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Educating Tomorrow's Authentic Global Leaders
Synthesis of Engineering, Management and Liberal Arts

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ABSTRACT

A quality global organization, of the people, by the people, and for the people, accentuates the design, nurturing, modification, and extension of the behavioural and emotional traits of all those in its circle of influence. This is only possible by synthesis of text and context by taking into account the shifting paradigms in global practices and varying societal needs. An engineering paradigm emphasizing ongoing process of holistic thinking, analytical character of scientific management, and implementation character of behavioural sciences is described. Embedded higher-order life, professional, and technical skills in training professionals for a global organization are enumerated. The professionals so trained distinguish logic from tradition, tradition from prejudice, prejudice from common sense, and common sense from nonsense. The paper thrashes out making and renewal of a global organization comprising quality professionals with life, liberty, and pursuit of happiness for the people it serves, no matter what the ethnic make up and location in the world. A course on Quantitative Analysis and Programming Methods, following this paradigm, in educating professionals for a global organization, is described.

Keywords: behavioural engineering, techno-entrepreneurship, outcomes, theory of constraints.

1. INTRODUCTION

In this global era, nations of the planet Earth are moving into trade blocks and multinational organizations. There is a need for renaissance professionals who are able to integrate science, humanities, and management concepts [1-5]. These changes require the 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 organization 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 and continuous improvement.

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Today, more and more organizations, 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. The emerging facts from the successful organizations 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 the change. The choice is stark: educate, innovate or evaporate. The innovation comes from seeking wisdom wherever it can be found [1, 6].

2. BEHAVIOURAL ENGINEERING

An outcome-based education (OBE) for quality assurance and its effectiveness in the global arena is in the air around the world. Research in propagation/promulgation of the acquired knowledge or intellectual property is being broadly discussed in every institution and in every organization. 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.*" 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. This paper is an integration of science, engineering, and management in the spirit of that stated in [1], [2]. An engineering process is an engine of invention, innovation, and growth. An algorithm of this process allows one to find pathways in an uncharted territory of human thoughts by using a "compass." Physical, biological, and behavioural scientist's 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 synthesize diverse disciplines are required.

If engineering becomes all technique and technology, it loses the higher purpose of service to humanity. In such circumstances, we become victims of our own creation. Behavioural engineering with strong foundation in the liberal arts holds the key to personal and professional development and defines the marks of an educated professional [7-8]. In the light of a diversity of definitions of liberal arts, it is always good idea to return to basics. The traditional liberal arts consist of two components:

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

Long time ago, we walked away from this concept of liberal arts for a well-rounded educated person. A new mix—a hybrid of technology embracing quadrivium, modern liberal arts embracing trivium, and management principles embracing the process that lubricates human interactions—is developing. This

integration of technical innovations with business practices is being coined as technopreneurship (or techno-entrepreneurship). Many believe that a goal-driven process of engineering with a goal of serving the humanity—a synthesis of technology and entrepreneurship—is a new liberal art and hence anticipated birth of behavioural or managerial engineering.

Recognizing this paradigm shift, U. S. Accreditation Board for Engineering and Technology (ABET) in its well researched *ABET Criteria 2000* [3] has nurtured the spirit of technopreneurship by listing outcomes (attributes) desired of technical graduates on graduation. When adapted to professional development across the board for all graduates, these a-k attributes (Criterion 3) as these are popularly known, are *re-stated* as follows (the changes from original criteria as these apply to multi-disciplinary professions are indicated in italics):

a. An ability to apply *traditional liberal arts and behavioural sciences in a techno-savvy world.*
b. An ability to design and conduct *field* experiments and *surveys*, as well as to analyze and interpret data.
c. An ability to design a system, component, process, or *procedure* to meet desired needs.
d. An ability to function on multi-disciplinary teams.
e. An ability to identify, formulates, and solves *real-life* problems *with a service emphasis.*
f. An understanding of professional and ethical responsibility.
g. An ability to communicate effectively.
h. The broad education necessary to understand the impact of *professional* solutions in a global and societal context.
i. A recognition of the need for, and an ability to engage in life-long learning.
j. A knowledge of contemporary issues.
k. An ability to use the techniques, skills, and modern *information* tools necessary for *professional practice*.

An example of this paradigm is followed in professional training in EGM321: Quantitative Analysis and Programming Methods course taught at Wilkes University in the Fall of 2010. The Course Outline [5] defines the objectives of the course as follows:

1. Solve the decision-making problems that confront and confound managers in both the public and private sector by developing mathematical models of these problems. (a, e, g).
2. Use computer and information tools based on Excel spreadsheet to design, model, analyze, and interpret the outcomes. (c, k)
3. Communicate comprehension in: **(i)** two written reports on individual case studies, **(ii)** in an oral and written summary of a business paper on

contemporary topic, **(iii)** in problem restatements in weekly assignments. (g, h, j)
4. Complete a team project, evaluate contributions of partners, and assess values and virtues of team dynamics. (b, d, f, g, k)
5. Prepare a portfolio of the course that highlights achievements in the course with presentation of a plan that outlines how students anticipate changes taking place in the management profession and how outcomes from this course will advance their career path. (e, f, h, i, j, k)

The letters in the parenthesis refer to a-k attributes given above. The course ran on an honour system that expected each student to put an honest effort in meeting the learning objectives. The purpose of the homework and case studies was to provide a working environment for the students to practice problem solving, thereby enhancing their analytical, synergistic, synthetic, syntactical, computing, and people-oriented skills. Their ability to integrate mathematical and engineering sciences in decision-making processes demonstrated the synthesis character of engineering.

A clear distinction between goals, objectives, and outcomes was delineated. The goals are sometimes referred to as global or general objectives; likewise, objectives are sometimes referred to as specific goals. The point is that goals are general in nature, while objectives are specific in nature, yet both refer to the desired outcomes—the mileage covered during a journey (objective) towards a given goal. Cognitive domain of most interest to learners in management involves knowledge acquisition and dissemination, critical thinking, and synthesis. The Bloom's Taxonomy divides this cognitive domain into six levels [18], as shown in Figure 1:

1. *Knowledge* — Recalling material one has learned. Remembering facts, principles, steps in a sequence, etc.
2. *Comprehension* — Understanding the material. At this stage one should be able to explain what he or she knows, translates to new forms and symbols and extrapolates.
3. *Applications* — At this stage one should be able to use the material in new situations, that is apply concepts, principles, rules, theories, and laws to find solutions to new problems—problems he/she has not seen before.
4. *Analysis* — At this level one should be able to break things apart so that relationships are understood. For example, one might analyze a conflicting situation using what he/she learned about people's behaviour.
5. *Synthesis* — one should be able to put together parts to form a new whole—that never was before. Engineering entrepreneurs do this when they write proposals, design new products, etc.
6. *Evaluation* — Here one should be able to use what one knows about a subject area to make critical judgments, rate ideas or objects and to accept or

reflect materials based on standards. The key skill is the ability to make judgments.

Considering Bloom's hierarchy of Fig. 1, any educational organization should stress more on problem- and project-based learning. It is well understood that academic staff who are in direct touch with students can better design the curriculum and related instructional strategies. The academic staffs are responsible for maintaining the vibrant curriculum. Benjamin Bloom headed a group of educational psychologists who developed a classification of levels of intellectual behaviour important in learning. Bloom found that over 95 % of the test questions that students encounter require them to think only at the lowest possible level—the recall of information. Bloom's six levels of Figure 1 within the cognitive domain span from the simple recall or recognition of facts, as the lowest level, through increasingly more complex and abstract mental levels, to the highest order which is classified as evaluation. Engineering curriculum based on OBE must develop students to embrace the top five levels other than just the knowledge delivery and recall.

Figure 1: Bloom's Taxonomy of Student Learning

The cognitive platform above explains how EGM321 course was structured. The level 1 relates to listening in the lecture rooms. That is not enough for a student to become an informed professional. He/she needs to restate ideas in different forms while posing questions in and out of the classroom (level 2). Application part (level 3) comes in when students attack complex problems and case studies. Analysis (level 4) allows a student to delineate the steps in doing individual design problems/projects that have a single outcome. However, level 5 brings the student to where he/she will be at the peak of profession—generating alternatives towards meeting the goals of a given project or organization. The level 6 brings the student to evaluating alternatives in the context of its usage and also to assess his team members' contributions in a team project.

The students were asked to assess outcomes by evaluating the competency level (on the scale of 1-5) at which each of these objectives was met. This gives us, in a teaching organization, a process of continuous improvement. Analogous paradigms can be set while training professionals in other areas and in other organizations.

3. CONTEMPORARY BUSINESS PRACTICES

Shifting paradigms require one to address the contemporary issues as these arise and develop associated leadership/management strategies in one's organization. Once, management and business books were separated from technical realities. Even today, these are full of abstract philosophies. This trend is changing in order to lubricate the process of human interaction and development in the wake of emerging technologies or brain-ware. *The Dilbert Principle* [4] depicts the process of human interactions through cartoons based on real examples in the business/industrial world. Adams postulates the presence of the Dilbert Principle at workplaces where "incompetent workers are promoted directly to the management without ever passing through the competency stage." The Dilbert Principle's presence in the professional world stems from the presence of incompetent professionals who are unable to keep pace with changing technology, but are shuffled to management positions to minimize damage. An engineering process will conclude just the opposite: It creates the maximum damage since the idiocy of incompetent managers permeates down to the worker level and hence affects the whole organization. Such administrators, pretending to be leaders, are not able to make competent decisions for implementing innovations or delegating authority. Neither will they assume responsibility of their actions as if it were a creation of some unknown super power. Professionals working in such an organization become street-smart for personal benefits. Hence appears the need for high ethical standards.

A quality organization and ethical standards of people comprising it go hand in hand. The name of W. Edwards Deming [10] and quality has become synonymous. The very first point of Deming's 14-point paradigm creates a constancy of purpose—to accept the obligation to constantly improve the product, service, or procedure through innovation, research, and education in all facets and in all departments. This automatically leads to his second point: Adopt a new paradigm that rejects "acceptable" quality, poor service, and ill-defined procedures as a way of life. The 12 other points emphasize a rethinking of the past practices in favour of renewal and innovations. Deming's Plan-Do-Study-Act (PDSA) cycle is a systematic way of problem solving. Removing bottlenecks are necessary for a given job that prevents people from performing at their best. Open communication channels drive out fears and remove bottlenecks. Removal of barriers presented by bottlenecks is well advocated in the ABET

Criteria stated above as well as in the Goldratt's Theory of Constraints discussed below.

In the light of current scandals in the American Corporate World, an ethical crisis has popped up. The world's perception of America and an American is split in the light of post-9/11/2001 developments. As an example, in Asian minds, America is a moving target, rife with contradictions. Images of a stable polity, a healthy economy, and cutting-edge universities blend in Asian minds with those of a parochial executive and legislative branches, social violence, and moral decadence. Perhaps American organizations are not looking at the world the same way as the organizations from other part of the world are looking at America. The goals of an organization or a nation are much higher than the goals of the people comprising it. This requires satisfying goals/needs/aspirations of the people in designing a strategic planning process towards the mission of a community of the people, by the people, and for the people keeping in view the law of *dharma* (performance of quality duties with high ethical standards), as advocated by Chopra [7]. Quality is the standard by which global community measures goods and services it values. Ethics is the standard by which the people in a community measure their own behaviour and that of the organization they serve. There seems to be a good correlation between the two. In virtually every case, when organizational ethics improve, quality also improves.

Almost every professional field now requires integration of teaching of ethics within the professional curriculum. There is a generalized and widespread perception that the organizations in America and elsewhere are suffering from a breakdown in ethics. It has pervaded every corner and stratum of society and hence been embedded in corporate culture. In general, Americans and others, driven by their faith, hold moral beliefs similar to their ancestors. Every culture around the world emphasizes honesty, personal responsibility, tolerance, and good citizenship. Why the need for teaching ethics? Perhaps, it requires an education to avoid disasters. Employees typically come to work with the intention of doing the best job possible but are stymied and discouraged at every level in a corporate world. Employees are sometimes prevented from doing the right things by systems that keep professionals busy in doing things right (fixing recurrent problems). Such a system discourages individual initiative, improved efficiency and improved quality. An ethical problem needs to be solved just like an engineering problem. VCR paradigm developed at Carnegie-Mellon University [17] is one possible platform on which to base the solution to an ethical problem. V stands for Values and Virtues. C stands for Consequences and Contingencies, and R stand for Rights and Responsibilities. VCR paradigm allows one to evaluate an action before executing, according to the law of *dharma* [7]. In training professionals on work ethics, the emphasis should be on finding ways to build strong character in professionals or the organization they serve with the intent to build trust and enhance trustworthiness among the stakeholders. After all, an efficient and reliable economic and political system is

always based on a moral foundation. This principles-based leadership [9] approach not only enhances our effectiveness, but also creates a healthy society that will judge professionals by their contributions to humankind.

The Goal [11]—written in novel form—is targeted towards enhancing the throughput of an organization that requires managers to understand a business practice, especially the manufacturing process. It is the first book in a sequence of four books, the other three being *It's Not Luck* [12], *Critical Chain* [13], and *Necessary But Not Sufficient* [14]. The series details the Theory of Constraints (TOC) in shortening the production cycle and problem solving by thinking processes. A TOC solution maps cause-effect relationships and allows one to sell the solution to a non-trusting hostile audience. It explains how the TOC and thinking processes work equally well in business, politics, and family disputes—offering peace or profit without compromise. The paradigm emphasizes the socratic method involving dialogue between a teacher and a pupil in the tradition of *gurukula* (home of the teacher) system practiced in ancient India. A TOC solution is based on the stakeholders' analysis that includes:

People: Their perceptions, motivations, values, habits, skills, and talents.
Formal Organization Structure: That evaluates physical environments, available technology, possible strategies, current and desired infrastructure, policies, and procedures.
Informal Organization: That analyses the culture, values and norms emerging from the interaction between people, the organization and world outside the organization.

4. ENTREPRENEURIAL BRAIN

In spite of the vast number of innovations in information technology, the human brain remains an incredible information processor and a remarkable knowledge manager. In any organization, people either produce, manage, or lead. However, a true leader has to perform all of these roles. Whole-brain thinking is a must for envisioning the future while designing a strategic plan. Ned Hermann [16] divides the brain into 4 quadrants: two on the left (quadrant A and B) and two on the right (quadrant C and D), as shown in Figure 1. The left half works more with logic, words, structures, and analysis. In contrast, the right half works more 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. Most of us are trained to be quadrant A thinkers who think in terms of numbers and words. A process to move us from Quadrant A to D can be generated to make one an entrepreneur—idea generator.

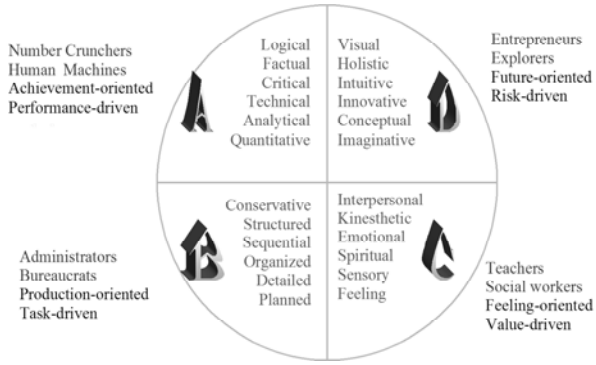

Figure 2: Ned Hermann's Four-Quadrant Model of the Brain with Predominance Indicated in each Quadrant

Professions requiring Quadrant A dominance are those of lawyers, engineers, computer scientists, analysts, bankers, and physicians, practicing external activities. Quadrant A thinking can be enhanced typically by the following activities:

- Undertaking case studies
- Collecting data, information, and judging ideas
- Dealing with hardware and things, not people
- Living in the present (carpe diem)
- Undertaking research using scientific method
- Reading textbooks and example problems
- Undertaking library searches
- Making hypothesis/theory and testing

Quadrant B dominant professions, with procedural activities, are those of: administrators, tactical planners, bureaucrats, and bookkeepers. Enhancement of learning in this quadrant is typified by the following activities:

- Following directions, e. g., in a recipe book
- Testing theories to find out missing links
- Using programmed learning and tutoring
- Planning projects, schedules, and execution
- Listening and keeping detailed instructions
- Meeting deadlines with no people concerns
- Practicing new skills repetitively and writing how-to manuals

Teachers, nurses, social workers, and musicians are interactively involved with people and are dominated by quadrant C thinking. The required skills for these professions can be enhanced by the following practices:

- Listening to and sharing ideas to generate motivation and enthusiasm

- Keeping journal to record feelings and spiritual values
- Traveling to meet and explore people-oriented activities
- Respecting others' rights and points of view
- Learning by teaching, touching, and feeling

Entrepreneurs, explorers, playwrights, R&D personnel, detectives, and artists are dominated by Quadrant D thinking (internal creativity). The persons desiring the enhancement of this type of thinking are recommended to practice the following activities:

- Looking at the big picture and the context.
- Participating actively, simulating, and asking "what-if?" questions.
- Respecting multiplicity and aesthetics.
- Brainstorming for and playing with wild ideas.
- Exploring un-obvious facts and figures.
- Thinking about present and future trends.
- Synthesizing to come up with innovations.

At an individual level, one can obtain mastery in any of these quadrants by continued applications of the stated activities. However, an organization exists by a whole-brain thinking and planning. Diversity is a byword by which to create an organization. The making of an organization, therefore, requires a diverse group of people each with strong bents in one of the four quadrants, but with a considerable overlap to interact with people with dominance in other quadrants. Explorers and detectives define the problem and explore the markets. Artists create ideas that can be translated into reality by engineers by careful evaluation. A producer will implement the solution, e. g., in a manufacturing environment. A judge will judge the effectiveness of an idea in a socio-legal system and find ways to protect the intellectual property. Leaders emerging from these self-directed work teams turn out to be effective and efficient strategic planners. They facilitate interaction so that creativity will flourish and provide an environment for ideas and technology convergence. Such leaders comprise knowledge organizations with a multinational character. Leadership in a knowledge organization deals with direction (production capability) while management deals with speed (production). A courageous leader will climb the tallest tree in a jungle (unknown territory) and cry: "wrong jungle!" even though he is advised to be quiet as his team cruises through the wrong jungle and progress is being reported in terms of mileage covered.

5. RENEWAL

According to Tom Peters—the management guru—every organization has Brahma—the Creator, Vishnu—the Preserver, and Shiva—the Destroyer. Once an organization is created, Vishnu takes over. In any organization, it is Shiva

who has to be protected to destroy obsolete practices so that renewal is a natural process. In making the case for renewal, Covey [6] strongly advises to move from dependence to independence and to inter-dependence. It is the inter-dependence, which is highly valued in a world where information travels at the speed of light. This inter-dependence can truly teach us the value of teamwork in a multicultural and multicoloured world. True success means not only material and financial wealth, but also enjoyment of life's journey, continued expansion of happiness, and the progressive realization of worthy goals [7]. A fully functioning global person with a knowledge of the self, the job, the organization, the environment, and the world can very well understand the value of an engineering process and with this knowledge develops the power of sound decision making. A principle-centered training based on an engineering paradigm follows these steps—first to gather and diagnose the data; second, to select priorities, values, and objectives; third, to identify and evaluate alternatives; fourth, to plan and decide implementation algorithm; and fifth, to compare results with original goals and objectives.

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