

# Innovations and Curriculum Development for Engineering Education & Research in India

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## Abstract

The dynamic nature of the curriculum process informed the thesis of this paper, which is innovations, curriculum development for Engineering Education & Research in India. Analysis of the Indian education sector reveals the challenges of incoherence in policy formulation and implementation. The selection and organization of curriculum content, curriculum implementation and evaluation, the development, distribution and use of teaching materials, and the relevance of the curriculum to the needs of society are also problems associated with the Indian Engineering Education & Research system. The paper reviews aspects of curriculum process such as policy, analysis, objectives, content, evaluation methodology and implementation. Therefore, the need for transformation in curriculum for all the Engineering educational and higher education levels becomes necessary. The paper submits recommendation on further enhanced strategies that will help in the development of education in line with modern trends in curriculum issues.

*Keywords: Engineering Education, Research, innovation, Curriculum, challenges of implementation*

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## 1. Introduction

Engineering is a global industry undergoing a period of unprecedented change. The future of engineering is being framed by global forces which transcend national boundaries such as the impacts of globalization, rapid technology advances, climate change and inequality. Through the application of science and engineering, humanity has the potential to meet all of its basic needs: water, sanitation, food security, shelter, energy, transport. Technological and scientific advances especially at the interface of advanced computing, biology and physics are leading exponential growth of innovation and opening a world of new possibilities and markets. It follows that engineering higher education needs to constantly strive to keep pace with these advances and in particular the contribution of engineering to these global opportunities and challenges. Higher education needs to prepare engineers of the future with the skills and knowhow which they will need to manage rapid change, uncertainty and complexity. Key here is the ability to tailor engineering solutions to the local social, economic, political, cultural and environmental context and to understand the impact of local action on the wider world. Although there is a global dimension within all subject areas, engineering and technology has unique importance in addressing global challenges, delivering environmental sustainability, international poverty reduction and economic growth. India also has the potential to be a global technology leader. Indian industry is competing globally in software and even in areas such, an automobiles, chemicals and engineering equipment. A critical issue for the future success of Indian industry is the growth of engineering education in India.

## 2. Higher Education Institutions

All HEI (Higher Education Institutions) engaged in engineering education need to undertake a review of existing courses to consider the extent to which the global dimension is adequately reflected. Higher Education Academy through its engineering subject centre to promote professional development around the concept of the

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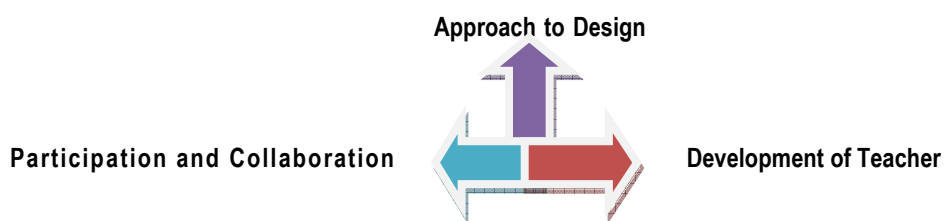
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‘global engineer’ incorporating links with existing initiatives on sustainable development and internationalization. Engineering education research represents a unique component of education & research. Research in engineering education emphasizes not only on research and discovery, but also, reform and implementation. Globally, engineering education research is on the agenda for the improvement of higher engineering education and the development of strategies for solving important issues for the future of engineering education, such as recruitment, the need for new competences and the ability to deal with new types of interdisciplinary and complex knowledge. Engineering education research should be characterized by a unique interdisciplinary approach where engineering education researchers do have various backgrounds in engineering, science, social science and educational psychology investigating higher engineering education. Research in engineering education is highly interdisciplinary and lies at the intersection of engineering, education and the learning sciences. Engineering education research must draw upon innovations and advances in the fields of education and learning sciences to strengthen the research.

Contemporary research in engineering education focuses not only on learning processes and individual versus team learning, but also on educational techniques for use in the classroom setting. Forward-thinking higher education institutions (HEIs) are adapting courses to equip graduates with the skills, knowledge and attitudes that are necessary to maximize the positive and far-reaching impact of engineering on society. Importantly, there is often a lack of knowledge of global issues amongst teaching staff and resistance to what is seen by some as a ‘dilution’ of core engineering content. The research function of academia remains a prime source of knowledge and innovation at national, regional and international levels. Educational system goes through various developments and changes viz-a-viz curriculum issues. Thus selection and organization of curriculum content, curriculum implementation and evaluation, the development, distribution and use of teaching materials, and the relevance of the curriculum is what is needed today. Teachers are the most influential factor in the Education change. The research program of CD&EI focuses on curriculum innovation by analyzing the process of designing curricula by communities of teachers, by identifying structures of participation of teachers and other practitioners in these communities, and by empowering teachers in their professional development. A curriculum considers the learners and their interaction with each other, the teacher and the materials. Curriculum overall can be viewed as a composite whole, including the learner, the teacher, teaching and learning methodologies, anticipated and unanticipated experiences, outputs and outcomes possible within a learning institution. The basic premise is that teachers’ professional development is most effective through their active involvement in curriculum design communities.

Here teachers are not passively receiving evidence from research and are asked to simply carry out teaching tasks, but they actively apply both research and practical evidence in co-designing curricular products and learning scenarios for their own classrooms. The three components of curriculum innovation can be represented by a triangle of which the design approach, teacher development, and participation and collaboration in communities are the three angles.



In research, collaboration while designing the curriculum, design communities is approached from two perspectives. The first one is the individual teacher’s perspective and the main question is whether collaboration among teachers as design community members, leads to more effective teacher development. Teacher’s professional development can be characterized as the gain in pedagogical content knowledge. Four topics are highly relevant in this respect: (1) the process of designing curricular products by teachers; (2) effects of

participation in communities and of collaboration among teachers; (3) curricular products as the main outcomes of the design process; and (4) providing computer-based support by external knowledge support and by knowledge produced and communicated by teachers and learners in the design process. The second perspective is the community's perspective and the main question is whether results from curriculum and learning research are best to be implemented through a design project in which teachers take part. Actually research says that the assumption that collaboratively designing by teachers will lead to closing the gap between theory and practice.

The integration of education, research and innovation working together as key drivers of the knowledge economy in delivering sustainable growth. The central research theme is participation and designing by teachers in curriculum design communities and the effectiveness of these factors on teachers' professional development and curriculum innovation in science education. Research shows that curriculum implementation will be positively affected by involving teachers, to varying degrees, in shaping curricular products and learning scenarios in their own classrooms. Further the focus is on empirical and theoretical contributions to foster teachers' professional development and to improve the relation of theory and practice in education, and focus on the practical implementation of these insights in empowering teachers by creating effective design environments in which they can collaboratively design curricular products and learning scenarios for their own classrooms. These are few factors that influence curriculum design viz: 1) political factors, 2) social factors, 3) economic factors, 4) technological factors, 5) environmental Factors, 6) student psychology. Care has to be taken that any curriculum needs to be developed in the light of the organisation or context in which it is going to be delivered. A strategic issue which needs to be considered is whether the course design, delivery and management is centralised or decentralised. This is often out of the hands of individuals involved in course development but has impact on all aspects of curriculum development. Centralisation can be seen at both national and organisational levels. Centralised curricula tend to be more structured and orderly and it is easier to ensure uniformity and a standard approach to teaching and learning. Also as curriculum planners, we need to facilitate this process for our students and ensure that students are ready to move onto the next stage of learning. It is always wise to utilise a student centred approach. This approach emphasises adult learning methods and approaches and uses active learning (in which students participate actively in the learning process) rather than a more didactic, teacher-led approach which traditionally saw students as passive recipients of knowledge, as 'empty vessels'. With developments in new technology, and information technology in particular, there are many more opportunities for course developers to introduce innovative teaching and learning methods. This can enable learning to be more flexible, learners can study in their own time via the Internet or an Intranet, lectures may be given over the Internet or via videoconferencing reducing the need for students or trainees (and teachers) to travel. As we have seen in the earlier sections, there is no real clear dividing line between curriculum development and implementation. Once the curriculum has been developed and tested, and revised as necessary, the curriculum is ready for implementation. It is important that those involved with implementing the course (usually teachers and examiners) as well as students, interpret the curriculum correctly, because the written word is not always interpreted in the same way by different people.

Universities are exploring ways to revise the engineering curriculum in order to meet the changing needs of industry and society. Any restructuring of an engineering curriculum must take into account the correlation between society, engineering competencies and the changing paradigm of engineering education. The 'employability' of graduates depends on a combination of high technical knowledge, practical experience and soft skills. Decreasing student enrolment figures in engineering in many countries call for appropriate measures to be implemented including the development of attractive programmes of study and challenging learning environments. In construction of engineering curriculum three aspects have been neglected: 1) students background in the light of formal and informal experience and interests, 2) student/student interactions, 3) teacher/student interaction. Innovation of the curriculum with regards to gender mainstreaming means broadly oriented integrated and content rich teaching material, diversity in teaching and learning methods. As an academic discipline, engineering is continuously undergoing a process of rapid expansion and diversification that is now significantly characterized by

interdisciplinary approaches. There is a rise of interest in increasing interdisciplinary studies. As a profession, engineering has to deal with scientific and technological matters, but increasingly economic, political, ethical, societal and environmental aspects are taken into account as well. Society places many demands on an engineer; to be technicians with a human side, be adept in interdisciplinary skills that include both technical and non-technical competencies that enable them to critically analyze, solve problems, communicate effectively, and be able to learn continuously as the workplace changes.

Introducing social science and other disciplines into engineering could, ideally, help bridge the rift that exists between producers and consumers of technology. Social sciences, humanities, cultural and management studies are also as important as the traditional applied sciences for the portfolio of engineering competencies because students need to understand the financial, business, environmental, economic and social constraints in which engineers operate. It is seen that problem-based and project based education, which increases the appeal of technical education and have a positive effect on the intake, retention and output of students. Surveys and reports undertaken to document and evaluate active teaching and learning methods indicate that project and problem based learning can satisfy the demands for required knowledge, skills and attitudes of engineering graduates. But active and experiential learning is not limited only to project orientation and problem based learning. It should also use ICT environments, various extra curriculum activities and more traditional forms like labs, exercises and design activities. Broadening and the repositioning of the curriculum is the challenge facing technical education for the next few years. Curriculum Research findings show the things to be followed viz.

### *2.1 Interdisciplinary approach to E&T courses*

The interdisciplinary, multidisciplinary, or holistic approaches in engineering courses are a positive step and curricular transformations and research is moving towards innovations. Engineering education is adopting multi-disciplinary approaches and more innovative teaching and learning methods are applied, but these are mostly developed without gender-mainstreaming in mind.

### *2.2 Teaching techniques and demanded skill system*

Alongside the developments in course content teaching environment and assessment innovations are in use. A focus on skills may be interpreted as representing a broadening of the remit of university education and at the same time a broadening of the term skill to include aspects of knowledge and theory.

### *2.3 Projects leading to curricula innovations*

Projects are an approach to non-traditional educational schemes for engineering students and teachers. As study programmes are mostly bound with output standards that make adding optional, interdisciplinary modules to existing programmes difficult, the gender-inclusive teaching and learning methods are successfully implemented through project work so hence and so forth. Now the aspects of curriculum process such as policy, analysis, objectives, content, evaluation methodology and implementation.

The paper submits recommendation on further enhanced strategies that will help in the development of education in line with modern trends in curriculum issues. Curriculum issues, either in an explicit or an implicit manner, are inextricably linked to current thinking and action on educational concerns and reforms around the world. Experiences of educational reform almost all over the world have shown that curriculum is at the same time a policy and a technical issue, a process and a product, involving a wide range of institutions and actors. Innovations reported under this category are in the area of curriculum and programme development; new approaches to teaching and learning, often combined with the introduction of new educational technologies; and quality assurance. Innovations therefore overlap with the relevance category. Innovations in curriculum have also increasingly taken the form of introducing new programmes as indicated above. The process of constructing the curriculum is unique to each national setting.

It is a complex outcome of the opinions and solutions that key stakeholders propose for society's requirements and needs. There are no 'successful' international models to copy. Many innovations with the curriculum include an emphasis on a particular field and the use of the core knowledge curriculum where basic

factual information is presented before any abstract concepts, leading to a focus on the mastery of basics. Curriculum renovation that is realistic and child-centred, that is quick in rejuvenating and revitalizing hope and passion for acquisition of broad-based knowledge that is worthwhile in a learner should be the focus of the structure. Methodology that will aid self discovery and problem-solving ability which allows learners the opportunity for creativity should be entrenched in the curriculum. The need for a paradigm shift from theoretical and paper certification to a practical application of knowledge necessary for future employment and skills development for self employment should be the cardinal objectives.

### 3. Conclusion:

Thus we can conclude that, an evaluative review of contrasting initiatives is desirable to provide environmental and sustainability in engineering education in different institutions, for Indian higher education. Academic programmes, policy statements and education projects should be analyzed, to highlight important developments, challenges and the prospects for future progress. Also an evaluative perspective on the diverse and innovative responses to sustainability emerging in Indian engineering & higher education, in curriculum development is obligatory and to address issues of practice on campus and in local communities only.

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