that addresses development concerns. The universities should also offer programs to improve the employability of young citizens and of relevance to industry. There is a need to tie closely postgraduate level vocational training programs and opportunities for bright candidates with lower vocational diploma or certificate to move into professional and other degree programs. Vocational training will have to get much greater attention. There should also be post-graduate level vocational diploma programs.

ix) **Focus on results and creating value**: Ultimately educational systems will be judged by the employability of its graduates and the value addition they provide to the growth of the society of which they are a part. They may also provide training in entrepreneurship and services in times of need and emergency. The results should also reflect the financial viability and sustainability of the different programs.

x) **Systems perspective:** Every program offered by a university should be viewed as driven and supported by a corresponding system. It should be run as a knowledge-managed enterprise. The system includes the group of faculty and associated personnel who drive the program, resources management, knowledge management and duly monitored for effectiveness by competent peer groups. Every program needs to be openly accountable and its state of activities and performance visible to the management. The administration also needs to align itself to ensure that every program is facilitated to achieve its mission and objectives.

As the Malcolm Baldridge [1] document states, central to all the above criteria is the design and development of new systems and processes that ensures the following objectives.

"**Delivery of ever-improving value to students and stakeholders contributing to improved education quality; Improvement of overall organizational effectiveness and quality; Organizational and personal learning**".

In this paper we broadly address the approach that address the needs of secondary and higher education that stands to immediately benefit from technology and enhanced learning and teaching and by the opportunities provided by the educational satellite. With focus on teachers, the same system may be adapted to address the school education also. In this context we delineate in the next section the four important parameters related to quality education that are substantially enhanced by the applications of ICT in Education.

ACTION POINTS: Educational bodies like the Directorates of Technical and Collegiate Education need to be totally changed to become forums that support and facilitate standing Groups of Subject Experts, Such Subject Expert Groups will be constituted at the national level for areas in professional and sciences subjects

2. KERALA EDUCATION GRID AND QUALITY EDUCATION THROUGH ICT

Kerala Education Grid [KEG] is a project of the Govt. of Kerala that addresses a collaborative approach of subject-specific knowledge sharing and support for teachers across a network of universities, premier institutions and colleges. Resource Centres [RC] for developing content and teacher training are being set up in NIT Calicut, CUSAT, College of Engineering Trivandrum and the IIITM-K. More will be set up in future to cover Arts, Sciences and other subject areas. Each Resource Centre maintains web-based collaboration area as discussed in Section 3.

The main objectives of IT facilitation of education over the Education Grid are to introduce such information systems, learning processes, collaborative learning and research environment across the schools, universities, colleges and institutions of education and research that result in the following gains to the educational system, the teachers, learners and researchers.

i) Enhance substantially the quality of learning experience in ways that help them to learn better and equip them to address real-world problems and issues in their respective relevant fields.

ii) Empower teachers and support them with quality teaching environment.

iii) The resulting IT facilitated educational system should be both sustainable and manageable.

iv) All the above to be achieved affordably and economically even as modern IT tools, systems and services are inducted into the education.

We propose to achieve the objectives by introducing TELT facilities and processes in the university education system. The approach for effectively establishing TELT is being addressed in the following three dimensions.

a) IT facilitation of the education systems that allows for establishing course specific knowledge sharing and collaboration among the teachers and scholars in each subject area.

b) Understand and implement such IT facilitated processes that enhance the quality and standards of education. This will be done in ways that bring in such new capabilities will help the universities to address their genuine roles in public responsibility and citizenship and to produce more employable graduates.

c) Put in place such learning environment and processes that help the universities to offer new programs, interdisciplinary bridging courses and take quality Indian education to foreign destinations.

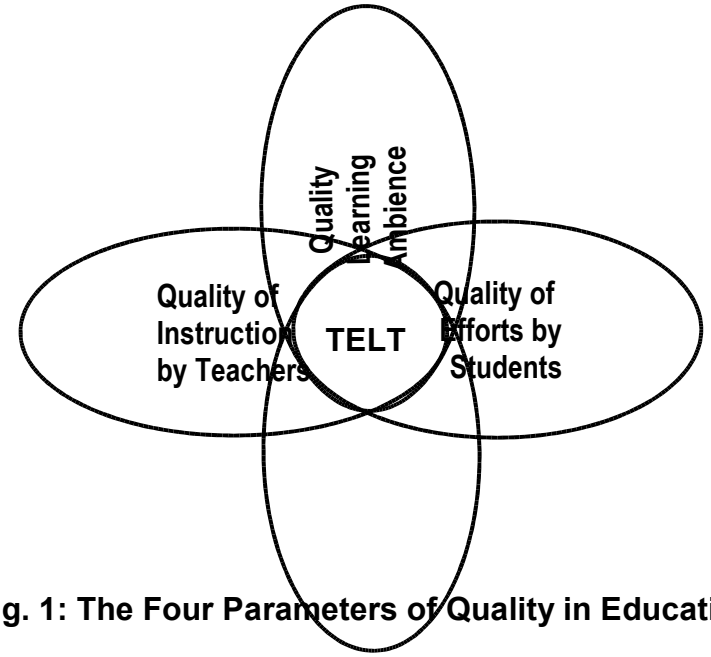


Fig. 1: The Four Parameters of Quality in Education

The key to effectiveness of effectively driven TELT assisted educational processes in uplifting the education system is its enabling approach to enhance the quality of educational programs and services in conformance with the vision and orientation given in Section 1. Central to all the parameters given therein is the capacity of the KEG to sustain the four quality parameters and processes illustrated in Fig. 1. These are briefly described below.

2.1 QUALITY RESOURCES

Institutions of education need varieties of resources. Besides buildings, classrooms, blackboards and traditional library, we need quality labs, computing services, information resources, Internet and communications. Today the computing resources are essentially general purpose. ***In the present from of access to Internet and unorganised information services, these computing and information resources detract the students from focused efforts and study.*** This is more because the Internet and information systems do not provide

focused content and interaction as relevant to the courses of study. ***The coming years will see the emergence of Knowledge Campuses.*** Here, the information space and computing systems will be customised for each course. ***There will be plenty of scope to customise the information and computing services through TELT that add immense value to the education system.***

A college typically provides the buildings, classrooms, library, labs, lecture theatres and similar facilities. These are supportive infrastructure to the learning. Internet, computer labs, LAN, servers, software or the audio-visual aids add some quality resources to a limited extent in today's environment. These will be substantially enhanced through TELT methodologies.

TELT addresses three levels of resources and processes that help enhance the quality of learning very substantially. The first level is the addition of infrastructure to support e-learning ambience. To support the KEG services, the colleges will be host to Education Server that support (i) Learning Management System, (ii) Online E-Library facilities and (iii) reasonable quality Internet services, (iv) online localized group collaboration and interaction services and (iv) synchronous and asynchronous interactions through discussions, message boards, etc.

The second level of e-learning addresses cost effective access issues for students and teachers so that they are equipped to effectively use the e-learning resources and facilities that will be made available. A college may start with the first level and upgrade their existing LAN and PC facilities for supporting the second level. At a third level, the college may go for enhanced e-learning infrastructure facilities that support multimedia streaming and synchronous e-classroom facilities. The synchronous facilities are rather expensive to own and manage. They may be added through centrally sponsored schemes (like the one proposed under MHRD's EduSat).

A major resource will be quality web-enabled focused content in the different courses that is rich in interactive components, quality exercises, linked digital resources. ***We propose to develop and maintain such content through knowledge sharing and collaboration processes whereby experienced teachers will help validate and maintain the quality and usage of such content in the different courses.***

2.2 QUALITY OF INSTRUCTION

Quality of instruction in a college is a function of several processes in place. At the core of this is the motivation, passion and the capacity of the teacher and the system concerned in

managing and sustaining a vibrant learning environment. KEG plans to provide a ***Course Knowledge and Collaboration Space*** over the Web. This will help the teacher interact with teachers of the same subjects in other colleges and some experts in the subject. In addition, the course material supplied through the education servers will have contents specially addressed to teachers and for special classroom needs. The server itself will support asynchronous discussion facilities that help both the students and teachers for diverse kinds of interactions. Classroom instruction is strengthened by capacity to monitor students' performance and alerts on students not doing well. In addition, KEG will conduct teachers orientation programs to provide subject specific participation and training on how to teach.

There is acute shortage of quality and experienced teachers in almost all the colleges. The bright student population in the colleges is not adequately motivated, directed or exposed to how they could apply what they are taught to real world problems. ***Instruction is a complex process***. It is not adequately covered by the information in the texts, books or the blackboard based sermons by a good teacher. Quality instruction should address the pedagogic processes as relevant to the world of the subject that is being taught. An earlier paper [1] provides a model that explains in some detail the five dimensions of pedagogy that is addressed through TELT to support quality education. ***The teacher is the pivot around which the following five dimensions of pedagogy are conducted.***

(i) How we ***introduce the problem*** or the topic that we are going to teach in ***relation to the real world scenario*****?**

(ii) ***Effective communication*** of the concept, the approach or the solution, i.e. the teaching process;

(iii) Worked out examples, illustrations, case studies or ***demonstrations that illustrate*** what is taught;

(iv) Make the students do ***quality exercises*** and group work that help them digest what is taught;

(v) Enhance the ***capacity of students to apply what is taught in real life situations.***

Even the best of teachers get little time to address the above issues effectively for all the students in the class. Here is where the web-enabled content and recorded lectures from the best of teachers will help drive the teaching processes. Such content that drive the teaching process will also assist the teachers in learning how to teach effectively. We shall directly address ***our challenge to build in the web-enabled course contents the instructional***

processes that help the colleges to conduct the courses effectively. Every effort is being made in the Education Grid project to address these issues. Over time and collective learning, we expect best practices to evolve from experience.

2.3 QUALITY OF EFFORTS BY LEARNERS

While quality of efforts on the part of the teachers is enhanced by supportive content and processes, students efforts are considerably enhanced by interactive content, question banks, threaded discussions and linked context-specific course library. Students may undertake interactive self-test that will be designed by experts in the field. These tests help the student to focus his/her study and identify what knowledge gap(s) he/she has. They will also be helped by supplementary content to study and bridge such knowledge gaps. KEG aims to ensure that students carry out focused study, not get digressed in superficial exposures and put in sufficient and purposeful efforts beyond the classroom hours so that they digest and master the skills and concepts.

It is not just the quantity of effort that a student puts in so important as the quality of efforts they put in that raises the standard of education. It is stated separately to emphasise that the efforts the students put in after the classes or the preparation they do before coming to the class or practical is critical to ensure quality education. The web-enabled instructional processes as built into the content help achieve this. A carefully developed and pedagogically sound content will have components that help considerably in enhancing such quality of efforts. The teacher too needs to put in considerable quality effort in the preparation for each class and in organizing the different learning activities. A combination of quality content and course management helps achieve these objectives.

In addition, several resources such as simulation, virtual reality presentations, rich illustrations, animation and visuals add much value and provide for faster understanding of several kinds of complex concepts and scenarios in almost all subjects.

2.4 QUALITY LEARNING AMBIENCE

The learning ambience is where good institutions like the IITs do fairly well. This happens by students discussing the topics beyond classrooms among themselves, group work, critical look at what is being taught and finding out what the world of the course is beyond the narrow confines of the syllabi. It is important that colleges nurture healthy discussion sessions and

intense study sessions. Adequate time, say one day a week should be given to indulge in seminars, discussions, interactive study, etc. so that they develop confidence and develop a real world view of the subject.

The content proposed to be developed aims to assist in maintaining all the above four quality parameters of the educational process. The KEG is adopting a Content Quality Metric (CQM) in guiding and assessing content that will help maintain the above four parameters. Some details on the CQM may be found in [1]. Colleges will interact with the RCs for effectively management of the TELT activities to get maximum benefit from the KEG services. KEG itself may undertake seminars organization in the colleges to motivate students and teachers and make learning fruitful and enjoyable. KEG will support initiatives by the colleges that help add value to themselves and help other colleges under the KEG.

The object of selecting similarly equipped students, placing them in a class and subject them to a campus life is to provide the very quintessential of the learning environment that constitutes the learning ambience. The students should be encouraged to discuss with teachers, with classmates, explore the library, surf the information space purposefully and expose to the subject-world in ways that enrich their understanding, appreciate the world of the subject they are studying, participate in group work and activities within and across subjects, listen to seminars by eminent experts, develop a sense of solving problems of the world, build things, add to their learning experience, etc. It is in these quality ambience parameters that most of our colleges fall considerably short of the minimum. The exams and marks oriented system discourages teamwork, or spending time purposefully outside the narrow confines of the texts and notes in the courses taught. For example, an engineering student in electronics or material science should have clear idea of what the requirements of a medical appliance are so that he/she can apply the skills learnt in the real world. This and several other lacunae in our education are best filled through TELT.

With imaginative management of web-enabled interactions across institutions, organizations in other disciplines, industries and R&D, such stimulating environments that provide quality learning ambience is best built into each course space over the web. KEG plans to address this issue in a substantive manner.

3. FUTURE LEARNING ENVIRONMENT IN THE UNIVERSITY SYSTEM

Technology Enhanced Learning and Teaching [TELT] environment will soon have to become the principal infrastructure in all educational institutions. TELT will have to be

given formal position and recognition in the university processes. Fig. 2 shows the KEG's approach to accord such formal position. The Learning Environment and IT Facilitation Layer is positioned at one level above the lowermost infrastructure and administration layer of the university system. Each lower layer supports the layers and the processes above it. This Learning Environment and IT Facilitation management layer has not been given adequate recognition in the current Indian university system. It plays the kernel role and is of fundamental importance in supporting the quality parameters discussed in the previous section. Currently this has been restricted to feeble library and laboratory support. We propose that every university recognise this layer formally and an Education Grid like approach funds and supports the infrastructure and services through this layer. Through this layer every institution or college will be able to create and share online resources with the other institutions. Such sharing is facilitated by the Education Grid functions as pointed by the arrows in the figure.

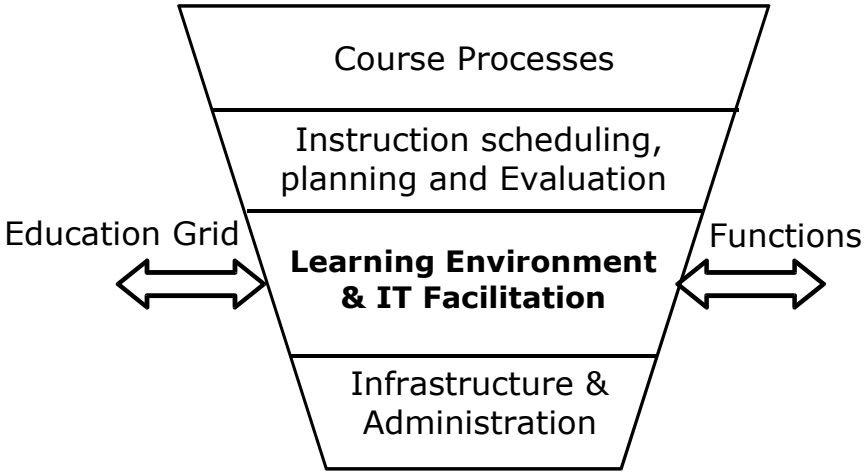


Fig. 2: IT Facilitation Layer in formal Education

3.1 EDUCATION GRID LEARNING ENVIRONMENT AND IT FACILITATION

In view of the fundamental importance, the functions of and processes over the learning environment and IT facilitation layer is explained here briefly. Every leading university in the world today is increasingly getting equipped to support TELT functions and the four quality parameters stated earlier. Whatever is provided by the different MHRD/UGC/MC&IT programs like INDEST, INFLIBNET, ERNET etc. are rather basic information and access services. But what the universities need is much more than these basic facilities. A teacher, student, research scholar or scientist who works in a focused subject area requires interacting and working closely with other scholars, teachers or experts in the same or allied subjects not only within the same organization, but also with those in other organizations. Thus each subject area

needs to have its own ***knowledge collaboration space*** over web that is exclusively managed by the group. This is illustrated in Fig. 3.

What the figure illustrates is an area where focused groups of researchers may collaborate among themselves and interact with the globally available information relevant to their field of study and research. ***IIITM-K under its Education Grid efforts has already nearly perfected the technology, deployment and management issues related to the maintenance of such Knowledge Collaboration Spaces in a wide variety of subjects over the same set of Education Servers.*** Today IIITM-K has rich experience in enabling the use and management of these education servers at over 20 premier institutions such as some of the IITs, IIMs, Indian School of Business, IISc, CUSAT and also in some leading R&D and industries such as ADA, VSSC, TCS and Ashok Leyland. Through these organizations, we are continuing to gain useful experience in the management of private collaboration spaces over the web. What these servers with associated server-farm provide is an Enterprise Knowledge Management environment that holistically integrates following multiple needs of academic and research institutions.

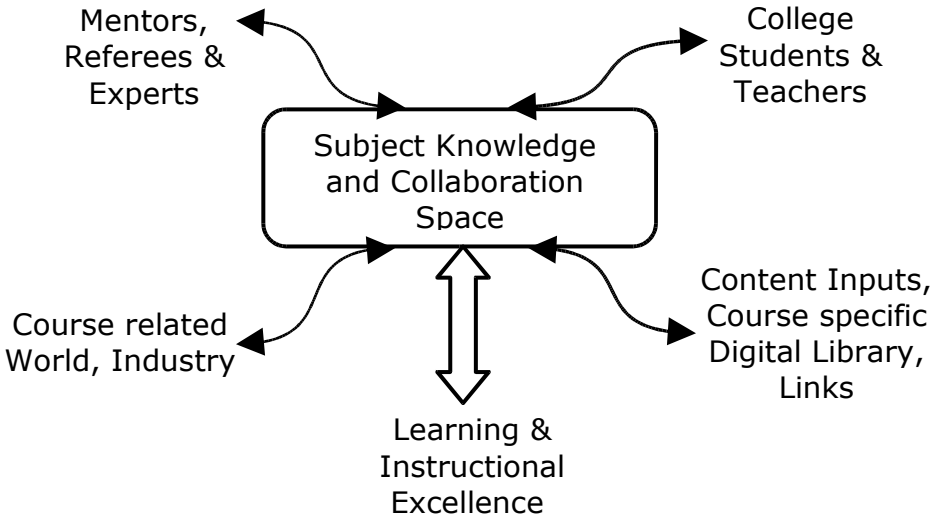


Fig. 3: Web-Enabled Collaboration Environment For Teachers and Scholars in Universities

i) Web-enabled interaction, collaboration and information organization environment. This is done through a Knowledge Interaction Interface available to every teacher, student and research scholar. It is explained later in this section.

ii) Online Digital Library with support for generic and custom metadata standards.

iii) E-Journals subscription and access control management for the Digital Library.

iv) Built in multiple document type search capability.

v) Indexed organizer for multimedia documents like streamed video, drawings, audio, photographs, etc.

vi) Support for documents in Indian languages.

vii) Group Collaboration area where any number of groups may be created and independently administered. Each group will have secured folders accessible through a browser, its own e-publishing management, group specific search, group mail, scheduler and task manager, etc.

viii) A full SCORM and AICC compliant Learning Management System with capability for learning objects porting and management.

ix) Capability for Grid based sharing of a given area (like a group or course space) with similar area in another college server.

x) Open links for integrating secure administrative information with commercially available open architecture based academic ERP packages.

The web-enabled knowledge collaboration spaces in different areas as illustrated in Fig. 3 are well supported over the kind of education servers with the above features. Such collaboration environment needs quality network connectivity among all the universities and colleges who are part of the Virtual Campus as outlined later in this proposal.

4. KNOWLEDGE INTERACTION ENVIRONMENT

The features of the Education Server listed above make it an advanced Knowledge Management platform for Education. Such fairly comprehensive knowledge interaction environment is what that the academicians, researcher scholars and students in education need. Till sometime ago the features as listed above were not available coherently in institutions. To understand how any student or academician will enhance his/her working environment, we present here the concept of ***Knowledge Interaction Interface or*** **KII.** The KII is illustrated in Fig. 4. The different components in it are briefly explained below.

1. **Digital Library:** Refers to the electronic form of library where classification of documents (multimedia included) follows conventional library sciences principles. There is much more flexibility available under an online Digital Library. The view and classification may be generic like a Dublin Core, and also custom made to suit the company's way of looking at

archival document clusters. Further, personalised view and e-publications related workflow are useful additions in this kind of library. This subject is still evolving.

2. **My Links:** A personalised library view of the user consisting of links to one's current favourites documents and links to permitted sites of interest. This feature becomes possible because of the web-enabled organization of all documents.

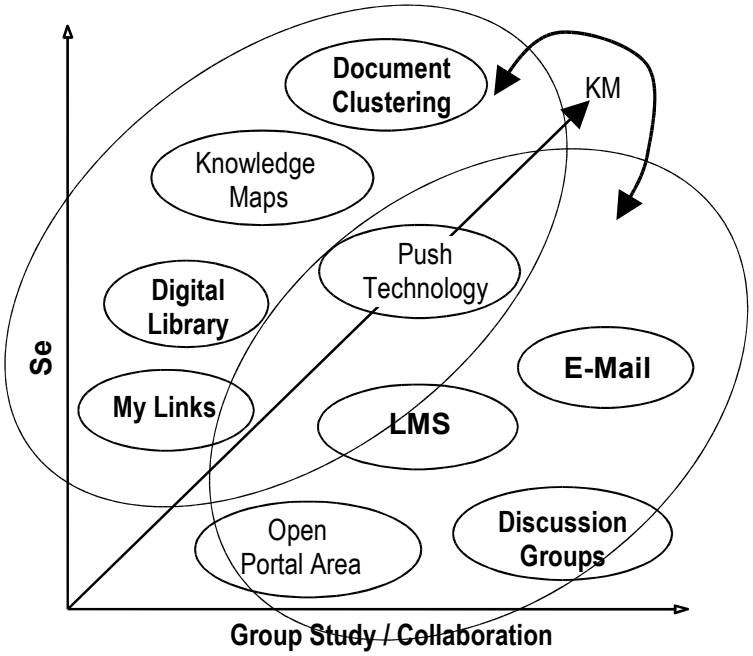


Fig. 4: Knowledge Interactions Interface

3. **Knowledge Maps:** There are two broad classes of knowledge maps. One is enterprise specific and relates to the ways the business and processes related knowledge is generated and organised. It will include a navigational map for the different knowledge areas in an enterprise. A second class of knowledge map is more generic and pertains to very large volumes of information as in data warehouses in specific fields. It may denote any custom classification that allows for knowledge queries in a subject area. For example, standards pertaining to a design and development process may be classified into a knowledge map that describes better the relevant organization of knowledge pertinent to the subject, it could be the way plant species are classified in Botany, or a class of molecules in Chemistry. The latter leads us to building custom data warehouses. Such classification helps us to imbed efficient search tools and the present developments in Semantic Web.

4. **Document Clustering:** This refers to the way a group organises informally the different kinds of documents relevant for managing and generated by its activities. This is best done

under specific groupware area. Here we may cluster project report, group findings, guidelines, progress reports, tasks related documents, customer requirements, etc. Each K-Citizen activity will require its own document cluster and some of its documents will be visible to the entire organization.

5. **E-Mail:** This has been a major collaboration tool and will continue as such. However, from a group's interaction and the individual's requirements, the present email clients are poor in design and need much improvement. The logic of E-Mail interactions between groups juxtaposed with a K-Citizen's internal knowledge requirements is not well supported. Capacity to organise single view access from multiple mail accounts for the individual is yet to get adequate attention.

6. **Discussion Forums:** Tools such as usenet and message boards have been quite popular. These allow informal socialisation that is important to engage the employees and management to discuss openly issues of common interest.

7. **Push Technology:** This is a reference to the ability of any smart Education Portal to observe identified activities and alert corresponding person(s) or groups who have to act upon such activities. For example, the administrator of a particular service will be alerted automatically whenever an employee leaves or joins, or, about who should be added to/ deleted from the service with associated log of the action taken. Various task assignments, monitoring of exception events, etc. are efficiently built using appropriate alert systems. Alerts may also be coming from external world through call centre activities, SMS messages or user's specific requests over a portal interface.

8. **Learning Management System (LMS):** LMS is a vast and complex system. There are dedicated products from some US sources. IIITM-K incubated Acado class E-Learning systems offer today the only full-scope international standards compliant LMS integrated with other knowledge management services. Since continuous education and retraining forms an essential part of any learning organization, LMS should form a natural component of any Enterprise Knowledge Portal. In academic and training establishments, LMS together with the Digital Library form the central components of the EAI.

The role of KII with components as stated above is to let the learner or the teacher carry out focused work along with other members in their research or study. ***The KII enables efficient context switching between self-study and group-specific collaborative work.*** In such a KII guided access to information and collaboration, we sustain the paradigm of ***'Right Information at the Right Time, to the Right persons, in the Right Places and in the Right Context"***.

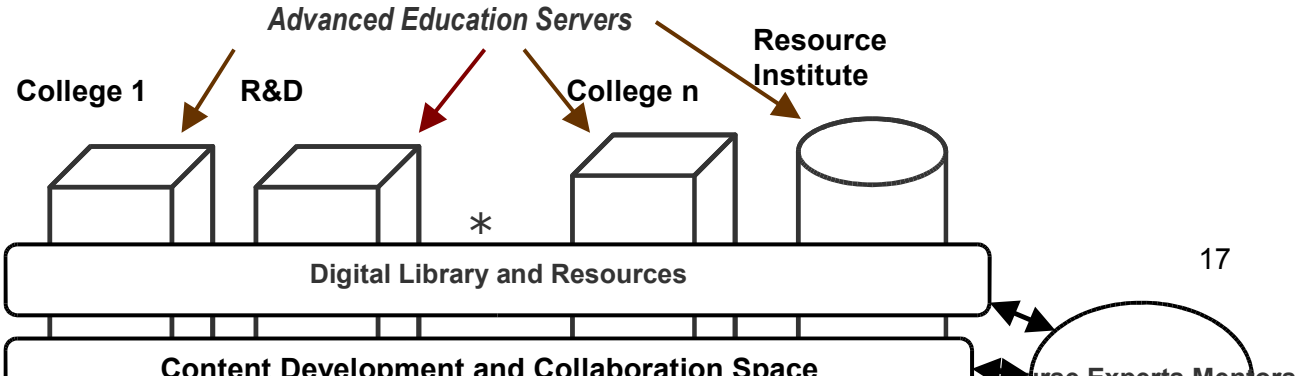
These five 'fundamental rights' as they are referred to is at the heart of enhancing productivity and learning quality at the group as well as at individual levels. Knowledge Management in the IT sense is the result of managing the processes that support the five 'Rights' over the KII driven web-enabled information, interaction and collaboration space.

Thus KII provides a comprehensive framework whereby any learner or a group of learners is equipped with the best efficient learning and collaboration environment supported by IT. The challenge in setting up the IT Infrastructure in Education is to establish the KII environment for every learner and knowledge worker with due focused processes based upon a sharing and caring approach as needed in every course, study and research activity.

5. EDUCATION GRID APPROACH TO COLLABORATIVE PROGRAMS

While the KII provides the way a teacher or learner will access and use the different IT facilitated study, learning, interaction and collaboration services, what we need as part of the IT facilitated Learning Environment is an open programs management framework that sustains the Knowledge Collaboration Space across multiple universities and colleges in every subject area. For this the Education Grid is perfecting the collaborative methodology as illustrated in Fig. 4 below.

Fig. 4 illustrates how the knowledge sharing and collaboration space for each course is built and managed over a network of Education Servers – one per institution. For each course, a group of subject experts and mentors rooted in an identified Resource Institute will maintain course-specific Digital Resources of relevance, manage the content development with a team of teachers, conduct teachers/users training and release validated e-learning content for use in the colleges over their respective LMS. This whole process will be supervised and enabled by a course management supported by the Education Grid. The advantage of this approach is that we may invoke pedagogically sound structured content of quality and release approved e-content under a university approved and acceptable process. Some elaboration of this methodology is given in [2]. The collaborative approach suggested here also empowers teachers to participate and make curriculum update a natural part of the process. Fig. 5 below shows the server farm in any academic institution may be established using a server farm with a Knowledge Management front-end portal providing the KII for every user.



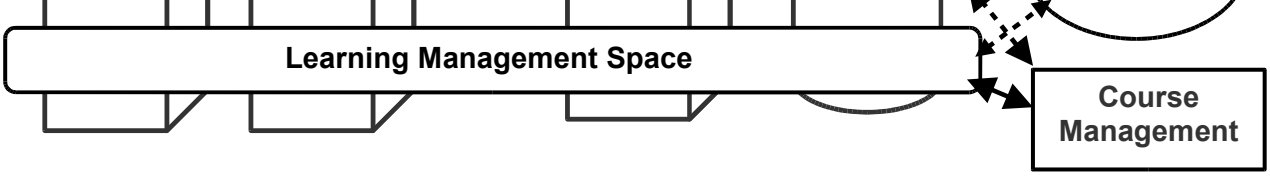


Fig. 5: Course Knowledge and Collaboration Spaces over Education Grid

Broadly, the figure shows the two kinds of environments that are supported over a future MHRD network. On the left is the 'Synchronous Classroom environment'. The other is the work environment for study and research that we refer to as the 'Asynchronous KII environment' as described in the sections earlier. These two environments are complementary and reinforce each other. A summary of the different component environment is given below.

i) **Synchronous Distributed Classroom Environment:** This is typically supported by TV broadcasts of lectures like the one conducted by IGNOU. Some form of interaction is also possible through return audio. Other examples of this type of support are the ones given by the HCL – Comnet serviced IIT Bombay Kanwal Rekhi School of IT's remote classroom concept based on GILAT International's technology. The one used by Some of the IIMs and XLRI are supported by Hughe's One Touch Systems. These may be extended by the MHRD's EduSat initiative. They require considerable initial ground investment at the receiving stations. It will be useful to have such facilities for (i) continuing education of teachers; and (ii) continuing education by the universities and premier institutions to those employed in industry, business, government and other organizations.

ii) **Asynchronous Knowledge Interactions Environment:** Much of this has been described earlier in the kind of KII support that every teacher or learner needs. This environment is necessary for all learners and teachers to do their intensive study and collaboration beyond the class hours. Without this as the base, the synchronous environment has only the limited value of providing the services good teachers at remote places. Asynchronous environment is essential in all regular institutions for the Digital Library and LMS services. A LAN based powerful web-enabling KII portal server like the Acado class developed at IIITM-K is best suited for providing the asynchronous

environment. Alternately one may build custom portals along with some LMS servers like WebCT or Blackboard. KII will also manage online e-journals access control for the different users.

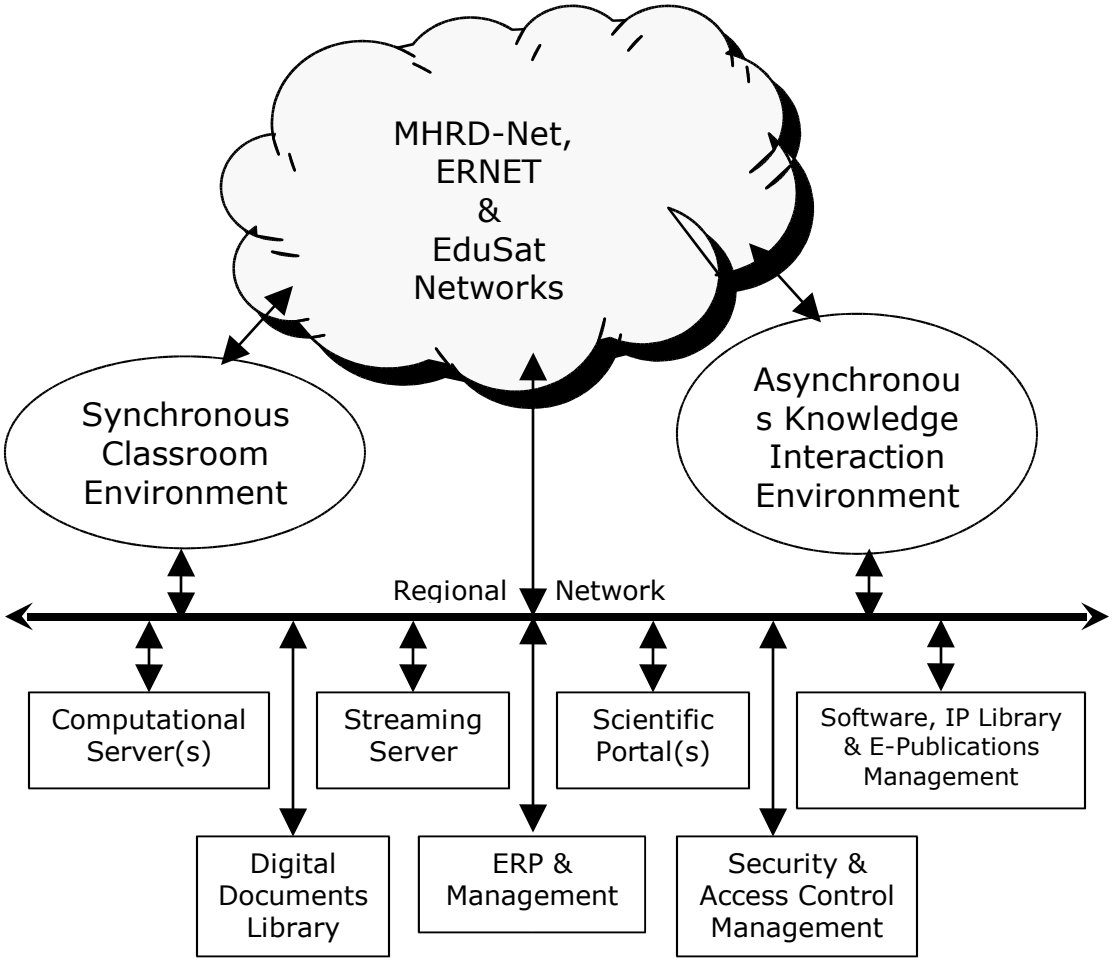


Fig. 6: Future Information Infrastructure for Education

iii) **Computational Server(s):** These are the mathematical packages like Octave or Matlab, Computer Aided Design, Simulation and Analysis packages of various kinds, etc. Some of them are expensive and complex to maintain. These are best maintained in premier institutions and made available over the Education Grid through the KII Portal to those who are registered in the different colleges in the courses where they are needed.

iv) **Streaming Server:** Ideally each college should have one streaming server to support a video-on-demand environment for recorded lectures playback. Such lectures are used by anyone in typical LAN or broadband environment for reviewing class lectures or those of eminent teachers in the subject.

v) **Scientific Portals:** Every University should develop and maintain Scientific Portals in selected subject areas of their strength. Here they shall develop and maintain advanced Datawarehouses in their chosen areas. The access to such Datawarehouse will be through an advanced web-portal that has built in computational query based (like the semantic web for example) visualisation of the relevant information sought from the scientific portal. For example, we may build scientific portal in Computational Chemistry, GIS based information of importance in Agriculture, in economic indicators, healthcare, etc. Such scientific portals will make the Universities tremendously relevant to the nation's development processes in the emerging knowledge driven economy.

vi) **Software, IP Library and E-Publications Management:** Modern University information services cannot any longer effective management of the software library or E-Publications Management in ways that respect and protect the Intellectual Property rights of the creators and copyright holders. All Information Systems managers should be trained to manage these functions.

vii) **Digital Documents Library:** This is the main online Digital Library that will also include e-Journals access management. Documents of all kinds including multimedia, e-books and other knowledge repositories like standards, etc. will be supported in the Digital Library.

viii) **Security and Access Control Management:** This is inevitable part of managing the total information and interaction framework for every valid user and suppliers of information in the modern knowledge managed enterprise. We need to train substantial numbers of professionals who are well tuned to manage such complex information and knowledge management systems of the future universities.

ix) **ERP and Management:** This refers to the administration, classical library automation, and similar Enterprise Resources Planning and office automation of diverse university functions. Several packages are available commercially to support these functions. Such packages will steadily improve in the coming years. There are several suppliers of these packages. One essential feature that needs to be kept in mind is that they are preferably open standards compliant and interoperable across institutions.

The approach to implementing and maintaining such comprehensive resources network as depicted in Fig. 5 in each region is described in the next section. It will take a while before the environment described here and the requisite information services management culture seeps into our university system. Even the best of institutions in the country like the IITs or IISc do not have coherent information systems, services or scientific portals management that address quality IT facilitated learning environment. Several steps are being taken in the KEG so that we quickly evolve into the seamless high quality knowledge sharing and collaboration connectivity across its member institutions as stated in this paper.

6. VIRTUAL CAMPUSES APPROACH FOR BUILDING THE FUTURE IT INFRASTRUCTURE

Our challenge is to build the capacity in the universities, institutions and colleges to assimilate the use of such advanced information and knowledge collaboration systems in their programs and daily activities. It is not possible or reasonable to expect that any single college or institution can support the kind of environment depicted in Fig. 5. So we propose that we build regional ***Virtual Campuses*** that are built over two layers of networks augmented by the Satellite Educational Services Network (SESN) as suggested below.

i) First link the group of institutions in a given geographical area over a broadband regional Virtual Private Network. Such networks with OC-1 (i.e. 52 Mbps) or OC-3 bandwidth are not expensive. We call this the Regional Broadband Networks (RBN).

ii) The second level consists of linking the RBNs over a national MHRD-Net backbone of initially OC-3 bandwidth later to be upgraded to STM-16, 2.45 Gbps bandwidth.

iii) SESN will provide an umbrella network that support (i) synchronous classroom environment beamed from designated RCs; (ii) provide asynchronous network services to remote and inaccessible areas or RBNs not easily linked to the national MHRD-Net.

The typical RBN structure that is proposed to be implemented as the Kerala Virtual Campus is given in Fig. 6. Kerala is a compact state with good terrestrial rural and urban connectivity. ***A***

good solution is to build the RBNs over the RailNet and Power Grid networks by (a) taking OC-3 connectivity on a state-wide basis and (b) investing or creating a Network Services company that maintains the access networks between the regional RBN backbone and the user institutions, colleges and universities. ERNET may be given the responsibility to negotiate with such parties in each region and have such agreements with competent parties who can serve as such network services providers (NSP).

It is important to distinguish these NSPs from the current low quality ISPs that will not suit the Virtual Campus needs. NSPs have to be concerned much more with the quality of network services in alignment with different types of media services that they have to carry. For example, networks of this kind will support real time and on demand multimedia streaming, computational resources accesses, etc. In the author's vast experience over more than a decade, he has not come across quality NSPs with the kind of reasonable tariff and competence needed to build and maintain such networks. The only exception he has seen is the Asianet Sat Com in the Trivandrum local area of Kerala. It is possible that parties like the Reliance Infocom, Bharti, Tata Indicom and hybrid fibre-coax cable TV networks operators may come up with such services in the future. For sometime to come we will have to nurture agencies that are capable of servicing such networks with quality and reliability.

6.1 VIRTUAL CAMPUS SERVICES TO COLLEGES

Students in colleges need several computing and knowledge resources. They also need an interdisciplinary environment to understand concepts in one year that are often applied to real world problems in another area. Present day colleges do not have the ability to maintain advanced computational and scientific portals that are at the bedrock of providing such services. However college education cannot do without teaching students advanced subject specific computational and knowledge management methods. Hence a Virtual Campus is built by giving access to colleges over the RBN such services that are maintained in postgraduate institutions and research centres in the area where competent experts and research scholars maintain the services.

It is possible that for every cluster of about 100 colleges in a region we can provide one set of computational and scientific portals in the appropriate neighbourhood universities and research labs that will support their study and academic programs. ***Every major university shall be equipped to develop and maintain advanced computational research centres and scientific portals in at least a few areas of their excellence associated with their postgraduate schools***. This will also ensure quality enhancement of the postgraduateducation

and research and also provide services. For this to happen, MHRD shall come up with the requisite mechanisms to identify institutions and universities that will be upgraded as Resource Centres for the region.

The structure of a typical Regional Virtual Campus Network is shown in Fig. 7. Efforts are underway in Kerala under the Education Grid initiatives to build such a regional Virtual Campus network serviced centrally by IIITM-K.

The Resource Centres are being put in place at NIT Calicut, CUSAT, College of Engineering and IIITM-K. More will be added in the other major universities of the state to cover the Arts, Commerce, Sciences, Agriculture and Healthcare subjects. The Resource Centres will also develop, maintain and conduct regular teachers training with E-Learning content in all the courses of the universities. The Virtual Campus network will also support offering open learning programs by the group of institutions on subjects of demand from the citizens at large. This is a major social responsibility function that has not received adequate attention by the universities. In summary the approach to managing the programs over the Virtual Campus will be governed by the following objectives.

(i) Education Grid is expanded to cover all subjects under the different universities.

(ii) Graduates in any subject under the university system are employable and capable of engaging themselves in creative and productive pursuits.

(iii) Teaching in the colleges shall be aligned to real world needs, excellence and emerging interdisciplinary nature of all subjects.

(iv) Inject some dynamism into the university system through visionary dynamic leadership and effective organization makes education learner-centric by leveraging upon emerging connectivity of the Internet, knowledge sharing and collaboration.

(v) Universities to fulfil social responsibility by offering continuing education in any topics on demand anywhere and support quality education to all independent of geography. Such continuing education will also add resources to the universities.

(vi) New Virtual University programs are initiated in interdisciplinary areas as needs and demand driven programs at postgraduate level by a package of courses offered by a mix of universities and premier institutions with emphasis on quality.

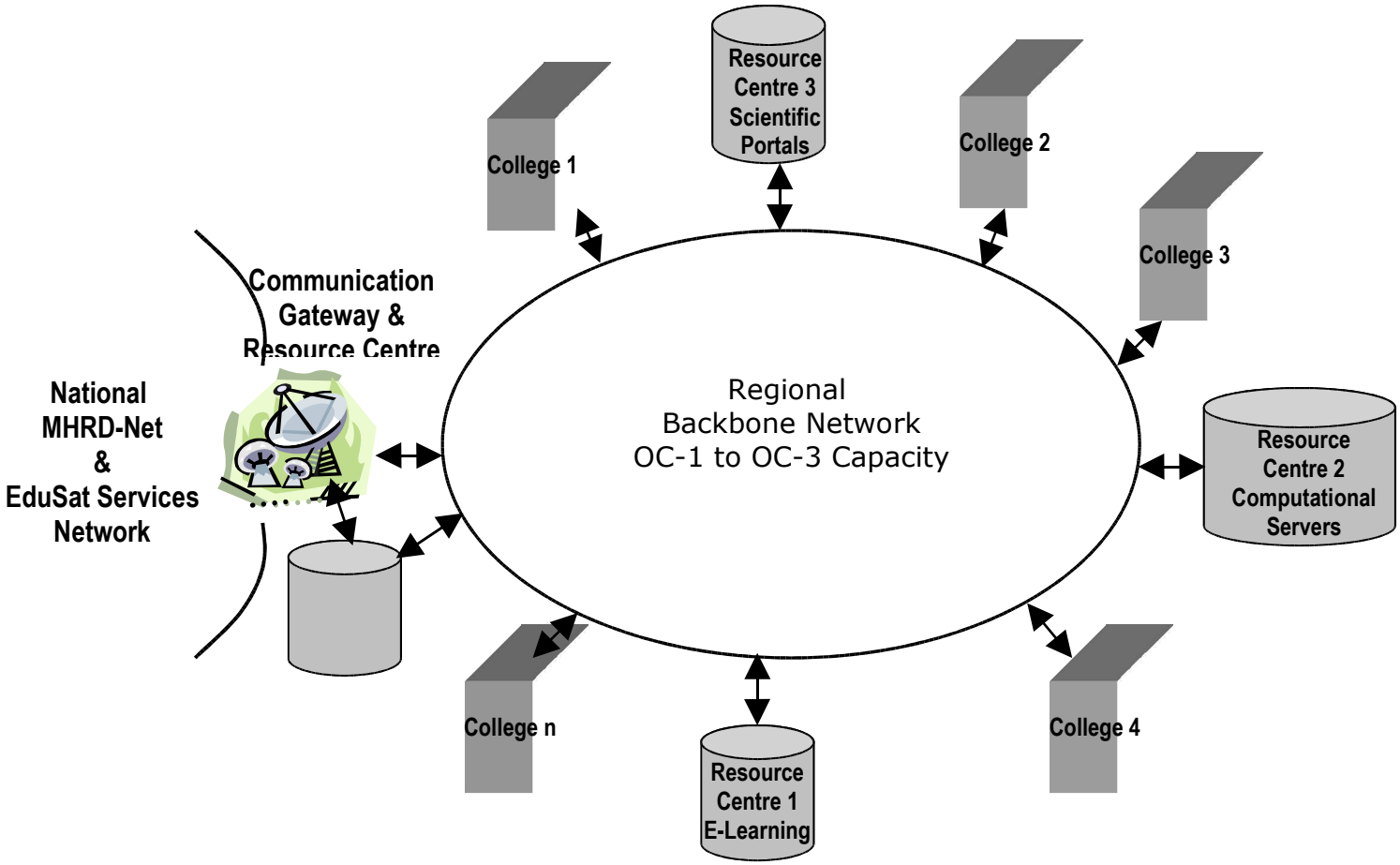


Fig. 7: Regional Virtual Campus Network

(vii) Universities to absorb effectively the potential of establishing and managing advanced study, research oriented scientific portals in wide spectrum of subjects. Different subject areas may be supported in different universities and premier institutions according to their respective strengths. Such portals will become computational and information portals of great value building the knowledge assets of the country.

Our goal is to revive the entire education system in ways that enable the universities to educate the society and empower industry, people or organisations through the kind of knowledge they need.

7. SATELLITE EDUCATIONAL SERVICES NETWORK

The impending launch of EduSat jointly by ISRO and MHRD provides several opportunities. Presently satellites in education use the TV modes (as done for example by IGNOU and UGC telecasts) or for interactive distance classrooms services provided by Hughes (through their One Touch Systems solutions), or by HCL Comnet that uses Gilat technologies. Some of the Management schools and IIT Mumbai's Kanwal Rekhi School of IT use their services. There is a large scope in expanding these services particularly for and schools and colleges teachers' training and for educational materials distribution. A major plan has to be evolved for vocational education programs.

However the effectiveness of synchronous methods will increase very substantially when they also get asynchronous KI support also. For example, IIM Kozhikode has such a combination for their Executive Training Program where the classes are conducted over a Hughes network and an Education Server supports asynchronous E-Learning environment over the Internet.

The best course is to combine both the Satellite Educational Services Network (SESN) and the Virtual Campus infrastructure stated in the previous sections. While doing this we keep the following goals in mind.

i) The Virtual Campus and the SESN Infrastructure are shared by all MHRD supported education from elementary, secondary, vocational, higher education, postgraduate to continuing learning programs.

ii) At the lower levels – elementary, secondary and vocational, we establish Resource Centres for development e-learning materials in every major local language. It will be good to locate such Resource Centres where the state-level educational bodies and

the universities with experts having good local languages knowledge can work together. These Resource Centres will also be linked to the RBN in the area.

iii) At the Higher Education and continuing education levels for teachers, industry, executives and government officials, we adopt the Virtual Campus approach.

iv) Equip at least two or three Resource Centres in each larger state with facilities for both Video studio and web-studio production of educational materials. Experiences of institutions like the IITs and IIITM-K may be taken for grooming such facilities.

v) A major detriment to the spread of ICT in the rural areas is the lack of right technologies. One is the unstable power in many areas of India. Two is the power guzzling PCs coming from abroad. Hence, develop technologies for (a) tropicalised low power consuming access PCs and (b) minimize parasitic investments such as large capacity UPS and air conditioning. Augmented TV using smart set top boxes is capable of providing a great deal of interaction using TV sets. This is eminently suitable for school education.

vi) Integrate the synchronous projection or TV based remote classroom technologies with streaming technologies over the RBN. Also deploy PC based Hard Disk Recorders for capturing and storing of TV lectures for a temporary period that can be later played in the schools over the low cost cable network or LAN. This will allow better capacity utilisation of the SESN TV lecture broadcasts.

vii) Above all fund and support strong and regular teacher training programs, computational and scientific portals management and associated R&D programs. Also we must include agriculture, health, culture and other subjects not normally covered under the MHRD to provide the necessary interdisciplinary environment that is urgently needed to raise our standards of education.

Effective use of IT or ICT in Education in the country as a whole needs infusion of large investment on the ground at all levels. We hope that the impending launch of EduSat provides the necessary impetus to bring in the much needed thrust, new vision and innovations driven approach to make quality education to all demand a reality in a short span of a decade or less time.

8. EPILOGUE

A large integrated national effort driven by the kind of vision and approaches presented in this paper is necessary by the MHRD and other ministries of the central government to realise the true potential of our country's young and aspiring students. Instead of raking our heads over cosmetic changes in the present bureaucracy driven education systems, let us take up the challenge of providing a learning environment and a new ethos of man-making education that equips the learner to take up the challenges of real-world problems and solutions. It will have to be based not upon a narrow competition for marks in exams but upon ***sharing and caring*** principles. If we execute with the right spirit, no young person in our country has to be denied the learning he/she aspires for.

With the Virtual Campus in place, the future will see the concept of PCs evolving into personal work environment, Virtual Campuses to support the seamless Knowledge Interaction and Learning Environment and the computational/Scientific portals.

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REFERENCES

1. National Institute of Standards and Technology, “Education Criteria for Performance Excellence”, Baldridge National Quality Program, Site: **www.quality.nist.gov**
2. K.R. Srivathsan, “Management of Refereed Content Generation and Utilization for Formal Education”, Global Journal of Flexible Systems and Management, Vol. 4, Nos. 1 & 2, Jan.-June 2003.
3. K.R. Srivathsan, “Kerala Virtual Campus Initiative – A Concept Paper”, available for private circulation.