

The Future of Engineering Education: How should engineering schools in Europe respond to the re-entry of China and India into the world of technology?

H.P. Sjursen

New York University, Polytechnic Institute
New York, United States of America

Opening Address

ABSTRACT: The ubiquitous influence of the global economy, mass migrations of labour, the growing internationalisation of universities and the many challenges posed by emerging technologies all contribute to the uncertainties that beset contemporary engineering education. In particular the spectacular rise, in the late 20th and early 21st centuries, of China and India has profound implications for engineering education. This discussion, after a summary of recent, salient developments in engineering education in China and India, will consider such thorny issues as curriculum standardisation, the role of English as the language of instruction, the trend of declining student competency in mathematics, and consideration of intellectual property and patents, all with respect to the differing approaches being pursued currently in Europe and Asia. The ultimate question of incipient Asian technological hegemony is reframed to consider the possibility of a new convergence. In conclusion, an approach to engineering education, which through modes of collaboration and shared expertise respects cultural traditions and encourages regional and national specialisations, is proposed.

INTRODUCTION

In this discussion, the very idea of engineering education will be reconsidered in light of several significant developments, external to engineering education *per se*, but nonetheless of extreme importance to that endeavour. These developments are in themselves independent of each other but their convergence in our time amplifies the influence each has on the education of both engineers and non-engineers alike. *Development* of course is not a neutral term suggesting as it does progress and improvement. Whether one should be optimistic about the future of engineering education is here an open question. The developments of import are three: 1) the astonishing and counter-intuitive implications of contemporary science; 2) the ubiquity and viral character of modern technology; 3) the enforced interdependence of disparate cultures posed by economic globalisation. Consider each briefly in turn.

Contemporary science since the discoveries of relativity and quantum theory has challenged the practice of engineering, which was firmly and successfully rooted in Newtonian physics. Scientific revolutions by their very nature undermine accepted belief and practice, and redefine common sense. This was dramatically true of the Copernican revolution which displaced the earth from the centre of the world to an undistinguished address in an infinite universe. One could no longer believe that ordinary observation corresponded to the true structure of reality. But Newtonian physics at least asserts the uniformity of nature and measurement within the paradigm of Euclidian geometry, theoretical postulates that bridge the concepts of science with the practical arts. To a great extent, engineering became the scientifically precise extension of traditional crafts. However, contemporary physics in forms such as string theory, quantum mechanics, nano-science, fractal geometry and chaos theory posits a wide gulf between theoretical science and intuitive, practical engineering. Such science demands additions to the engineer's toolbox and requires an expanded or at least different mathematics skill set. Recent advances in the biological sciences ally it more closely than ever with the physical sciences and create new agenda for engineers. Much of this scientific theory has led to powerful new and emerging technologies that beggar the traditional precautionary methods of engineering.

Contemporary science, therefore, has altered radically the tasks assigned to engineers. The differences to engineers are not limited to the requirement to comprehend an ambiguous, complex and non-intuitive scientific construction of reality but also to grasp the implications of technologically enhanced actions with a multitude of unanticipated and possibly destructive, long-term and irreversible consequences. The burden thus imposed upon the engineer's course of study is hard to overstate. In a sense, engineering has become the fulcrum to transfer science to society. One might suppose that this would pertain only to certain branches of engineering but in fact the discoveries of contemporary science now influence every aspect of life. Engineers perforce have become our age's *renaissance men* when the requisite breadth of knowledge clearly unattainable.

Technology as understood today is a term, perhaps, too broad to be useful. What isn't technology? It is no longer limited to devices, tools, machines and other hardware. Software engineering and the attendant idea of cyberspace or cyber-reality is only one indication of the expansion of the domain of technology. Ours is surely an age of technology. In *The Postmodern Condition* Jean-Francois Lyotard comments: *Scientific knowledge is a kind of discourse. And it is fair to say that for the last forty years the* leading *sciences and technologies have had to do with language: phonology and theories of linguistics, problems of communication and cybernetics, modern theories of algebra and informatics, computers and their languages, problems of translation and the search for areas of compatibility among computer languages, problems of information storage and data banks, telematics and the perfection of intelligent terminals, to paradoxology* [1]. Technology, in other words, not only influences the means of production but is the means of discourse and communication. Every human interaction is mediated by technology which, as Lyotard suggests, informs our imagination and nourishes our desire. It is this fact that has led to the ubiquity and viral character of technology: it spreads in an invasive manner, oblivious to boundaries both natural and political, and establishes itself in regions unprepared for its sudden arrival. The introduction of a device such as a mobile phone or laptop computer brings with it a virtual universe of life-changing possibilities which, in turn, create expectations, desires and practices which are often unguided and unregulated. The life-world is inalterably modified in ways that can just as easily weaken as strengthen the recipient community. These facts are relevant to engineering education in two ways. The first is that engineers of whatever specialty are now also social engineers. And, secondly, regarding any device the assessment of responsibility has to extend beyond the anticipated end-users.

The advances of contemporary science together with the seductive power of new technology combine to impose extraordinary requirements for engineering education. Engineers must both be conversant with the complexities and nuances of contemporary natural science *and* capable practitioners of the human and social sciences as well. Indeed, more than renaissance men engineers need to be today's philosopher kings.

This dilemma for engineering education is magnified by the globalisation of the service economy and financial markets. (One emphasises services more than trade in goods only because the latter is a longstanding phenomenon while the exchange and imposition of expertise is an aspect of the broadened range of technology.) Obviously it is technology - transportation, communications and systems - that facilitates and necessitates this globalisation. To the challenges to engineering education mentioned already globalisation adds dimensions of cultural and linguistic differences calling for enhanced communication skills and enlarged sensibilities.

A simple example from the *green revolution* makes the point. The hope of the green revolution was that modern agricultural technology could be transferred from the West to the so called third world and effectively eliminates hunger. It was recognised that regional food preferences and growing conditions had to be taken into account and so, therefore, institutes were established in Mexico, India and the Philippines to engineer the adaptation of the technology. In the Philippines at the International Rice Research Institute the task was to genetically engineer a variety of high yield rice suitable to the climates of southeast Asia that would also mature more quickly (allowing two crops rather than one each year), have a higher protein content than extant varieties, be disease resistant and not require expensive machinery for cultivation. The Institute succeeded admirably in the fulfilment of these requirements, but the new variety of rice was unpopular because it did not resemble locally popular varieties. The new rice was superior according to the criteria of the green revolution but was deemed unsuitable on other grounds. It was cultural insensitivity or, possibly, ignorance that led to the rejection of the superior rice. One can adduce numerous examples where technology transfer has been unsuccessful or led to untoward consequences due to miscommunication or a lack of cultural awareness. The local or regional deployment of technology becomes a major issue in a highly globalised economy.

GLOBALISATION AND THE EXAMPLES of CHINA AND INDIA

It is now acknowledged nearly universally that the economic and geo-political world center of gravity is shifting (how quickly is a matter of debate) from the West to Asia, with India and China presumed soon to regain the influence and power they had in previous eras. The question anxiously put in Europe and the United States is how we should respond both to preserve our own hard won quality of life while at the same time establishing meaningful and mutually beneficial cooperation with these two re-emerging great powers. Yet the size, complexity and diversity of both China and India, and with long and polysemic histories, and varying characteristics of the systems that fostered their return to prominence on the world stage in the 20th century, makes these considerations complex. The lessons of colonial history only exacerbate the difficulty. Nor can China-India be considered an entity.

While both India and China have a long history, their histories are very different. China has been by a large and stable, centrally run state throughout its history with limited periods of instability and a lack of a single authority. India's history has been exactly the reverse. The periods when a single king or political authority ruled over even the major part of India's territory can be counted on the fingers of one hand. In China's case there was a deep desire for unification of the country as a driving force of nationalism in the twentieth century. ... In India's case, there never was any authority that has ruled over all of India; indeed, not even the British or even the present Indian government. India has been idea in world culture for millennia, but its borders had been fixed only in the late nineteenth century... [2].

This suggests a useful approach to building cooperative enterprise and encouraging mutual understanding may be to focus on development within natural regions and the cooperation possible on that level rather than exclusively on that of the nation-state.

As these considerations focus upon science and technology and the implications of both on engineering education it will be appropriate to focus upon the collaborations of universities and polytechnic institutes in China and India and in the West. As it is now the case both in China and India that many technological universities are, largely due to strong government financial support, becoming world-class institutions the moment is auspicious.

In large measure such collaborations, whether research oriented or educational, challenge the widely accepted thesis of Samuel Huntington that argues that certain cultural traditions inhibit and strive to destroy others and that this condition must be overcome in order to realise the salutary benefits of Western modernity, a capitalist economy and a rational, scientific worldview [3]. Two opposing questions specific to this concern are on the one hand *Have India and China by now inherited sufficiently the operative values of Western modernity, capitalism and scientific rationalism to become full and respected participants on the world stage presently dominated by Western technology?* or, conversely, *Do residual cultural norms and values stifle global collaboration and mutually beneficial economic development?* The thesis of Huntington presumes such an either/or while education and research collaboration do not.

The ideals of the European enlightenment and liberal democracy are often said to be intrinsically western and contrary to the traditional and prevailing values of China and India. Without trying to resolve this debate the presupposition here is that within both Chinese and Indian traditions there are strong philosophical structures entirely compatible with, although conceptually different than, the principles of Western modernity. In particular, the approaches of Rabindranath Tagore, whose multiple modernising tendencies are well known within Indian traditions, and certain revisionist views of the Confucian tradition, beginning as early Song-Ming neo Confucian thought and continuing today with a lively re-examination of the classics, offer useful insights [4]. In fact, Song-Ming neo Confucianism is not as remote as it might seem from contemporary concerns as discussions therein regarding practicality (somewhat different than American pragmatism, although that too, especially in the versions presented by Dewey, is now part of Chinese discourse) offer a valuable perspective on technology. Ironically, while both Tagore and the neo Confucians were developing varieties of cultural nationalism, they nevertheless lay the ground, each in their own traditions, for a trans-cultural ethical humanism open to diversity, change and development.

Also, both China and India have strong, but distinctive (from each other and the West) traditions in natural science and technology. The reclaiming of these traditions is an important intellectual project in both places.

Regardless of the particular perspective it is essential that a pluralistic outlook be accepted. While traditional cultural claims should be respected, it must also be the case that the limits of the legitimate claims of culture be understood. This is imperative both on the level of ethics and pragmatic technology, as the success of mutual enterprise depends upon agreement concerning values and rights [5]. Much of the work of Amartya Sen has been directed toward exploring the kind of global economy that will not lead to the decline and often serious deprivation of certain regions at the expense of growth and success in others [6].

Keniche Ohmae has more recently argued that technology is the foundation for the new regional economies that have replaced the nation-state driven economy [7]. As he sees it, the economic *challenges and opportunities* of the future are to be found in those regions of the world with innovative technological environments.

The majority of discussions of the future of India and China tend to abstract from their historical-cultural legacies and consider only the extent to which western models are successfully emulated. As Yaheng Huang and Tarun Khann point out, there were two different paths to technological development following western precedents: *...China's export-led manufacturing boom is largely a creation of foreign direct investment, which effectively serves as a substitute for domestic entrepreneurship* and *...India has managed to spawn a number of companies that now compete internationally ...many of these firms are in the most cutting-edge, knowledge-based industries* [8]. Such observations, while pointing to issues important to economic development anywhere, tend to be narrowly construed, taking too little account of the cultural environment that constitutes the arena for economic development and technological innovation. Careful consideration of such crucial topics as knowledge and human resources, educational policies, systems and institutions, including engineering education and technology development in China and India is also imperative [9]. In other words, the phenomena that Huang and Khann describe may be better approached if re-contextualised under the broad historical/philosophical categories briefly suggested above.

One can understand these aspects through issues of regional economic development. For example, the opportunity exists for Yunnan province in SW China to develop markets and access to seaports through India, Bangladesh and Myanmar; conversely, there is opportunity for these regions to plug into growth in China; the complementary nature of high tech in India and China leads to an opportunity for synergistic development cantered in this region [10].

A recent paper by Wu Xiaobu et al frames the issue of regional, technological development as follows: *Today's economic map of the world is dominated by what are called clusters ... clusters not only become the basic framework of* *regional economy, but also act as the main form of spatial distribution of global economy. With the enhancement of both investment and trade activities among countries, the pace of global industry transfer speeds up, which results in interregional technology gaps and industry clusters as byproducts. ... The questions are how the industrial clusters in developing countries collectively identify, pursue and acquire external technology resources from industrially advanced countries by constructing external innovation networks to strengthen their technological capabilities in virtue of industrial clusters' advantage, and how they can effectively internalise external technology resources acquired, and successfully transit from imitation to innovation* [11].

In his widely read work, *Capitalism with Chinese Characteristics,* Yasheng Huang argues that one of the great potential strengths in China is the existence of a highly motivated rural entrepreneurial class [12].

In his intriguing historical analysis, *Adam Smith in Beijing*, Giovanni Arrighi maintains similarly that historically the economies of Asia were based more on locally specific industry than was that in Europe - a tendency that continues today and which supports the possibility of strong, regional development [13]. The current climate of opinion in China particularly appears poised to benefit from regional technologies and the situation in India is, perhaps, even better. Bill Emmott predicts a power struggle between China and India that he says will shape the global economy for at least the next decade [14]. The alternative could be regional cooperation.

Many of these issues were anticipated by Joseph Stigliz who argued that the policies and approach of the IMF has not recognised the differences inherent in local and regional economies and therefore somewhat paradoxically contributed to movement resisting globalisation [15]. And from a different political standpoint, Jagdish Bhagwati points out that technology and technical change foster far reaching local and regional cultural changes that require acknowledgement and adjustment in a global economy. The penetration, for example, of American popular media culture, perhaps a double affront to traditional culture because of its wide acceptance and popularity, ought not, Bhagwati argues, lead to protectionist policies but rather encourage measures to support indigenous cultural activity [16].

Thus, Huntington’s clash of civilisations appears not to be inevitable. On the contrary, technology, if deployed regionally in a manner that fosters localisation and addresses specific needs, can be a powerful force of mediation and reconciliation. Moreover, collaborative models that multiple sources of input are more likely to produce innovative results.

THE SPECIFIC TASK FOR ENGINEERING EDUCATION

It is clear that engineers have been placed upon the stage of world history at a decisive moment when both the global balance of power is shifting and the natural environment is under stress. The enormity of the challenge is incommensurate with the current state of engineering education. What should be done?

Among advanced professional degree programs *engineering* is uniquely tailored to create technological leaders for tomorrow’s technologically advanced and competitive global society. But to meet the demands and challenges mentioned above, engineering instruction will have to be expanded and integrated with other disciplines from the human and social sciences. An integrated program will draw upon courses across an array of disciplines, from the standard skills of engineering and technology, the physical and biological sciences, mathematics and the liberal arts. Additionally, a contemporary program should integrate invention, innovation and entrepreneurship into all phases of study. Such integration can nurture a learning environment conducive to the creativity that is essential to leadership in tomorrow’s world of technological innovation and the management of technological enterprises. Moreover, it is essential for practical global awareness that the curriculum be collaborative and international.

In this discussion *integrated* refers to the situation where engineering studies are assimilated into an arts and sciences curriculum and *global* refers to current political and economic realities.

The big questions facing engineering education are: *What will engineers be required to do in the world of the near future, perhaps less than twenty years from now? How will technological advances change the role of engineers? How will the changing political and economic balance influence the engineering profession? What steps should engineering educators take in the face of these dynamic realities?*

A clue to this may be found in the United States National Academy of Engineering’s list of Engineering’s Grand Challenges [17]:

1. Make solar energy economical;
2. Provide energy from fusion;
3. Develop carbon sequestration methods;
4. Manage the nitrogen cycle;
5. Provide access to clean water;
6. Restore and improve urban infrastructure;
7. Advance health informatics;

8. Engineer better medicines;
9. Reverse-engineer the brain;
10. Prevent nuclear terror;
11. Secure cyberspace;
12. Enhance virtual reality;
13. Advance personalised learning;
14. Engineer the tools of scientific discovery.

How can an engineering curriculum prepare students to contribute to solving these grand challenges in the context of a dynamic global economy influenced by incipient changes in the political balance of power? Engineering curricula have been barely able to assimilate the increased demands for scientific and mathematical knowledge made by modern technology let alone the new social pressures fostered by a shrinking world.

Currently, engineering education exhibits two maladies. The first is within the domain of technical or engineering training narrowly defined and has to do with engineering skills *per se* and with their relationship to science and mathematics. In a sense, this is because engineering itself has become both more technical and less technical. There are many illustrations of this seemingly contradictory phenomenon. More and more engineering projects are extremely scientific and require deep knowledge of a variety of disciplines covering the full spectrum from biology to physics. The representation of the knowledge from these disciplines tends to be highly mathematical as mathematics is the language that permits discourse between biology and physics. But at the same time much of this is apparently simplified, made available, with an impressive degree of operational sophistication, even to those with a minimal grasp of the underlying processes by means of computer technology. Thus many very complex processes are masked by pleasing and rather simple computer interfaces. This creates an illusion of competence and one of the unpleasant tasks of engineering education is often to dissuade students of false presumptions of understanding.

Engineers, perhaps more than ever before, need to be scientists and competent applied mathematicians. This is to say that engineering rests upon complex theoretical ground and that innovative engineering research and practice needs to cultivate that ground. The problem for engineering education is that the demands of rigorous and contemporary science education are simply more than can be fit into an undergraduate engineering program. Moreover, the mindsets of science and engineering, if not inimical, only share limited commonalities. Engineering students frequently articulate impatience with, and distaste for, their required science courses. This leads to the other side of the dilemma. If engineering students prefer practical, *hands-on* project-oriented, experiential learning while disdaining theory, the fact is that the majority enters engineering school with very little background for this kind of work. It is increasingly rare to meet students, who have had much or any experience tinkering or repairing equipment. The students who have rebuilt a carburettor and put together a ham radio station are few and far between. In part, this is due to technological advancement and the ubiquitous presence of the microchip that makes it incredibly difficult or impossible to figure out how something works by carefully disassembling it and looking. The discovery of mechanical principles that could be achieved simply by taking an alarm clock apart is no longer an option found on every bedside table.

So this is the dilemma of engineering education. Students need more science and advanced mathematics in order to prepare for the sophisticated, advanced and innovative engineering work that will shape the future. The rigor and intensity of this kind of study is such that it cannot simply be added to the curriculum. Furthermore, it is not what most engineering students are well prepared to do or desire. On the other hand, what they do desire and what is also essential to engineering, *hands-on* experiential project-based learning is something most students have almost no background for. So the challenge engineering faculties' face, before being asked to improve their students' communications skills, leadership tendencies and project management acumen is already nearly overwhelming. Where, short of making the undergraduate degree a 5 or 6-year program, is humanities education supposed to fit in?

The realistic answer is that it cannot. From the standpoint of the humanities, it is important to acknowledge this and imagine an honest strategy to address the loss. The adjective *honest* is used specifically. For the temptation will be, in order to save faculty lines and assuage accrediting agencies, to offer courses of instrumental value - perhaps something like technical writing - and claim that such instruction, without doubt valuable, provides all the humanities that engineers really need. If this kind of cosy relationship were to become normative, it would be a dishonest representation of the humanities and do a great disservice to both the engineering profession and the public at large, evermore in need of engineers whose human perspective is both long and broad.

It is against this background that engineering programs need to be measured. For a program to be successful engineering education needs to be integrated on various planes:

- Engineering programs need to be situated on a single path that begins in primary school and continues to post-graduate education in diverse fields.
- Engineering education must function in partnership with industry and able to foster entrepreneurship.
- Engineering like modern technology is international and migrates without concern for political borders or cultural differences. Engineering education must necessarily have a global outlook.

- Since engineers build, maintain and operate the material world human values, preferences and behavioural standards must be integrated into engineering processes. The ability to think through the ethical implications associated specifically with engineering activity and emerging technology.
- Engineering needs to be creative, inventive and innovative to be able to offer novel solutions to both new and persistent problems.

In the spirit of these objectives several fundamental or general theoretical questions are posed:

1. Can the training and skill building of engineers, in an era of scientific and mathematics-based high technology, be combined (i.e., *integrated*) in a significant way with liberal arts education? Are the demands to master the core STEM disciplines so great as to preclude the incorporation of the liberal arts within the undergraduate curriculum?
2. Since many engineering projects require global collaboration it stands to reason that engineers should be prepared the cultural knowledge and appropriate communications capabilities to function successfully within this context. Do the liberal arts serve this function? Do the realities of global multiculturalism inhibit the free inquiry basic to the liberal arts? Are the values implied by technology culturally neutral? (On its face the answer to this question seems to be most emphatically no).
3. Which languages are essential for high technology engineering? Can one rank the relative importance, for example, of the *BRIC* languages? What about Arabic, Spanish and the traditional languages of European science, French and German? How important is English? Does India have an inherent advantage over China on the basis of its English heritage? Does the prevalent use of English create a cultural hegemony within scientific and engineering circles? If one language (e.g., English) is given priority and is used as the base language, what biases may be built into translations?
4. Can technology serve as a mediator of cultural difference?

These questions lead to concrete research problems:

1. What is required in pre college education to prepare students for this type of engineering education? Is it the case, as is now widely argued, that elementary school pupils and junior and senior high school students need to be introduced formally to engineering (in addition to mathematics and natural science)? If so, then what specifically should be included?
2. How is the famous *two-culture* problem propounded by C.P. Snow to be overcome on all levels in the case of engineering education? [18]
3. It is generally said that scientists and engineers need different sets of mathematical skills. How different? At what point, if any, should math for scientists and math for engineers diverge? As engineering becomes more complex and intertwined with science (due to the character of many emerging technologies) will this difference in need be sustained?
4. Advances in technology (e.g., the *synthetic cell*) continue to pose challenges to ethical theory requiring a new type of ethics (as for example Hans Jonas's suggested *ethics for the future*) [19].

Additional issues need to be considered:

1. The global and largely horizontal integration of engineering.
2. Supply chain and outsourcing issues.
3. Localisation of engineering and technology requirements and needs.

CONCLUSIONS

These reflections have done no more than recognise a set of fundamental challenges and point to their inter-relatedness in the case of engineering education. These large challenges are the challenges of the future and, therefore, challenges for education on all levels and in all specialisations. They are particularly vexatious for engineering education due both to the overburdened character of the engineering curriculum and the vital role engineers will need to play in the (hopeful) resolution of the problems.

A truly transformative overhaul of engineering education is needed if tomorrow's engineers are going to possess the skills, values and temperament needed for the tasks they face. Perhaps, more than any other form of education, engineering education needs to be global. Given the trajectory of China and India a Eurocentric view is no longer possible. Traditional parochialisms of any form are anathema for the kinds of challenges future engineers will face. Multicultural discourse will be a prevalent feature of engineering collaboration. It has been here suggested that local and regional perspectives and traditional, indigenous knowledge should have a place in this discourse and that images of a modern, just and stable society may not be derived from the values of the European enlightenment exclusively.

A series of broad questions and issues has been identified. Engineering faculty, students, representatives of industry and other natural stakeholders should brought together in a variety of fora to discuss and debate the possible means to achieve integrated, global engineering education.

But how is the transformative, global integrated engineering curriculum to be designed and implemented? The most likely approach may be to create international CDIO [20] workshops and establish a CDIO curriculum process that can be shared across institutions. The CDIO process permits and encourages multiple input sources and diverse solutions suitable in different contexts. Certainly online platforms can be used to facilitate the CDIO process.

Beyond that, and this is perhaps the greatest obstacle, engineers and non-engineers alike must recognise the centrality of engineering methods, and perspectives, and identify the means to include them in a trans-national public discourse. Without that the only motivation for engineering success will be greed, and that surely will be destructive.

REFERENCES

1. Lyotard, J-F., *The Postmodern Condition: A Report on Knowledge, the Field: Knowledge in Computerised Societies*. Manchester: Manchester University Press (1979).
2. Desai, M., *India and China: An Essay in Comparative Political Economy*. In: Tseng, W. and Cowen, D. (Eds), India's and China's Recent Experience with Reform and Growth, 3 (2005).
3. Huntington, S., *The Clash of Civilizations and the Remaking of World Order* (1996).
4. Bell, D., *China's New Confucianism: Politics and Everyday Life in a Changing Society* (2008).
5. Benhabib, S., *The Claims of Culture -Equality and Diversity in the Global Era* (2002)
6. Sen, A., *Development as Freedom*. New York: Alfred A. Knopf (1999).
7. Ohmae, K., *The Next Global Stage: Challenges and Opportunities in our Borderless World*. New Jersey: Wharton School Publishing (2005).
8. Huang, Y. and Khanna, T., Can India overtake China? *Foreign Policy*, July-August, 74-81 (2003).
9. Ray, J.K. and Prabir De, P. (Eds), *India and China in an Era of Globalisation: Essays on Economic Cooperation*. New Delhi: Bookwell -South Asian Research Society (2005).
10. Parayil, G. and D'Costa, A.P., *The New Asian Innovation Dynamics: China and India in Perspective (Technology, Globalization and Development)* (2009).
11. Wu, X., Gu, Z. and Zhang, W., The Construction of Innovation Networks and the Development of Technological Capabilities of Industrial Clusters in China. *Inter. J. of Innovation and Technol. Management*, 5, **2**, 178 (2008).
12. Huang, Y., *Capitalism with Chinese Characteristics: Entrepreneurship and the State* (2008).
13. Arrighi, G., *Adam Smith in Beijing: Lineages of the Twenty-first Century* (2007).
14. Emmott, B., *Rivals* (2008).
15. Stiglitz, J.E., *Globalization and its Discontents* (2003).
16. Bhagwati, J., *In Defense of Globalization*, 118 (2004).
17. National Academy of Engineering (2010), 21 January 2010, http://www.engineeringchallenges.org
18. Whelan, R., *Fifty years on, CP Snow's 'Two Cultures' are united in desperation*. The Telegraph (2010), 16 September 2010, http://www.telegraph.co.uk/technology/5273453/Fifty-years-on-CP-Snows-Two-Cultures-are-united-in-desperation.html
19. Jonas, H., *The Imperative of Responsibility*. Chicago: University of Chicago Press (1984).
20. The CDIO™ Initiative (2010), 16 September 2010, http://www.cdio.org