Architectural Curriculum Enhancement for Promoting Sustainable Built Environment in India

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ABSTRACT

The world today is grappling with the challenge of balancing development through responsible use of natural resources. The challenge only becomes more pronounced for developing economies like India, where improving the quality of life of the masses needs to be mindful of already starved natural resources. To this effect, the advent of clean energy economy is an imminent solution since it has the potential to respond to the challenges and deliver the projected growth in a sustainable way.

To ensure that India is well prepared to transition to a clean energy economy, it needs to review its economic growth indicators in a holistic fashion. Workforce development is perhaps one of the most critical indicators for economic growth. It not only depends on the number of employed workers but also on the skills that they apply and how these skills evolve with the changing context. Education, a strong building block of workforce development, has an important role to play vis-à-vis its application at various levels in the development of a professional and can play a key role in imparting appropriate and contemporary knowledge through continuous curriculum enhancement to cater to the changing professional requirements, offering refresher courses, professional certification programs, vocational training, and other continuous learning programs. Technical education curriculum that supports the foundation of a profession and the ability to enhance it not only provides the required change for today but also establishes a process of evolution that would be able to respond to any subsequent changes in the future. This paper evaluates the potential of curriculum enhancement in the design and construction industry targeting building design professionals. It will discuss a plan proposed by the USAID supported ECO-III project with the support of Bureau of Energy Efficiency, Ministry of Power (India) that reviews the existing structure of the architectural curriculum in India, identifies methods for enhancement and outlines activities that can help in integrating sustainable design practices with the existing educational framework in partnership with the Council of Architecture.

Introduction

Economic Growth

India, a developing economy is projected to grow at a rate of 6.1% in the year 2010 and is likely to have a GDP of USD 4 trillion and a population of 1.5 billion by 2030 (McKinsey & Company 2009). It is imperative for India to maintain its future growth in a sustainable fashion.

Managing the growth of urban cities, both existing and new, by offering clean air, water, housing and other basic amenities as India's rural population continues to migrate to cities will be a big challenge for the country.

Built environment has taken central stage in these discussions, because the rate of construction from the projected growth has reached unprecedented levels. The building sector currently consumes 35% of India's electricity production (CEA 2009). In addition, it is estimated that this sector as a whole is poised to grow at a rate of 6.6% annually up to 2030, with commercial sector currently growing at a rate of 9% per year. Recent study by McKinsey (McKinsey & Company 2009) has estimated that by 2030 the built up area is projected to increase from one billion square meters to four billion square meters for the commercial sector and from eight billion square meters to 37 billion square meters for the residential sector. The building construction industry is one of the core sectors of the Indian economy and the net spending in this sector is expected to increase to about USD 370 billion by 2013 (IHS 2009). This pace of construction presents both challenges and opportunities for improving energy efficiency in commercial buildings. On the one hand, changing standards in the indoor environment of commercial buildings means that buildings are consuming more than twice the energy per unit of floor area as before (IRG Discussion Forum 2008). At the same time, it is easier to build energy-efficiency measures into new buildings than to retrofit existing structures.

To successfully deliver this, a system needs to be put in place that addresses the complete cycle of conceptualization and implementation of sustainable building design and delivery practices by mobilizing stakeholders at various levels. This includes policy level changes to refinements in the curriculum (focus of this paper) in order to ensure that the existing and future professionals are equipped to respond to these requirements and challenges (Kumar et. al. 2010).

Energy Efficiency Policies and Market Mechanisms

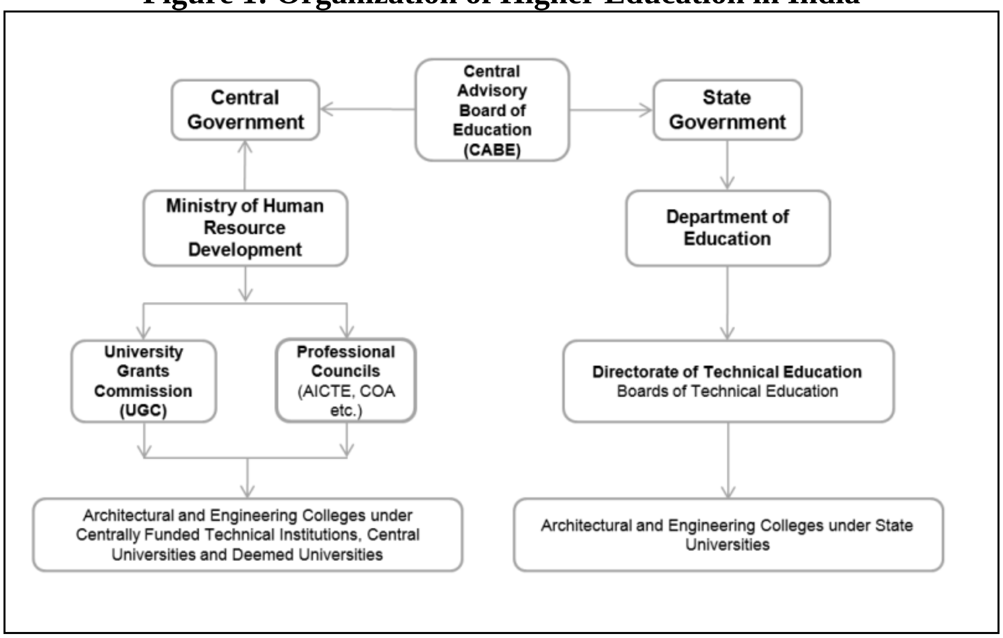
To give impetus to energy conservation in the country, Government of India enacted the Energy Conservation Act (EC Act), which came into force on 1st March 2002. Under the Act, Government established Bureau of Energy Efficiency (BEE), a statutory body under Ministry of Power. The EC Act has given the mandate to BEE to implement the provisions of the Act, and spearhead the improvement in energy efficiency of the economy through various regulatory and promotional measures (Ministry of Power 2001). This Act led to the development of the Energy Conservation Building Code (ECBC), which lists a set of requirements for various building systems that impact its energy performance. The government has also, through the Ministry of Environment and Forests (MoEF), instituted the Environmental Impact Assessment (EIA) procedures made mandatory through its notification in 2006 for listed development activities (MoEF 2007). GRIHA and LEED-India, the most widely used third party green building/development rating systems, have created awareness about green buildings and have helped in the market transformation vis-à-vis demand for green buildings. Lately, there has also been some movement towards understanding and designing net-zero energy building, which incorporates the principles of energy efficiency and renewable energy in a building.

Education

In its 11th Five Year Plan, the Government of India has placed high priority on education as one of the most important means of achieving the country's development goals and has shown its commitment by allocating a five-fold increase in funding for education over the Tenth Plan. This means an increase in the share of education from 7.7 to 20% of the total plan outlay. In order "to prepare a blueprint for reform of [our] knowledge related institutions and infrastructure which would enable India to meet the challenges of the future", the Government established the National Knowledge Commission (NKC). Over the last four years, the Commission has been submitting its recommendations, which have been incorporated in the 11th Plan for successful implementation both at the Centre and at the State levels (NKC 2009).

At the national level, the Ministry of Human Resource Development (MHRD) develops and implements policy guidelines for smooth functioning of the educational institutes (Figure 1). COA in India is responsible for the development of curriculum and ensuring quality in architectural education. All India Council for Technical Education (AICTE) and COA monitors educational institutes imparting professional education in the field of engineering and architecture respectively. State-funded and self-financed architectural educational institutes come under the purview of Directorate of Technical Education (DTE), which is a state level body (Planning Commission, MHRD 2009).

Figure 1: Organization of Higher Education in India



Source: Planning Commission 2009, MHRD

Currently, there are more than 140 architectural schools in India providing diplomas and degrees (COA 2009). The Government of India is in the process of formulating proposals to incorporate energy efficiency related modules as part of both compulsory and optional courses in architectural schools. For instance, the establishment of National Institute for Advanced Studies in Architecture (NIASA) started jointly by the COA and the Center for Development Studies & Activities (CDSA), to strategize the development of programs on specialized and technical topics in architectural schools. There is a general interest in most architecture schools to offer undergraduate and post-graduate courses in building science but they are constrained because of multiple factors (Kumar et al. 2009). Postgraduate programs in these disciplines are being offered at a few institutes, for example, CEPT University, Ahmedabad (Masters in Interior Architecture and Design – Energy and Sustainability) and TERI University, New Delhi. Some architectural colleges have also started to partner with the industry to create courses and programs that could potentially bridge the gap and provide interdisciplinary education. One such instance is the Center of Excellence by Autodesk at Sir JJ College of Architecture in Mumbai.

Professional Scenario

Workforce[1]

Workforce development is perhaps one of the most critical indicators of economic growth (Waits & Vandegrift 1998). Currently, there is an increasing concern regarding a mismatch between demand and supply of skilled labor and its preparedness in terms of the skills and knowledge level, especially in fast growing sectors (McKinsey & Company 2009). Studies have highlighted that today's workforce development implies more than employment training (in a conventional sense) and includes contextual and industry driven education and training, reformed colleges and networks of stakeholders, especially as any curriculum enhancement program will target the development of this workforce (Giloth 2000).

India's IT sector, sensing the need for a pipeline of smart and well-trained IT professionals has been working to develop educational programs such as Infosys' CampusConnect and Wipro's Mission 10x and IBM India University Relations. These companies are already working to accomplish these objectives in the computer science stream and have been reasonably successful in scaling up the initiative to a national level by working with a network of institutes and educators. The authors believe that individuals and organizations interested in enhancing architectural education can take a leaf out of the educational initiatives of the IT sector and propose Public-Private Partnership models that would start to bridge some of the gaps identified in this paper and work with existing institutions to strengthen and improve the entire ecosystem of architecture education.

The building construction industry is the second largest employer next to agriculture, employing a mix of technical specialists, skilled and unskilled personnel. 82% of this workforce encompasses unskilled workers without any formal education (as shown in Table 1). By and large, skill development for this workforce category takes place through informal channels such as family occupations, on the job training/working, etc. Training needs for the building trades sector are highly diverse and require a focused effort on their own – something that the authors have decided not to address in this paper.

[1]For the purposes of the study, the term workforce consists of all people engaged in a sector to render services in exchange for monetary compensation.

Table 1: Workforce Employed in the Construction Sector

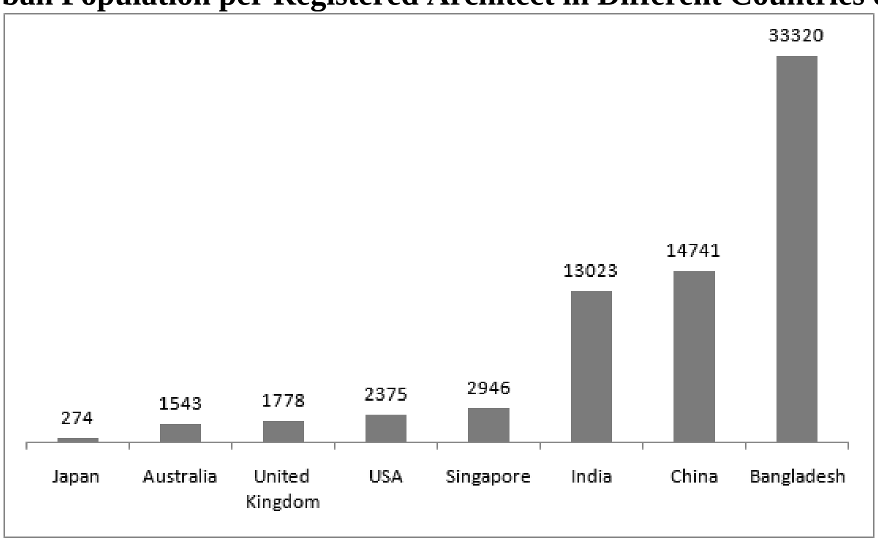
Background of Labor Force	Numbers (in 000s) in 2005	Percentage
Engineers & Architects	822	2.65
Technicians & Foreman etc.	573	1.85
Clerical	738	2.38
Skilled workers	3267	10.57
Unskilled workers	25600	82.45
Total	31000	100.00

Source: Planning Commission, Government of India

Engineers and Architects constitute 2% of the projected workforce and a review of the data provided by COA indicates that on an average, approx. 2,100 architects (approx. one third of the students enrolling for architecture degrees) have been enrolling with COA as professional practitioners each year for the last five years resulting in approx. 34,000 architects in India in 2009. When compared to other developed countries such as UK and USA, the magnitude of urban population per architect is significantly high in India (Figure 2). This highlights the need for significant efforts to be made to increase the ratio between practicing architect to student enrollment for a degree in architecture to meet the current and projected demand for more commercial and residential floor space.

A recent study has highlighted that only 13% of the potential talent supplies in low-wage nations is suitable to work for multinational companies due to the low quality of significant portions of the educational system and its limited ability to impart practical skills (McKinsey & Company 2005). Consequently, the professional development process will also need to focus on aligning the curriculum content and practical training to international standards in order to allow these professionals to avail opportunities of working in various organizations including multi-national companies, an inevitable building block for a growing and globalized economy.

Figure 2: Urban Population per Registered Architect in Different Countries of the World



Source: United Nations 2008, UIA 2005a

The Need for Integrated Design

Energy-efficient design is a critical building block for sustainable built environment and is a result/outcome of a process that involves multiple stakeholders. The process is initiated by appropriate policies; it is driven and benchmarked by market mechanisms; and expressed through a building that integrates all disciplines through sustainable and contextual solutions.

This integrated process, or "whole building" design process includes the active and continuing participation of users, code officials, building technologists, cost consultants, civil engineers, mechanical and electrical engineers, structural engineers, specifications specialists, and consultants from many specialized fields. The architect plays a pivotal role of an integrator and project manager in the integrated design process and is involved in the building delivery process from design to construction. The role takes the shape of identifying, hiring and coordinating with consultants (HVAC, MEP, structure) assuring compliance with multiple codes and standards and managing the delivery of the design intent at the construction stage. The success of the integrated design method is also dependent on the knowledge and skills of professionals from building trades such as mechanical, electrical, plumbing, sheet metal worker, glazing and insulation installers, etc.

Architectural Education

Broad Framework

The architecture curriculum is developed and monitored by national organizations in different countries such as National Council of Architectural Registration Boards (USA), Royal Institute of British Architects (UK), COA (India) etc. to train architects as per the needs of the construction industry in the country. With the increased globalization and outsourcing of architectural work, there is a need to improve the quality of architectural education to raise the overall professional standard, design the degree program that would allow graduating students the flexibility to choose more than one profession while still utilizing the knowledge and training, and provide exposure either through course work or through practical training on contemporary issues such as energy efficiency, environmental sustainability.

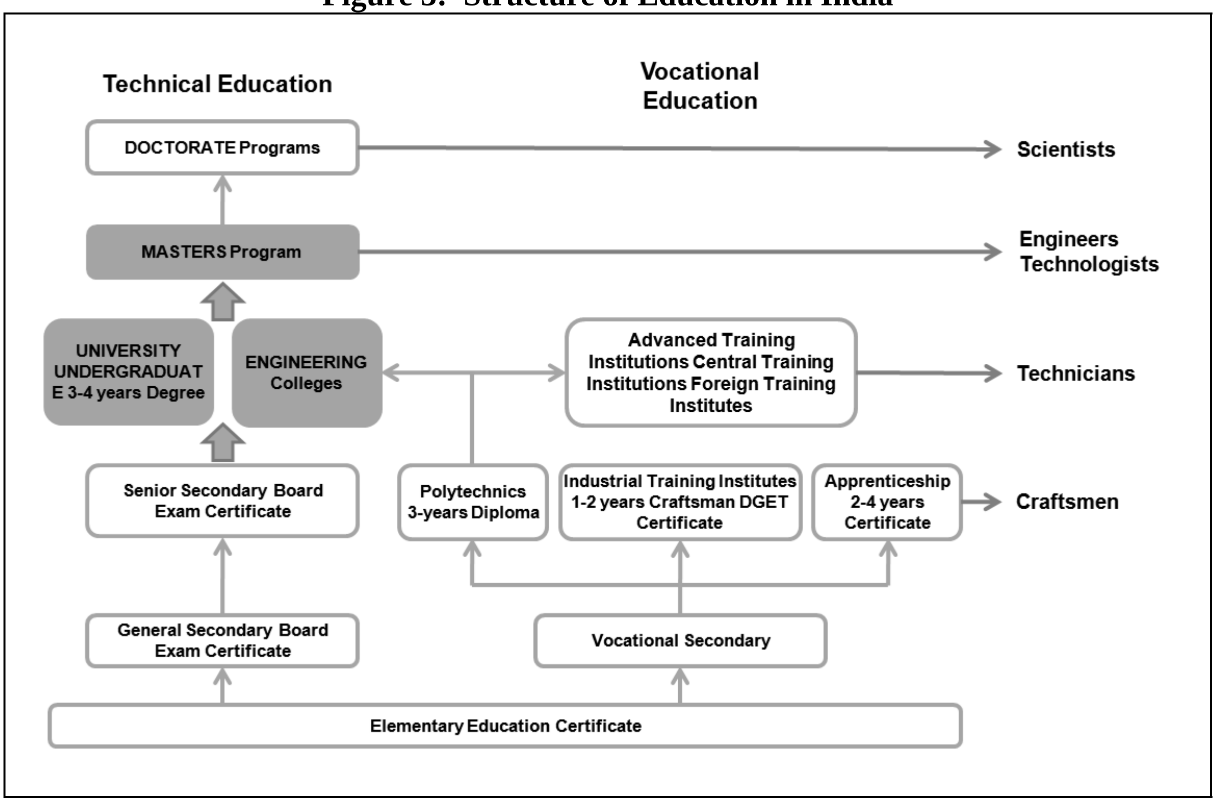
International Union of Architects (Union internationale des Architectes, or UIA), founded in 1948 is an international non-governmental organization that lays down guidelines for consideration regarding the architectural education and professional practice. UIA and UNESCO framed a charter for architectural education (UIA, 2005b) to be used in developing a curriculum for architectural studies worldwide. It states that architectural education should also involve acquisition of knowledge in the fields like sustainable design and low energy design along with the knowledge of core subjects like Architectural Design, Construction Techniques, Building Services etc. Architectural education should also teach professional skills such as project management and coordination with consultants in order to improve the building delivery process. UIA places a lot of emphasis on energy, environment and integrated design when it talks about architectural curriculum. The reason why these have not been incorporated into the architectural curriculum around the world is probably because UIA, at present, is only an advisory organization and has no direct say in the way in which curriculum is structured in different countries (Kumar et. al. 2010).

In India, COA's vision of architecture is that of a 'social art' affecting the very existence of human beings and encompassing the four important fields of Humanities, Science, Art and Technology. It views architecture as a broad and complex field with multifarious layers which result in a plethora of specializations that one sees today, each complementing and supporting the other. COA emphasizes the importance of networking and associating with experts from allied fields reiterating the significance of integrated design that authors have already mentioned in the previous section. The COA also expresses its concern towards "national priorities in the fields of energy conservation, ecology, environmental pollution, protection and preservation of architectural heritage, low-cost housing, urban renewals, rural upliftment, economic development at local and district levels, etc." and the fact that the profession of architecture should be capable of responding to such needs (COA 2002).

Curriculum Structure

In India, skill acquisition for the workforce takes place through two basic structural streams—a small formal one and a much bigger informal one. The formal structure as highlighted in Fig 3 includes: (i) higher technical education imparted through professional colleges, (ii) vocational education in schools at the post-secondary stage, (iii) technical training in specialized institutions, and (iv) apprenticeship training.

Figure 3: Structure of Education in India



Source: World Bank 2008

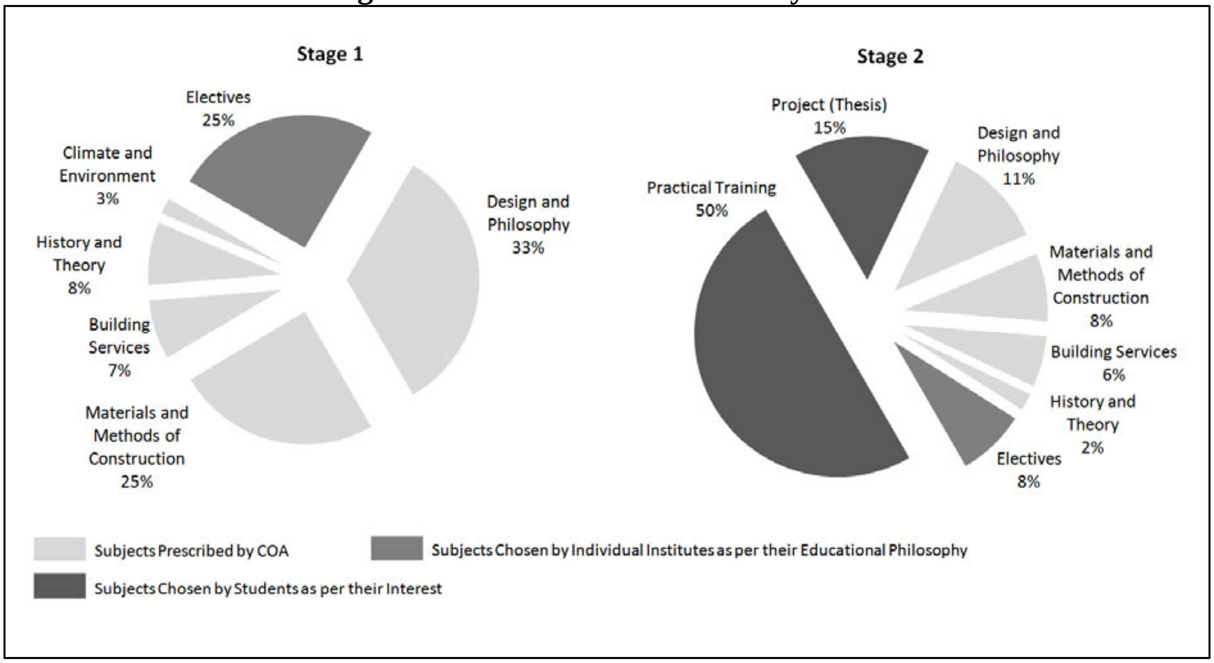
The architectural education falls under the category of Technical Education. The eligibility for enrolling in an architecture undergraduate program in India is a minimum of 50%

aggregate marks in the Higher Secondary Certificate (HSC or 12th Standard) examination with mathematics as a subject of examination (COA 2008). Majority of the architectural institutions in the country admit students on the basis of the marks obtained in National Aptitude Test in Architecture (NATA) administered and approved by COA.

For the architecture course, COA states that it shall be of minimum duration of 5 academic years/10 semesters of approximately 18 working weeks each, inclusive of one year of practical training in a professional's office. This five years degree course may be conducted in two stages of three and two years. During the first stage, the focus of the education is to develop and enhance the creativity and knowledge of the students and to induce the fundamental skills necessary for an architect. A unique aspect of architectural education is the emphasis on *Design Studios* where students learn and hone their architectural design skills and are required to incorporate the knowledge gained from theory courses in to the design solutions that they come up with in the studio. Typically, at the end of the Design Studio, each student or team (if the design is a group problem) is required to explain the key concepts and the philosophy behind the design and also defend the design decisions based on the questions posed by design jury team members. This process is fundamental to the development of the students as it prepares them well for the challenges they are likely to encounter during professional practice. In the second stage of the architectural education, students study the more technical courses of the architectural curriculum and in the eighth semester, they are required to undertake a design or research thesis where they spend a semester working on the design/research topic and come up with a comprehensive solution. The final or the fifth year is that of practical training where the student goes to work at an architectural firm either in country or abroad, thus gaining valuable professional experience (Kumar et. al. 2010).

During the Stage one, COA has given a freedom to the institutions to choose 25% of their subjects as shown in Figure 4. Also subjects such as Climatology, Building Services and Equipments, Architectural History, Building Byelaws and Codes, as prescribed by COA provide opportunity to incorporate content related to passive solar and sustainable design, importance of traditional architecture, introduction to first principles while designing energy and water-efficient buildings, energy efficiency of building systems, introduction to Energy Conservation Building Code (ECBC) and National Building Code (NBC). Similarly in the stage two of the curriculum COA suggests electives such as Sustainable Architecture, Energy Conscious Architecture and Environmental Studies that can cover the concepts of Building Physics, Building Diagnostics, and use of more sophisticated lighting and energy simulation tools. Further during the stage two, institutes can encourage students to choose their thesis topic and practical training in the fields related to sustainable architecture or energy conscious design. Content related to use of computational tools as design aids can be covered in Computer Applications (non graphical applications) as proposed by COA.

Figure 4: Courses as Prescribed by COA



Source: COA 2008

It is evident that the COA has given a lot of freedom to the institutions to tailor the curriculum based on the vision, educational philosophy, research and teaching interests of the faculty members and the current trends in the building industry. While this paper puts emphasis on the incorporation of environmental and sustainable design related courses into the curriculum, the same approach can also be applicable to other fields of architectural education such as professional and practice management as laid out by UIA and discussed briefly in section 3.1.

Curriculum Survey

The paper has so far discussed how rising economic growth is resulting in a transformation of the built environment that is also placing new demands on the architects and other professionals involved in the design and construction industry. Sustainable development, being a very broad topic, the authors have deliberately focused on how refining the architectural education can make significant impact in introducing sustainability concepts at all levels of design and construction. The first step in the curriculum enhancement program, as an outcome of the above discussions, was, therefore, to evaluate the existing architectural curriculum to gain some insights into how an effort can be initiated, incorporated and sustained to include sustainability as an integral part of the architectural education.

In order to appraise the current architecture curriculum, the ECO-III team designed a survey that was sent to 136 architectural institutions in India in 2007 and responses were received from 28 institutes (Kumar et. al. 2009). This helped the ECO-III project to identify 18 partner institutes and launch the educational curriculum enhancement program in 2007.

Since then, awareness about sustainable practices, green technologies, energy efficiency has increased as a result of ECBC being launched by the BEE, building rating systems such as LEED India and GRIHA, and an enhanced understanding of the environmental impact of building design etc. The ECO-III project has also received queries from a large number of architectural colleges who have expressed a keen interest in joining this initiative. Consequently, there was a need to administer another round of survey and questions in the new survey were more technical than the earlier one and were based on the lessons learned from the first survey. The revised questionnaires were sent in March, 2010 to 72 architectural institutes based on the interest shown in ECO-III educational initiatives, response to the earlier survey, and the objective of identifying institutes from other geographical region who can be included in any expansion of the partner institutes in future. The intent is to collect more detailed information on architectural curriculum, professional qualifications and interests of faculty members, and institute's interest in the field of building science and sustainable design. The response to the second round of survey is awaited. A summary of the objectives and key findings of the first survey is enclosed below:

Educational background of the teaching faculty. Survey questions specific to the architectural faculty's educational background revealed that most of the faculty members had a post-graduate education. Approx. 91% of the faculty teaching building services had post-graduate degrees. However, there is a shortage of faculty with a doctoral degree. Only 26% of faculty teaching environmental sciences and 35% of the faculty teaching building services had a Ph.D.

Domain knowledge and need for skills enhancement. A set of questions was designed to understand the domain expertise possessed by faculty members when it came to teaching environmental design courses and the exposure to the latest diagnostic and computational tools. The perceived degree of difficulty in recruiting faculty for the environmental sciences and building services courses was cited as one of the major reasons for institutions' inability to lay more emphasis on environmental design courses.

Curriculum analysis and the emphasis on environmental design. As shown in Table 2 below, the survey showed that Architectural Design was the most important topic followed by Materials and Construction Techniques and Environmental Design.

Table 2: Relative Importance of Different Topics in the Curriculum

Topic	Importance	Rank by Mean
Design and Philosophy	4.55	1
Materials and Methods of Construction	3.93	2
Climate and Environment	3.83	3
Building Services	3.69	4
History and Theory	3.48	5

Source: USAID ECO-III Project. 20010d

Considering that integration of environmental design and building services courses in the architectural design studios is critical to the development of an integrated design philosophy, the survey probed this issue but the results, not surprisingly, were not very encouraging. Institutes offering courses in environmental design field have not integrated it well with the design studios. The courses are taught as standalone electives and almost no or very little effort is made to incorporate the knowledge and principles into the overall conception of building structure and design.

Course content. While COA offers considerable flexibility to all the colleges and provides high-level guidance on structuring various subjects where concepts related to building science and sustainable design can be addressed, few institutes are able to teach the concepts from the first principles. Fundamentals of building physics and diagnostics that can not only help architects in designing low-energy and green buildings but also allow them to pursue other careers in energy and policy analysis that can directly affect the built environment at the macro level are rarely discussed in the curriculum. Therefore there is a need to upgrade the existing courses with relevant content to address this significant gap in the present architectural curriculum. As a result of this gap, computational tools to evaluate energy performance of buildings can be difficult for students to fully comprehend and master during undergraduate course. Environmental courses are not usually offered to the students at the bachelor level though there are more specialized options when it comes to the post-graduate level.

Course delivery. Subjects with high technical content need elaboration with examples as well as explanation of basic rules of thumb that are widely used in the profession with the help of the first principles governing them. Very little effort is made to incorporate the practical aspects of design into the teaching methodology. This results in limited assimilation of environmental science and energy efficiency concepts with the overall building design sensibility. It is necessary to note that COA's curriculum model offers enough flexibility to include or exclude any course or change course credit structure. Proactive institutes have taken advantage of this flexibility in order to enhance their environmental science course structure.

Research. The low percentage of faculty members with advanced degrees is probably a factor in relatively fewer number of research publications (theses, papers and dissertations) on the subject of energy efficiency, building science, and energy management. In the last five years, out of the 12 institutions reporting on this aspect, only 26 postgraduate theses and 10 doctoral dissertations on the theme of energy efficiency or energy management have been submitted. The survey found that in most institute's libraries, the emphasis is on books, journals, and magazines covering architectural design and practically no access to students and faculty members to international journals and publications covering topics such as energy efficiency, life-cycle cost analysis, role of building and appliance codes in designing sustainable buildings, etc.

Quality of infrastructure (laboratory, computational, and diagnostic facilities). Most academic institutions do have laboratories to house tools and equipment to understand and explore the concepts taught in the studio-classroom environment. However, there are significant opportunities to equip the laboratories with diagnostic and performance evaluation equipment and simulation software tools.

Awareness about building code and energy policy. The awareness of Energy Conservation Building Code was found to be high along with the enthusiasm towards involving students and faculty in learning more about ECBC. About 93% of the responding schools were aware of ECBC and 100% were interested in training their faculty and incorporating ECBC as part of the new course. This indicates that there is widespread interest with the architectural community in learning about ECBC.

Based on the findings of the survey, the following observations can be made:

1. There is a clear need for conducting periodic surveys on the status of architectural education and profession in the country. There is very little statistical or even qualitative information available on specialized programs, placement details of graduating students and the little that exists is either out-dated or sometimes inconsistent with other published data. It is almost impossible to take stock of the current status of architectural colleges, their curriculum structure, and practicing/teaching professionals with such insufficient data. All efforts of re-structuring or re-visiting education curriculum will be thwarted unless a more robust and detailed survey is carried out and its results are in public domain for easy access. USAID ECO-III project made an attempt to conduct a national survey of architectural curriculum focusing on the Building Science component of the structure but it will be much more effective if an organization such as COA/NIASA can take the responsibility to conduct periodic surveys by expanding its current activity to include more questions on placement and professional preferences as well as emerging trends and requirement of the industry which can then be used to refine the curriculum.
2. In order to propagate knowledge and learning, it is important to create networks, establishing platforms that can encourage sharing of ideas and information. It saves one from reinventing the wheel – one person's findings can become another's knowledge and, consequently, basis of new findings. ECO-III project undertook an exercise to identify open courseware and teaching materials that are being offered by institutes such as Massachusetts Institute of Technology, University of California Berkeley, University of Strathclyde, and others in the field of building science and sustainable design (USAID ECO-III Project, 2010c). Educational institutes, students and professionals, all need to come together at various levels and start interacting to form a dynamic group with a constant exchange of information. One such network for building science educators is the Society of Building Science Educators, which is an association of university educators and practitioners in architecture and related disciplines who support excellence in the teaching of environmental science and building technologies.
3. It has been observed that India, even now, does not offer many post-graduate courses that are internationally recognized and as a result does not see the inflow of students with the best and the sharpest minds – a bedrock of educational policy in many countries where there is a conscious and deliberate attempt to attract the brightest students from all around the world. In the field of sustainable architecture, someone seriously interested in pursuing advanced studies even today needs to identify a master's or doctoral program at international institute to get the maximum mileage out of her efforts. The time has come to start taking clues from reputed institutes across the world, offer or restructure post-graduate programs and make a concerted effort to increase knowledge transfer through student and faculty exchange programs.
4. There is a serious dearth of rigorous research work in the field of architecture in the country. It is important, therefore, that research grants be made available through organizations like MHRD, Urban Development Department (UDD), Bureau of Energy Efficiency (BEE), etc., to encourage faculty members to go for journal publications and patents. Such grants can provide architectural research the impetus that it needs to be undertaken and recognized on an international platform. It will also offer a new avenue for many architects to seek new opportunities where their formal education and training can be used in an effective manner and help with nation building.

Conclusions and Recommendations

"One of the glaring ironies of modern education is that schools try to prepare students to live in a time that does not exist by concentrating their studies on a time that has ceased to exist. Even in very cursory ways … the future is rarely considered in the standard curriculum. Even 'contemporary' courses deal almost exclusively with current events – which is to say events in the very recent past. The tacit assumption seems to be that tomorrow will be like yesterday or, at the very least, like today (LaConte 1975)."

An architect is going to be responsible for earth's resources and for the health and well-being of the masses as she tries to address, through her design, the collective concerns of land and water use, energy conservation, energy efficiency, adaptive reuse, along with building function, aesthetics, security and comfort. In order to equip design professionals for such a role-play, it is important to educate her in management, as much of the project as of the resources at her disposal in terms of her knowledge and skills, and more importantly, to continuously be able to update the same in order to get the most out of a team. The architect is required to know about codes, standards and ratings, concepts of green and sustainable buildings, and, furthermore, be able to address these within a given socio-cultural and economic context with assistance from a multi-disciplinary team. It can be a daunting but also a very rewarding profession if responsibilities are carried out with sincerity and diligence.

Based on the background research and analysis conducted by the authors, findings from the curriculum survey, and the professional demands being placed on the architectural community, the following recommendations are made:

- **Technical course content development/enhancement**. Content development for courses that can teach the sustainable concepts from the first principles (e.g. Building Physics, Building Diagnostics, etc.);

- **Skills enhancement/continuous learning for faculty members**. Conduct workshops for faculty members (Train the Trainers) to make them aware about the possibilities of specializing as a sustainable designer, energy efficiency policy expert, building science researcher, etc.;

- **Integration of theory/elective courses with design studios.** Structuring of a Design Studio that would encourage the students to use the concepts learned in Climatology, Building Physics, etc. and assist them in incorporating the sustainability principles in the design problem;

- **Infrastructure improvement (laboratories and library).** Help create the infrastructure that would allow the students to go out in the field and understand the concept of building performance by taking thermal, lighting, and acoustical measurements and performing analysis and equip the computer laboratories of architecture department with reliable and robust energy, lighting simulation tools and design aids that can assist students in designing and analyzing more complex buildings. Over the years and across the globe, it has been observed that computer simulation tools can help in educating students about the environmental parameters and behavior of a building (Hensen et. al. 2004). These tools are useful in providing hands on training to the students in absence of the required physical laboratory infrastructure. These simulation tools also offer an opportunity to carry out research projects and apply their findings in design. Similarly, libraries in the architecture colleges need to have access to journals and publications covering the topics of building science, energy efficiency policy, etc.

- **Encourage faculty members to conduct research and publish**. As highlighted by the National Knowledge Commission, there is a need to conduct quality research in all educational institutions. To fill this gap, research and analysis should be encouraged to satisfy the curiosity of students and faculty members to learn about green buildings, latest building materials and technologies, energy-efficient systems, etc., funds must be made available by the government, and faculty's performance should be linked to the quality of his/her research.

- **Emphasize project and practice management**. In today's world, architects need to play multiple roles and need to lead a design team consisting of many professionals. Project management is an indispensable and basic skill that must be taught by professionals who are knowledgeable and have practical experience.

Activities under the ECO-III Project

Activities undertaken as part of the ECO-III Project's Educational Curriculum Enhancement Program have been striving to fulfill some of the aforementioned recommendations:

- Selection of the energy simulation software has been made based on the technical rigor of the underlying engine (LBNL and Gard Analytics 2004) along with the availability of a good user interface that would allow for wider uptake and experimentation by the students. The project has procured 180 educational licenses of building energy simulation tool (specifically Design Builder/Energy Plus), and distributed partner institutes who share the vision of using reliable and technically robust computational tools as design aids while designing buildings.
- Selection of reference materials (Five Volume E-Source Technology Atlas and Windows System for High Performance Buildings) has been made on the appropriateness of technical materials suitable for the architectural students to cover technical aspects related to building design in a way that attracts architecture students to the field. The project, in partnership with BEE, distributed the energy simulation software tool licenses and reference materials to 18 partner architectural and engineering colleges in India. This program is being expanded to include 40 architecture and engineering colleges in the next phase.
- The project has been conducting various follow-up workshops aimed at awareness and training on basics of building physics, simulation and energy efficiency in buildings. In order to address the problem of dearth of faculty members who are proficient in teaching sustainability related courses, the project has conducted train-the-trainer workshops wherein teachers involved or interested in teaching such courses have been provided with reference materials and guides in the form of tutorials as aids for self-learning and teaching (USAID ECO-III Project 2010b). So far, the project has trained 750 students and faculty members under its educational initiative. The project also organized a

workshop in February 2010 that had a focused session on the state of architecture/engineering curriculum and the potential for developing/enhancing skill set for energy efficiency (USAID ECO-III Project 2010a). The outcome of the session was a series of recommendations such as the development of supporting teaching material within the existing curriculum framework as a starting point of the curriculum enhancement program.

- There is also an ongoing initiative in partnership with Vienna Institute of Technology to develop web-based classroom teaching materials to cover the fundamentals of Building Physics (Thermal and Lighting Design) for undergraduate students of Architecture with the vision that it will be available to all architecture colleges in India.

While a few activities have been initiated in the last three years and a few more will be executed in future, it is imperative that given the relevance of the effort and the long-term impact that it can have on the built environment in India, a much bigger national effort that brings together MHRD, COA, Ministry of Urban Development, and the Bureau of Energy Efficiency is needed to take this forward. Wherever desirable, international assistance should be sought in this long-term capacity building effort because there are many in the educational fraternity who would be willing to contribute to this challenging and exciting effort.

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