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Invited Article

Life-Long Education for the Global Workforce in the Socio-Engineering Age

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ABSTRACT

Socio-engineering is a field built out of several disciplines, and could be said to be a synthesis of engineering, the humanities and the social sciences. Global leaders trained in the spirit of socio-engineering tend to be free-minded, and value life, liberty and the pursuit of happiness for all stakeholders, regardless of ethnic makeup, intellectual leanings or geographic location. Knowledge engineering is the art of infusing the liberal arts in the practice of diverse professions in order for the debate of issues with a view to solving problems often encountered in real life but not in textbooks. The focus of knowledge promulgation for the global economy is on the welfare of all organisational stakeholders through a sound social environment for effective human interaction in managing contemporary ideas and values. Stakeholder analysis for needs and outcomes requires a design, a plan for nurturing, change management and the understanding of behavioural and emotional traits. The outcome is expected to be a synthesis of text and context that takes into account the shifting paradigms in global practice and varying societal needs. Professionals so trained distinguish logic from tradition, tradition from prejudice, prejudice from common sense and common sense from nonsense.

Keywords: Socio-engineering; global economy; knowledge engineering; brain; mind; outcome-based education; stakeholder; behavioural engineering

INTRODUCTION

The word 'engineering' originates from the Latin '*ingenium'* and '*ingeniare'*, from which also is derived the word 'ingenuity'

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or 'cleverness'; with regards to the field of engineering, the reference is to ingenuity in contrivance or design, and especially in relation to strategic planning. In fact, 'engine', a term derived from 'engineering', refers to a whole that drives a multitude of compartments by bring them into motion. The term 'leader' is an analogue of engine. Just as how an engine powers a set of compartments, a leader drives various departments in an organisation, putting power in the hands of stakeholders, creating e-motion and cultivating emotional intelligence. The followers, as stakeholders, will power the organisation with a win-win paradigm for all to feel rejuvenated in fulfilling the organisation's mission, vision and values. It is no miracle that the process of engineering is the application of scientific, economic, social and practical knowledge in order to invent, design, build, maintain, research and improve policies, procedures, systems, structures, machines, devices and materials. It is an ongoing process of quality deployment and assessment of the products or outcomes. In search for total quality management, holistic thinking, management of resources and creating avenues for implementation of the emerged outcomes are of paramount importance. The goal is to embed higher-order life, professional and technical skills as a natural process of disciplinary education. Stakeholder analysis for needs and outcomes requires a design, a plan for nurturing, change management and understanding the behavioural and emotional traits. In this context, social sciences and humanities are interwoven in continuing discourse as people and ideas merge to foster whole-brainthinking as a lifestyle i.e. from cradle to grave. Lifelong education and socio-engineering are buzz and biz words for the present century. These buzz words are expected to make human interactions thrive and unshackle the human mind from the slavery of old paradigms in this techno-savvy age.

Education is the process of becoming along the journey of achieving one's goals, as expressed by Frederick W. Robertson: "Instruction ends in the school-room, but education ends only with life". While formal training ends in college or university, education continues for life with lifelong education or continuing education as a worker continues her life journey through career development and enjoys life beyond retirement as a valuable resource for the community she lives in. That is why graduation ceremonies in the US are called "commencement", signalling the beginning of a new journey into career and employment. Education is simply the soul of a society as it passes from one generation to another (as quoted by G. K. Chesterson). The humanities play a principal role as education is indispensable to the individual and society, for without it we would lose all the knowledge we have accumulated since the beginning of time. The social sciences lubricate the process of human interaction, providing strategies the individual to learn the culture of a society, the accepted ways of doing things and, above all, learning the process of change management to create a better future for Earth's habitats. Behavioral

engineering allows the individual to socialise into the prevailing culture and learn the rules of conduct and expectations about future behaviour. Education of the 21st century must not only rest on a platform of cognizant teaching, it must also provide a milieu for self-learning and development, inculcating values and promulgating norms and social skills that will enable the individual to develop his personality and sustain the social system. Roth (2014) firmly asserts that college teaches young people to think and to engage, allowing them to better themselves and their societies. In his vision, "liberal education matters far beyond the university because it increases our capacity to understand the world, contribute to it, and reshape ourselves."

The global workforce transcends boundaries of disciplines as well as those of nations, anytime, anywhere. It is meant to ensure that the workforce will be able to succeed in a world marked by interdependence, diversity and rapid change. Education of a global workforce provides knowledge and understanding of culture, language, geography and global perspectives. Most importantly, a global education enables students to understand their roles in a global community and teaches them how their actions can affect citizens throughout the world.

The key component of a knowledge economy is greater reliance on intellectual capabilities than on physical inputs or natural resources (Powell & Snellman, 2004). Strategic planners in academia, government and industry focus heavily on knowledge production in terms of patents and publications. Less attention is paid on outcomes that include knowledge dissemination and impact. While all organisations are interested in how many answers an individuals may have, we are even more interested in how they behave when they do not know—when they are confronted with life's problems, the solutions to which are not immediately known. The larger goal is for enhanced performance under challenging conditions that demand strategic reasoning, insightfulness, perseverance, creativity and craftsmanship to resolve complex problems.

The global economy is in transition to a knowledge-intensive economy as we come out of the psyche of being under the rule of the colonial British Raj, which depended largely on agricultural- and labour-intensive economies. In a knowledge economy, a significant part of a company's value may consist of intangible assets such as the value of its workers' knowledge (intellectual human capital), which is impossible to document in terms of financial wealth. The humanities and social sciences play a significant, pivotal role in defining the traits of a knowledge worker and are now integrated in desired educational outcomes as in the ABET portfolio (ABET, 2014) of the US Accreditation Board for Engineering and Technology (ABET). Natural integration of these so-called liberal arts skills are now at the core of Washington Accord's (WA's) desired outcomes (Washington Accord, 2014) embraced by 17 participating countries (Arora & Arora, 2014).

In this global era that relies on interdependence between countries, trade blocks and organisations are evolving into multinational entities. There are the age-old challenges that every young person faces:securing a job, finding a life partner, finding one's justified place in the interconnected global economy etc. Now there also are new challenges to negotiate: global terror, nuclear proliferation, managing the downsides of the Internet, religious and cultural conflicts, climate change, to name a few. The challenges are both ideological and ecological; they share underlying similarities as they all deal with management of the planet's limited resources in the wake of unlimited human wants. In finding the optimal solution, we assess how humans relate to one another and how we choose to live our lives. There is a need for renaissance professionals who are able to integrate science, the humanities and management concepts (ABET, 2014). These changes require academia to design a goal-driven engineering process for budding professionals to solve any problem—technical or non-technical—as opposed to learning specific solutions to a specific set of problems. A knowledge-based quality organisation comprises professionals with diverse talents who identify the real problem, solve it effectively and efficiently, generate alternatives, evaluate possible outcomes, implement solution(s) and, above all, provide a framework for renewal (Covey, 1989) and ongoing improvement (Goldratt & Cox, 1992).

Today, more and more organisations, including universities, are waking up to newer demands and are haphazardly setting rules in response to realities just to survive, not thrive, in a highly competitive workplace. Cooperation among competitors is a new paradigm leading to educational blocks and the ability to cut across the boundaries of disciplines. The emerging facts from the successful organisations indicate that the real source of power in a knowledge-based economy is the *management of ideas* coming from diverse professionals. The only constant that traditions do not survive is change. The choice is stark: educate, innovate or evaporate. The innovation comes from seeking wisdom wherever it can be found (Arora, 2009; Arora & Faraone, 2003).

In an online survey (The Star, 2015) of about 300 respondents, the outcomes indicated in Fig.1 were anticipated, consistent with the survey by Steven Institute of Technology and State Higher Education Office SHEEO, discussed by Arora and Faraone (2003), as shown in Fig.2 (Koen, 2001; Van Horn, 1995). Deficiencies in ethics, listening, written and oral communications and responsibility and management were found. Employers' expectations in technical proficiency were exceeded. The ongoing practice of the humanities and social sciences as a natural component of disciplinary training plays a predominant role in filling knowledge gaps that exist between the current state of education and traits desired in a knowledge

economy. Care must be taken not to create more subjects in developing soft skills, but more emphasis on natural integration of these subjects with disciplinary specifications.

Global renaissance professionals do not need formal training in integration of science, technology, the social sciences, the humanities and management (Arora, 1998). They are self -learners who ask themselves and fellow planners insightful questions. A process of lifelong learning is always in the minds of potential or seasoned global leaders. Our research indicates the following attributes of a global leader:

- Concerned with one-time, future-orientated tasks directed toward innovation and change
- Works under limited resources and unlimited human wants
- Makes a reasonable projection of end results under highly uncertain and

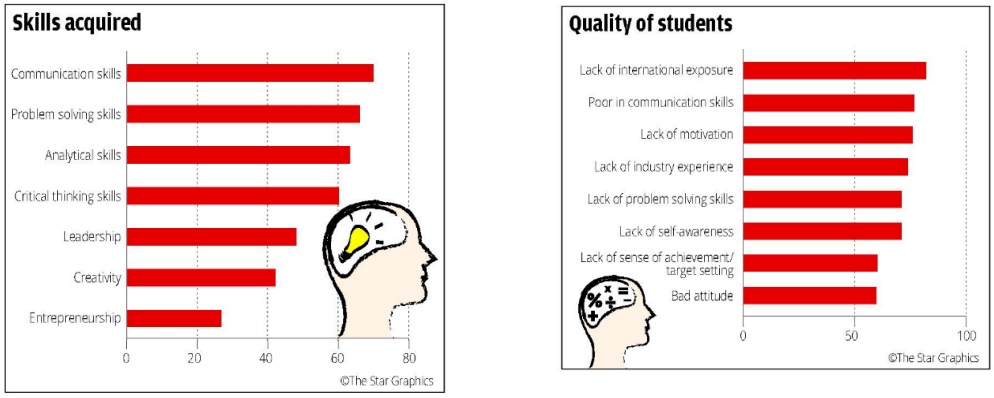

Fig.1: The results of a survey by The Star, Kuala Lumpur, Malaysia on the skills desired in the workforce of tomorrow, as well as the lack of some desired attributes.

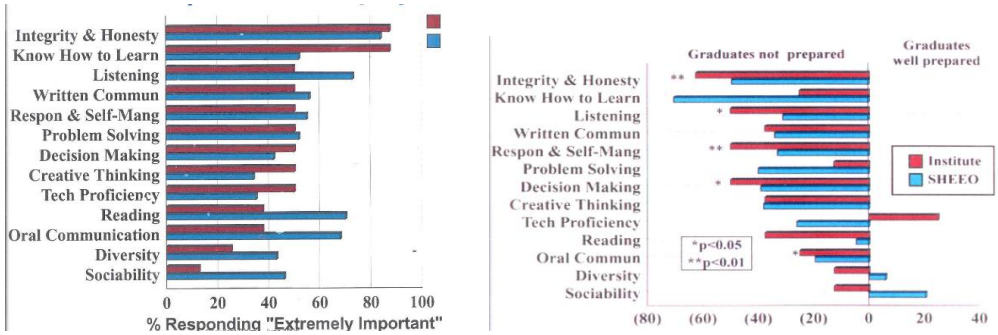

Fig.2: Attributes sought by the employer (left) and the existing gaps in the training of global leaders.

unpredictable environments of the future

- Deals with, motivates and controls highly trained, creative people, directing them and the organisation to success.

As a comparison, it may be worthwhile to examine the attributes of common workers:

- Concerned with present-orientated, periodic repetitive tasks
- Desired goal is strict adherence to predetermined policies, procedure and methods
- Deals with the enforcement of plans, schedules, policies and procedure where the results of decisions are much more predictable
- Can direct people who can take instructions

While the value of higher education in providing access to improved jobs, better earnings and career prospects is an important driving force for people to invest in higher education, these gaps show serious reforms are needed in not only creating desired outcomes, but also in creating a process of ongoing improvement through assessment practices. In an examination-orientated culture, a mark of colonial British education, nurturing and measurement of the desired attributes is a daunting task that can be designed with the ongoing process of quality control. British education has gone through dramatic transformation with the rise of the Washington Accord (2014), of which Britain is a founding member. However, independent colonies it left behind are struggling to redefine themselves, especially those in Asia and Africa. One semester of study abroad or internships are being practiced in American universities to capture the essence of global education. That mindset of a global education requires cooperation from all stakeholders including parents, students, government planners, strategic thinkers, employers, employees etc.

The next section of this paper, provides the philosophical basis on which to plan research methodology that cannot be unique. Each constituency must assess the needs of the participants and act accordingly to achieve the desired outcomes. Several models of curriculum development are discussed. The paper then proceeds with outcome-based education (OBE) that brings out the need to address the desired outcomes in an educational milieu that are transferrable as knowledge travels with the speed of light through the Internet and other communication channels. The example of a Hong Kong university to embrace the OBE paradigm is stated and the importance of English as a language of instruction is accentuated for scientific, technological and management education, including the humanities and social sciences. Section *Behavioural and Social Engineering* considers the liberal arts that can be extended to embrace discipline specific outcomes. The example explored is the STEM (science, technology, engineeringand mathematics) programme initiated in the

US in response to embarrassing experiences faced by the US-educated workforce in international competitions. That itself demonstrates that the problems we face are global rather than local. When Wall Street in New York sneezes with its Dow Jones Industrial Average (DJIA) going down, reverberations are felt throughout the globe. A couple of metaphors are mentioned to drive the point of perceptions as we assess our systems and achievements. Section *Tame the Mind, Create the Brain* brings out vividly the connection between attitudes (mind as a brain software) to create the brain as hardware so the underutilised/unutilised capacity of the brain may be capitalised on. Ned Hermann's model (Hermann, 1991) of the brain is one possible application of taming the mind to create a brain conducive to human development. However, it is not the only one. Other alternatives can be designed. Bloom's Taxonomy (Sosniak, 1994), which takes one from the lower level of memorisation to th ehigher level of transformation in acquiring and applying knowledge, has itself gone through transformation. The old version as stated below, extensively used by engineers, relies on knowledge, comprehension, application, analysis, synthesis and evaluation, in the form of a pyramid. In fact, evaluation is the assessment. However, many as seen in the literature argue that to embrace all disciplines, the sequence must change to remembering, understanding, applying, analysing, evaluating and creating. Our model relies heavily on propagation, engagement, discovery and synthesis (PEDS). A knowledge bank with circling PEDS flattens Bloom's taxonomy. PEDS is an extension of Ernst Boyer's model of scholarship (Boyer, 2014) that is much more dynamic for adaptation. Section *Renewal and Ongoing Improvement* is on renewal to embrace change management as requirements of the global society change. Mind-body-soul integrated power to drive change is emphasised. The concluding Section *Concluding Remarks* is not a conclusion in the traditional sense but more of an advisory on how an individual can enhance the habit of the minds towards organisational goals and have a fulfilling personal and professional life.

RESEARCH METHODOLOGY

The paper is an amalgamation of ideas generated from theauthors' experiences as implemented in the classroom and interaction with educators around the globe, including evaluation of the programmes. Catalano (1993) was the first to point out the stochastic nature of curriculum development which can have many models from which to construct the methodology of the delivery process. He made a comparison between a deterministic scientific paradigm and one that is chaos-based. His chosen alternatives are listed in Table 1. There appears to be consistency of the left brain (vertical) thinking with the traditional model of engineering education and in turn with a deterministic paradigm existing in educational institutions. Similarly, parallelism exists between right brain (lateral) thinking and a holistic curriculum

and the chaotic paradigm. With new advances in our understanding of the process of thinking, we are recognising the need to nurture both analytical (left-brain) thinking skills and creative (right-brain) skills, as shown in Table 1. Such is the paradigm presented in Section *Behavioural and Social Engineering*.

Fromm (2003) described the total engineering enterprise playing an unparalleled role in the American precepts of citizenry's "unalienable rights to life, liberty, and the pursuit of happiness ." Whether those words are translated into the current terms of security, defense, health care, wealth production, entertainment or others, the foundation of that enterprise is its educational system. That system provides the world with the creative talents of emerging professionals who will drive the economic engine for the betterment of society and enrich the human condition in the decades ahead.

Bordogna, Fromm and Ernst (1993) suggest a paradigm shift based on several reports and papers, revealing a common theme: engineering is an integrative process. In engineering the education of the future, it is no surprise that the process of integration is being sought by WA countries for all disciplines. The Malaysian Qualification Agency (MQA), for example, accepts the methodology of the Board of Engineers Malaysia and is trying hard to embrace OBE to embrace all disciplines, to in fact propagate an intellectual culture. The roots

TABLE 1
Comparison and Contrast Among Models of Whole-brain Thinking, Traditional Versus Holisticand Deterministic Versus Stochastic

Whole Brain Thinking		Models of Engineering Curriculum		Scientific Paradigms	
Left Brain (Vertical)	Right Brain (Lateral)	Traditional	Holistic	Deterministic	Chaotic
Sequential	Holistic	Reductionist	Integrative	Reductionist	Integrative
Linear	Diffuse	Develop Order	Correlate Chaos	Linear	Non-Linear
Concrete	Symbolic	Engineering Science	Functional Core of Engineering	Discrete Data	Visual
Analytical	Intuitive	Analysis	Synthesis	Deductive Analysis	Intuitive Synthesis
Independent	Cooperative	Independance	Teamwork	Specialist	Interdisciplinary
Positive	Spontaneous	Solve Problems	Formulate Problems	Static Understanding	Dynamic Understanding
Explicit	Emotional	Research	Design	Explicit	Implicit/Trial & Error
Goal-Oriented	Process-Oriented	Techno-Scientific Base	Societal Context	End Points	Process
Verbal	Nonverbal	Understand Certainty	Handle Ambiguity	Certainty	Lack of Certainty
Numbers	Pattern	Abstract Learning	Experiential Learning	Algebra	Geometry
				Value Free	Value Laden

of contemporary collegiate education based on intellectual values should be shifted towards total integration after assessing the needs of a particular constituency. Bordogna et al. analysed current emphasis on reductionism vis-à-vis integration and recommended a holistic approach in which process and knowledge are woven throughout the curriculum, consistent with the holistic model of engineering education seen in Table 1.

A new construct for systemic change in education is designed in terms of taxonomy of intellectual components connected holistically with a core focus on developing human potential, as opposed to the present system in which students are passed serially through course filters. Based on the findings from the literature, the education of the future must be relevant, attractive and connected. Relevancy to the lives and career of students prepares them for a broad range of careers, as well as for lifelong learning involving both formal programmes and hands-on experience. Attractiveness keeps the potential workforce excited and rejuvenated. Intellectual content of disciplines must include contentment with life and its virtues as an individual advances in life's journey. Connectedness comes into play to address the needs and issues of the broader community through integrated activities with other parts of the educational system, industry and government. The outcomes are necessary to show the worthiness of public and private investments in academia.

The target question to answer in the concluding remarks is: How may we condition the habits of all stakeholders in an organisation, including the university as a knowledge company, so that ideas will converge with a win-win paradigm beneficial not only to the individual, but also to a community, the nation and the world at large? Minds conditioned in this way can design a curriculum or learning culture by researching desired outcomes that change with changing times.

OUTCOME-BASED EDUCATION (OBE)

With the rise of Massive Open Online Courses (MOOCs), the focus is shifting from teacher to learner, from propagation of knowledge to the fraction received at the intended target, and from getting a piece of paper called a degree to values added to one's personal and professional profile. So is the challenge we are all facing in academia to answer the question: What values did we add to the student's creativity and innovation (C&I)? The cries of "Educate, Innovate or Evaporate," are being heard from all corners of the world (Arora, 2012) and all segments of global economy.

Research in propagation/promulgation of the acquired knowledge or intellectual property is being broadly discussed in every institution and in every organisation. To quote Theodore Von Kármán, Caltech's Provost during its formative years, "Scientists discover the world that exists; engineers create the world that never

was" (Testing Engineers and Consultants, 1966). In other words, science is about being driven by curiosity to understand the world. Engineering is about using science to transform the world. Engineering executes and business reports. An algorithm of this process allows one to find pathways in the uncharted territory of human thoughts by using a *compass*. Physical, biological and behavioural scientists study the world as it exists, for which *maps* exist and are readable. Engineers create the world that never existed for which *maps* are not yet produced, requiring a *compass* to guide the discovery process. During this discovery process of the unknowns of the future, knowledge and willingness to synthesise diverse disciplines are required. The interplay of our passions, our values and our conscience can be our compass. But the decisions we make cannot be driven by individual considerations alone. Not only will they be about our personal and professional life i.e. about family and career, they will also be about our life as citizens of our country as well as of the world.

Arora (2009) discussed managing resources in a nano era where nanotechnology is predominant. The creativity of the human brain was explored i.e. how it can be enhanced through whole-brain thinking. Arora and Faraone (2003) considered the process of being an entrepreneur. Many in academia believe technopreneurship, an amalgamation of technology and entrepreneurship, is the art of applying the liberal arts, the soul of the educated person. The Accreditation Board for Engineering and Technology (ABET, 2014) lists the process of measuring outcomes for all engineering schools in the US. ABET is also a member of the Washington Accord (2014), a consortium of 17 countries that embraced OBE or Outcome-Based Education in 2014. The countries are: Australia, Canada, Chinese Taipei, Hong Kong China, India, Ireland, Japan**,** Korea, Malaysia, New Zealand, Russia, Singapore, Sri Lanka, South Africa, Turkey, the United Kingdom and the United States. Social and behavioural aspects of engineering are naturally integrated in technical training of graduates in WA countries. These attributes now are being tried out in other disciplines as well. Arora (2009, 2013) lists these attributes to train tomorrow's global leaders. In Arora's vision of GC2020 (Global Criteria 2020) the graduates coming out of a four-year degree programme in a university must acquire:

a. The ability to apply traditional liberal arts and behavioural sciences in a techno-savvy world

b. The ability to design and conduct interviews, surveys or laboratory/field experiments as well as to analyse and interpret data from diverse sources

c. The ability to design a system, component, process or multidisciplinary procedures to meet desired needs

d. The ability to function on multidisciplinary teams

e. The ability to function in multicultural and racially diverse environments

f. The ability to identify, formulate and solve real-life problems with a service emphasis for assorted groups

g. The ability to understand social, political, professional and ethical responsibility

h. The ability to communicate effectively to racially, culturally and professionally diverse groups of people

i. The broad education necessary to understand the impact of educated inference in a global and social context

j. Recognition of the need for and the ability to engage in lifelong learning

k. Knowledge of contemporary issues

l. The ability to use the techniques, skills and modern information tools necessary for workplace practice

These attributes are not written on stone. They form a starting point for an educational entity (e.g. Ministry of Education of a country) to use as a template for constructing a constituency's slate of outcomes that can be mapped out of or into the design of courses, activities, internships etc. in general, building the knowledge ecology of an academic institution as a knowledge company. As a matrix is generated from where these outcomes come, the process of total quality management identifies the gaps that exist and a plan for ongoing improvements is created. Specialised disciplinary outcomes are added to the list to make a complete landscape. Recently, Hong Kong universities followed such an approach (Day, 2012). As a former British territory entered the 21st century with liberation and accession to China, its government concluded that the education system it had inherited from the British was too rigid, narrow and elitist to produce such a workforce. After concentrating on one subject for three years, students graduated from university with a bachelor's degree but without being taught the knowledge and skills they might need to navigate the complexities of a modern, globalised society. In enacting the reforms, the Hong Kong government's principal goal was to improve education, but another goal was to make the territory into a preeminent higher-education hub in the South China region. English is the language of instruction. Hong Kong itself offers a vibrant, accessible mix of Chinese and Western cultures.

English is emerging as the global language especially for business and engineering. Countries that do not teach global subjects in English are falling behind in the academic landscape. Russia and Germany, especially, face that challenge. The reason is obvious: the industrial revolution started in Britain and with that, the English language was used to propagate the sciences and engineering and now, organisational behaviour through scientific (or engineering) management. Like it or not, we are stuck with English as the language of communication as information travels on the Internet, where impact-worthy journals are published in English, and lectures by prominent educators are broadcast over the media in the English language.

BEHAVIOURAL AND SOCIAL ENGINEERING

Behavioural engineering, an extension of the social sciences to embrace implementation, has its basis in the liberal arts. The liberal arts automatically embraced the fine arts and other cultural factors through the context in which they are practised. This was the mark of an educated professional in medieval times. No person was considered educated unless he was well-versed in the liberal arts. In a way OBE is the implementation of the liberal arts in modern context. In the light of a diversity of definitions of liberal arts, it is always a good idea to return to the basics. The *traditional* liberal arts consisted of two components:

- Quadrivium: Arithmetic, Geometry, Astronomy and Music
- Trivium: Grammar, Rhetorics and Logic

A long time ago, we walked away from this concept of including the liberal arts for a well-rounded education. A new hybrid bringing together technology that embraces quadrivium, the modern liberal arts that embraces trivium and management principles that embrace the communication is developing. This integration of technical innovations with business practices is coined as 'technopreneurship' (or techno-entrepreneurship). Many believe that a goal-driven process of engineering with the goal of serving humanity—a synthesis of technology and entrepreneurship—is a new liberal art and hence anticipate the birth of behavioural or managerial engineering from the humanities and the social sciences. Quadrivium based on physics as a foundation is the text of liberal arts. Trivium forms the context in which the liberal arts are practised. Text and context must be practiced simultaneously to derive synergy from social and behavioural interaction. Arithmetic, the basis of quantitative reasoning, is the language of physics. Geometry, an offshoot of Einstein's space-time, is the basis of all sorts of graphics and visual displays. It is also the basis of right-brain thinking capturing the images of the holistic situation. Astronomy, a branch of physics, teaches us about the balance in the forces of nature that sustains life on the planet. Music is a collection of frequencies forming a transmitted signal that resonates with the receiver. Noise is considered dissonance. In communication channels, it is important to keep a high signal-to-noise ratio. To borrow an analogy from optical fibres, a signal must be replenished as it loses its communicative power in a human enterprise. Naturally, noise should be eliminated so signal-to-noise ratio is high, ideally infinity. Grammar or syntax forms the basis of a genre that can be discipline specific and is necessary to understand messages contained in a sentence or structure. Rhetorics, communication in written, oral or graphical form is meaningful for transmitted signals to propagate without much noise added. Logic forms the strong foundation of reasoning and allows us to organise our thoughts in a structured manner in a sentence, paragraph or document. A desired mantra while practising trivium as a context of quadrivium is: Say what you are going to say (or do), Say (or do) it,

and finally cap it by saying what you have said (or done). Chemists and biologists are reconditioning their thinking based on molecular dynamics using the principles of quantum physics (Arora, 2015). Similarly, good engineering is viewed as an integration of disparate ideas and resources (artificial and natural).

In a new format, popular in the minds of US strategic planners, science, technology, engineering and mathematics (STEM) are replacing the traditional liberal arts in designing educational delivery in a competitive global marketplace. The American educational system designed the STEM delivery programme after receiving some sobering news from international competitions that its students were not able to reach a particular mark. Less wealthy nations like Estonia, Slovenia and Finland fared better. The workforce of tomorrow must have a competitive edge in a globalised, high-tech marketplace. The United States is a global leader through the genius and hard work of immigrant scientists, engineers and innovators. It has not ignored that valuable resource in learning from its failures. STEM still forms the stem or stalk of traditional liberal arts in connecting with the sciences and the humanities. STEM must be increasingly coordinated with total curriculum development where the ecology of an academic institution is based on OBE. Not every one of the desired traits can be assessed through examinations as the interconnected world is used to. Many of these traits naturally arise while students are soaked in the ecology of an institution. Clinton (2006) was first to point out that family values play an important role in propagating STEM culture at the child level. Hillary Clinton's ideology that "it takes a village" to educate a child underscores the need to make all stakeholders participate in the education of the workforce of the future. In a bold new General Education Plus (GE+) experiment adopted at the University of Colorado (Lord, 2014), there was a bold determination not to dilute the undergraduate curriculum, rather to enrich it through integration. Educational pedagogy is integrated with the process of engineering, making STEM closer to the ideals of the liberal arts. Through a focused curriculum development process, STEM is planned as a design-based four-year general engineering sequence that retains the essentials of total integration, capped by an additional semester of student teaching in an urban high school.

Newton's laws of physics come in handy when using physics as a liberal art. The first law, the law of inertia, defines status quo. It also illustrates that a human being is fundamentally a peaceful person, and this can be discovered through the meditative process of staying close to oneself. The second law states that change is possible only when there is a motivational external force. That is where our ambitions come in to motivate us to change for good or bad because of external influences. The third law is interaction between two bodies. If one rubs someone's shoulders, one gets rubbed in the process. When one hates someone (action), one gets the reaction of hate.

Action and reaction are equal and opposite. Action is done by one entity and reaction by the other in a two-entity interaction. The meditative process teaches discovery of peace in us as we discover that by our very nature we are peaceful (inert) until external influences urge us to transform our behaviour and mode of thinking. Meditation rooms at US airports are now a common sight and help us understand that one is not a sinner as it encounters obstacles of security checks and alike. Things do happen externally for which a person may have no control, but actions, reactions and know-how of crisis management are.

Real world problems are complex and sometimes are solved by metaphors and analogies taken from other disciplines. Here is one metaphor. In the eastern environment, the blessings of a priest are needed to find an auspicious time to launch a venture. In the West, the blessings of a lawyer are needed to protect the intellectual property. Intellectual property is actually universal; it is spawned through generations and does not belong to one person. Imagine this scenario: in a Fukushima-type nuclear accident, a lawyer, a priest and an engineer are set to be beheaded. The lawyer's head is the first to be put on the block, and the guillotine lever is pulled. When the blade gets stuck before it reaches her neck, she is released and she walks away shouting that justice has been served. Then it is the priest's turn. The blade gets stuck again before it can slice off the priest's neck; he is released and he walks away praising a higher form of justice. As the engineer's head is placed on the block, he cranes his neck to look up at the malfunctioning machine and yells at the executioner, "Stop! I think I see the problem." So, even in death an engineer is devoted to professionalism and ethics. Or, maybe he thinks of renewal while practising his profession. He anticipates vibrant life beyond death. That was 20th-century engineering where truth held the highest power. In the 21st century, many distractions hinder our ability to see the future. A courageous leader is investigative. She will climb the tallest tree in the jungle and shout, "Wrong jungle" even if she is expected to keep quiet if her team finds itself in the "wrong" jungle. Here, progress is reported in terms of mileage covered without any outcome or worse, with negative outcomes.

Another metaphor explains the problem of perception or misperception. A man is taking a walk in Central Park in New York. Suddenly, he sees a little girl being attacked by a pit bull. He runs over and starts fighting with the dog. He succeeds in killing the dog and saving the girl's life. A reporter who was watching the scene walks over and says, "You are a hero, tomorrow you can read it in all the newspapers: "Brave New Yorker saves the life of a little girl."

The man says, "But I am not a New Yorker!"

The reporter answers, "Oh, then the morning newspapers will say 'Brave American saves the life of a little girl'."

"But I am not an American!" says the man.

"Oh, what are you, then?"

The man says, "I am a Pakistani!"

The next day the newspaper reads, "Islamic extremist kills innocent American dog while a little girl watched in vain. Connections to terrorist networks are being explored."

In the interconnected world brought together by the Internet, such incidents are becoming normal and show the extent of how social and behavioural processes are being engineered for good or bad by the very media which are dedicated to bringing news and current events to the public at large. We need not go too far. Remember the last four Presidential elections in the US after Clinton left office. The lack of professionalism of our leaders has affected the whole world economy. Hence, no global leader can stand tall and still on his or her own turf. The vibrations of his or her actions reverberate throughout the world at the speed of light because of information transfer.

TAME THE MIND, CREATE THE BRAIN

The Brain Research through Advancing Innovative Neurotechnologies (BRAIN) initiative is a consortium of more than 100 scientists, spearheaded by the US National Institutes of Health and the National Science Foundation. It provides intellectual cross-pollination for the researchers involved. These scientists are determined to find answers to some of the most enduring mysteries of the human brain that rewires itself with healthy attitudes of the thinking mind with emotional intelligence. The three-pound lump of wrinkled tissue—the brain, with no moving parts, no joints or valves—not only serves as the motherboard for all the body's systems but is also the seat of our mind, our thoughts and our senses that we exist at all and are live persons with a soul or the soul of oneness residing in each of us. Human beings can harness the tremendous information processing capability of this three-quart-sized internal computer, estimated to have about 17 billion bytes of storage and astounding speed. The mind with healthy emotions and attitudes is the brain's software. The mind can be tamed by soaking ourselves in creative environments and activating the hidden forces of the brain. Healthy mind-body connection has been propagated in a number of studies. This powerful knowledge-managing resource must be used in enhancement of creativity and innovation (C&I). Recent research has come to the realisation that the adult brain retains impressive powers of "neuroplasticity"- i.e. the ability to change its structure and function in response to experience (Time, 2007).

Fig.3 indicates the functional areas of the brain that process different forms of information. Neuroplasticity means that the brain is capable of learning new tricks to utilise the under-utilised capacity of a given area. It appears that Nature has embedded a circuit theory practised in electrical engineering in the head of a person that enables information to travel at startling speeds of the thinking mind as electrical energy. The mind (or attitudes) indeed is the software of the brain hardware that programmes it to meet certain outcomes and

perform certain functions. Mind or thinking processes energise the brain. That is why the BRAIN research initiative is at the top of the agenda of US strategic planners and funding agencies.

The Human Genome Project in the US is drawing a new map of the brain in order to identify underutilised areas. From research so far, more than 98% of similarity has been found in human beings. Our mind or attitudes create the brain that makes us different from others. The agony of the human mind is to focus on the 2% of differences, ignoring the 98% of similarities. There are uncharted territories that can be tapped for enhanced productivity in delivering personal and professional satisfaction. The brain rewires itself to learn new tricks and changes its structure and function even in old age. Multiple objectives are fulfilled in studying and understanding the information-processing capability of the human brain. The left half works with logic, words, structures and analysis. In contrast, the right half works with emotions, pictures, whole entities, relationship among parts and synthesis. The left half is sequential and time-bound (masculine); the right is holistic and time-less (feminine). In Asian philosophy, these two aspects form the yin-yang (feminine-masculine) combination. No person can have whole-brain dominance. Whole-brain thinking in the workplace can be activated by diverse personnel forming a team. Here comes the need to engineer social behaviour of diverse people in an organisation.

As shown in Fig.4, most people are right-handed, and think and operate from the left half of the brain comprising Quadrant A and B. The dominance of Quadrant A indicates that indeed we are human machines who are achievement-orientated and performance-driven. A knowledge economy requires a strong foundation in right-brain thinking. A discipline trainer dominant in Quadrant A

Fig.3: Processing capability of the human brain (Source: Time (2007))

must connect to Quadrant C where spiritual values reside. On the other hand, a manager dominant in Quadrant B must connect to Quadrant D to become a leader, innovator or entrepreneur. Bloom (Fig.5) noted that the education given by a university as a Knowledge Company keeps learners at the lowest level. However, to capture the hidden forces of the brain, as shown in Fig.4, higher levels must be tapped. These higher levels can be commissioned through design of educational delivery resulting in assessment at the highest level to confirm that outcomes have been achieved. That is the spirit of the WA.

Arora (2009, 2012) went beyond Bloom's Taxonomy in defining a process that centres on the knowledge bank. Arora's

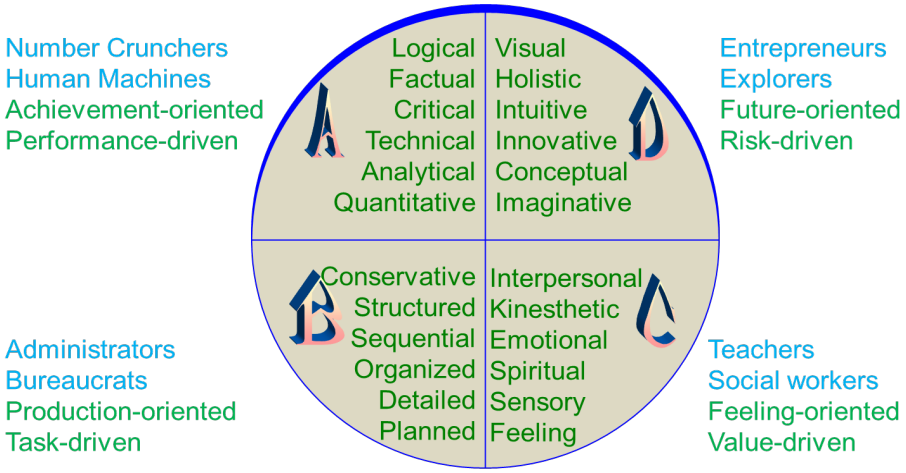

Fig.4: Ned Hermann's Creative Brain ranging from quadrant A on the left showing a lower level to the higher hierarchy quadrant D for creativity and innovation (C&I)

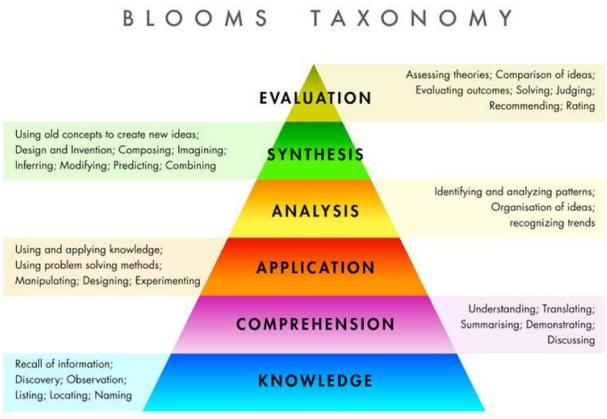

Fig.5: Hierarchy of learning by tapping the hidden forces of the human brain by moving to higher levels (Source: Internet)

model is more dynamic, as shown in Fig.6. Traditionally, academic leadership relied on a triad of duties and responsibilities—teaching, research and service—to assess the academic value of a faculty member to the university. The emphasis these days is on assessable desirable outcomes that students must possess on graduation that in turn will build a strong reputation for any university. The shift is from teacher-centred to student-centered (customer-focused) education with a view to assess not only the knowledge (learning) that has been promulgated but also what fraction (outcomes) has been received by the learners and implemented (objectives) in life beyond the walls of a university.

Arora's paradigm is based on the Carnegie Commission for the Advancement of Teaching's *Scholarship Reconsidered* (Boyer, 2014). In Arora's vision, the faculty portfolio is divided into four categories: defining, planning and inspiring intellectual development of the whole person (promulgation or propagation of the acquired knowledge to replace teaching); the assistance, perspective and consultation provided to practitioners (engagement with professionals within and outside the university); the integration of knowledge across departmental and school boundaries and even university boundaries (synthesis); and basic and applied research (discovery). A planetary model of these four functions is shown in Fig.6.

Arora's planetary model of Fig.6 encompasses Bloom's Taxonomy. Knowledge, both contributions to and drawn down from the central knowledge bank is like the sun radiating light from exploding hydrogen bombs in its interior from a fusion process, the source of enlightenment in all forms. It forms the core of Arora's model and maps the lower-level of Bloom's pyramid and makes it dynamic. Comprehension, application and analysis can be mapped into dynamic engagement and discovery mode. Synthesis is common in both models, which

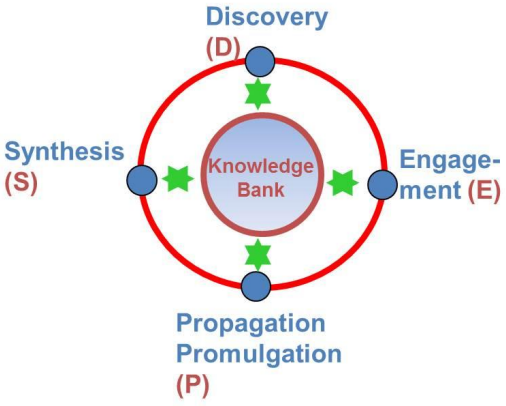

Fig.6: Priorities of the professorate to propagate a unified paradigm and learners to receive engaged training with discovery and integration naturally built within a curriculum

bring out vividly the engineering process of integration. Assessment (evaluation) is the natural process that keeps the activities in orbit and in dynamic state. In physics jargon, it is the centripetal (centre-seeking) force that keeps all PEDS activities in focus to craft a process of ongoing improvement (Goldratt & Cox, 1992). Arora's planetary model, therefore, is all encompassing from cradle to grave of a knowledge engineer as it shows the natural renewal process.

Considering the emerging socio-behavioral engineering age (Augustine, 1998), the need for effective and efficient integration or organisation of knowledge becomes more significant. The implementation of work modules as basic building blocks to achieve the curricular objectives has merits, but requires an interface to achieve its full potential as PEDS: promulgation or propagation of the acquired knowledge; engagement through knowledge management; knowledge discovery or creation; and synthesis of knowledge across departmental and school boundaries and even university boundaries.

Mentoring of students and research associates is an effective medium for the synthesising of various functions of guru-scholar-technopreneur. The development of higher cognitive skills that enable students to be independent learners and independent problem-solvers who know how to utilise their knowledge is an important goal of lifelong education with enduring impact throughout one's professional career and perhaps beyond retirement age. Left to their own devices, trainees will do what is easiest for them, which is to use their own learning style. It will take them less time, but it will not enhance skills in their weaker areas. Table 2 presents an assessment model based on PEDS. The priorities of the professorate at entry level must originate with discovery mode as the highest priority moving on to engagement mode as a person advances along the professorate hierarchy. There is an assumption that all other functions are established by the time a professorate achieves the ultimate rank or is promoted to a leadership position. The numerical score is the weight on each activity with a total of 10. For example, at the entry level, 40% emphasis should be on D (discovery) mode.

Similarly, when students are engaged in the knowledge delivery process, the work

TABLE 2
Changing Priorities of the Professorate Higher Up the Hierarchy Forming a Pyramid Structure Where the Leader Forms the Apex of the Pyramid

	P	E	D	S
Entry	3	2	4	1
Assoc.	4	1	3	2
Prof.	1	3	2	4
Chair	1	3	2	4
Dean	1	4	2	3
Admin	2	4	3	1

modules should be designed so that they are able to integrate all four PEDS functions by social interaction and in forming dynamic teams for learning enhancement.

RENEWAL AND ONGOING IMPROVEMENT

Augustine (1998) has defined the 21st Century as the Socio-engineering Age. As stated earlier, engineering is not a discipline, rather a process of integration. Goldratt (1992) lays out a process of identifying bottlenecks to enhance productivity following a system approach. An organisation cannot override the capacity of a bottleneck. Therefore, to enhance the output, the capacity of the bottleneck must be elevated for smooth supply-chain management. Adams (1996) portrays bottlenecks in a humorous manner through cartoons. In his portrayal of *Dilbert Principle*, he advocates: "The most ineffective workers are systematically moved to the place where they can do the least damage: management. Of course, this creates maximum damage, as their idiocy permeates corporate life. It seems as if we have turned nature's rules upside down. We systematically identify and promote people who have the least skills."

In Indian mythology, the Brahama-Vishnu-Shiva trinity is invoked in discovery of divine forces in the 'person within a person'. It is in the person within each of us, sometimes called the soul, where infinite potential resides. Covey lists three habits to create a Brahama the Creator in oneself by having private victories through gaining independence. Habit 1 (Be Proactive) is about taking responsibility for one's life. Habit 2 (Begin with the End in Mind) is based on imagination—the ability to envision in our mind what we cannot at present see with our eyes. It is goal driven, requiring an engineering process to move backward to find resources to meet the ends. Habit 3 (Put First Things First) is about prioritising. It is about our life management as well—our purpose, values, roles and priorities. The next three habits create Vishnu the preserver by moving from independence to interdependence. These three habits create the public victories and establish connections with the world at large. It is interdependence that is highly valued in a networked global economy where information travels at the speed of light. Habit 4 (Think Win-Win) sees life as a cooperative arena, not a competitive one. It is not zero-sum game demanding "I win, you lose;" or if you win, I lose. In a cooperative arrangement of resource sharing (covalent bonding in the language of chemistry), we make a community where everyone enjoys resources equally well. Habit 5 (Seek First to Understand, Then to Be Understood) is about enhancement of our listening skills. Listening is not hearing. Hearing is instantaneous with no permanent retention. Listening is about signal processing that gets embedded in our head, creating mindfulness. Habit 6 (Synergise) is making 1 and 1 equal 11 (not 2 or sometimes 1/2). It is about forming effective and efficient teams with open-mindedness embedded with the adventure of finding new solutions to old problems,

putting new wine in an old bottle and relabelling. The seventh habit of renewal is realisation as Shiva, the destroyer of ignorance, within oneself so transformation/ renewal is a natural process. It is about "Sharpening the Saw" that re-shapes the expression of the self. It encompasses physical, social/emotional, mental and spiritual forces. Covey has recently added an 8th habit that is another form of renewal as stated in *Good to Great* (Collins, 2001). It is in effect a renewal to thrive, innovate, excel and lead in the new reality. The goal is to march towards fulfilment, contribution and greatness beyond being efficient (rate of production) and effective (long-term retention).

The higher education system is undergoing dramatic changes due to many underlying factors, particularly technology innovation, emergence of knowledge economy, shifting demographics and globalisation. It is important for us to review the best practices that will bring out the necessary outcomes desired of the 21st century workforce. Taming the mind with correct attitudes to create a collective brain of the combined workforce for a knowledge organisation will become essential in the years to come.

CONCLUDING REMARKS

In the Socio-engineering Age, which embraces nano culture, innovations are being discovered to enhance creativity in synthesising man-made artificial forces and ever existing natural divine forces. Managing resources by engineering the social and behavioural patterns, as advocated above, are a must to derive synergy from a well-integrated training system both in and out of academia. As natural (God-made) and artificial (man-made) forces are understood and synthesised, there will be even greater need for a programmed approach while solving problems in the natural habitat of an organisation, whether in Asia, Europe, USA or anywhere else in the free world. In the search for an integrative process, the following resolutions for personal and professional attainment of all stakeholders are recommended:

- While planning for success, each one should consider oneself a contributing member of a larger enterprise. Our success is driven by how we talk, look, write, listen, create ideas, solve problems, motivate, persuade, lead, organise, handle anger and sleaze, and deal with power figures and outside organisations. In this capacity, we will be connoisseurs of talents, more curators than creators. Add motive and determination to achieve a goal and all stakeholders will progress towards that goal.
- Each stakeholder must have a sense of gratitude towards fellow workers. It is gratitude that transforms to a great attitude that reaches great altitudes in search of life, liberty and the pursuit of happiness. Success is getting what you like, but happiness is liking what you get and being grateful for it. Mind-body-soul integration through expression of gratitude takes our attitudes to great

heights in appreciating the meaning and enjoyment of life forces. With gratitude, we can switch perceptions from problem to opportunity, from resistance to acceptance, from ending to beginning, from sickness to healing, from anger to forgiveness. Once we put gratitude into motion, we ignite energy in motion (e-motion or emotion), thereby turning thoughts into motion that spurs the brain to take right actions: Train your mind, create your brain. Habitually grateful people have more energy, optimism, social connections and happiness. Gratitude means counting our blessings, being thankful and acknowledging everything that we receive is by the grace of those around us. It is living our life as if everything were a miracle, being aware persistently of how we have been blessed by others. Gratitude shifts our focus from what our life lacks to the richness that is already present. We must never forget that the highest appreciation is not to utter words, but to live by them. In the trinity advocated by Arora (Arora, 2015) living what one preaches includes: Buddham Bhav (Be an enlightened wise person); Dharmam Char (follow the path of righteousness); Yogastha Kuru Karmani (establish yourself in total integration of mind-body-soul to perform an action, in fact any action and manage reaction).

- Each stakeholder must resolve to get out of his/her cubicle by communicating effectively with people that may or may not think or operate in similar manner as another stakeholder might. Each one must realise that human nature is such that silence is deafening and curiosity overwhelming. The silence of a person is an indication that he or she is shaken psychologically and emotionally for a variety of reasons. A courageous leader will ignite curiosity in a silent colleague who is identified as not participating with enough enthusiasm. It is like creating resonant behaviour by matching the "frequency" of the driver (leader) with the driven (follower).
- Each stakeholder will keep on reminding him/herself about what is important in engineering his/her future and of those in his/her circle of influence. Not only will he/she produce quality attributes among generic "customers," he/she will also create a quality educational organisation by relating to his/her colleagues and by forming effective and efficient teams. As a member of a team, a stakeholder will remain an intimate ally to his/her colleagues and peers alike. He/she may not have the loudest voices but he/she will have the most attentive ears. The ingredients are a combination of her competence, commitment, caring, fairness, candour and generosity.
- Each stakeholder will harness the tremendous information processing capability of their own three-pound three-quart-sized internal computer—the brain, estimated to have about 17 billion bytes of storage and operating 100 times faster than a real computer.

He/she will not waste this powerful knowledge managing resource for self-cancellation of his/her own endeavours with his/her own selfish motives. He/she will enhance the creativity of this nature-given resource with engineered patterns and processes to give his/her stakeholders what they need to succeed and live a meaningful life. Each one will use mind-power software to tame the mind to create the brain hardware for all in his/her circle of influence.

This list is not meant to be exhaustive, but to demonstrate the fact that we are not working or staying in isolation in this interconnected global economy. We must learn synthesis not only with disciplinary diversity, but also with the world's diversity in all its forms (Tobias, 1994). All stakeholders must work together, collectively staying synchronous to the value, virtues and needs of various segments of the global economy. Knowledge is an important ingredient to possess what can be converted into products or services as conditions and times change for the human enterprise to respond in a fast changing world, promoting people-to-people projects for happiness and contentment. Conversion is the key that converts knowledge in engineering the pathways for human enterprises.

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