

Training tomorrow's leaders

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ABSTRACT: As stated by Margot Cairnes (2009), in our present world of rapid discontinuous change and wicked problems, the majority of leadership training is still competency and skills based. However, these competencies and skills are still based on what worked for leaders in the past when the world was simpler, less dynamic and far easier to understand. If we adopt this approach, we are merely training people for yesterday. Mark Satov (2010) argues that success often requires being adept at managing conflicting behaviour and that our engineers must know when it is all right to put away the abacus and practice intuitive thinking. Cairnes and Satov agree that effective leadership and management training takes place on the job, not in the classroom. Soft skills are hard to teach well from a textbook, because these concepts are easier to learn intellectually than to apply. Tomorrow's leaders are developed on the job where they work on solving problems in complex social and political environments supported by high level programs aimed at learning by doing, learning about themselves as they do, and learning about relationships as they happen.

INTRODUCTION

Margot Cairnes, a Sydney-based leadership strategist, has pointed out that in our present world of rapid and discontinuous change and wicked problems, the majority of leadership training is still competency and skills based [1]. However, these competencies and skills are based on what worked for leaders in the past [1]. She goes on to further criticise current leadership training:

> *Most training is run to a formula - the* sausage factory *school of leadership - with their seven habits, rules or answers which sell books and fuel the multibillion dollar global online training and management school markets, not to mention the huge industry of in-house training. Formulas and models appear to provide certainty. Yet study after study tells us that we are not producing functional leaders and that we are facing a leadership crisis. By concentrating on formulas (modelled on past, now out-dated success and behaviours) we are training people for yesterday - when the world was simpler, less dynamic and far easier to understand* [1].

Toronto-based management consultant Mark Satov argues that (leadership) success often requires being adept at managing conflicting behaviour [2]. Satov says that *our engineers must know when it's all right to put away the abacus and practice intuitive thinking*.

Cairnes [1] and Satov [2] both suggest that effective leadership and management training takes place on the job, not in the classroom. Satov argues that *soft skills*, which often can be compensating behaviour that one of your subordinates lacks, are hard to teach well from a textbook, because these concepts are easier to learn intellectually that to apply [2]. He suggests using actual workplace situations as lessons to show employees how they could have achieved certain objectives without sacrificing others. Carnes reinforces this and argues that:

> *The way to develop today's and tomorrow's leaders is on the job where they can work on solving problems in complex social and political environments supported by high level programs aimed at learning by doing. Not just learning about doing but learning about themselves as they do. Learning about relationships as they happen. Learning about strategy in real time* [2].

In this paper, we will examine *engineering leadership education* beginning with an examination of the attributes/capabilities of an engineering leader. We will then look at the means of effectively developing these attributes, recognising that there will not be general agreement due to *the variety of teachers, students, programs of study, careers, and industry sectors* [3]. However, the overall consensus is that effective leadership development requires much more than classroom activities using textbooks, case studies, theories and models.

ATTRIBUTES/CAPABILITIES OF AN ENGINEERING LEADER

In their very detailed summary of the 1995 ASCE Civil Engineering Education Conference, Russell and Yao [4], when discussing technical competence and *successful* engineers, noted:

> *An engineer is hired for his or her technical skills, fired for poor people skills, and promoted for leadership and management skills.* [4].

ABET, Inc., formerly, The Accreditation Board for Engineering and Technology (ABET) in the USA in its criteria for engineering accreditation articulates eleven student outcomes, (a) through (k) under Criterion 3: Student Outcomes [5]. Bowman and Farr [3] have divided these eleven criteria into two categories, namely, *Leadership Criteria* and *Technical Criteria*. The seven *Leadership Criteria* are listed in Table 1:

Table 1: ABET Criterion 3: Student Outcomes that address leadership criteria.

Outcome Designation	Student Outcome
(d)	An ability to function on multidisciplinary teams
(e)	An ability to identify, formulate, and solve engineering problems
(f)	An understanding or professional and ethical responsibility
(g)	An ability to communicate effectively
(h)	The broad education necessary to understand the impact of engineering solutions in a global/societal context
(i)	A recognition of the need for, and an ability to, engage in lifelong learning
(j)	A knowledge of contemporary issues

Engineers Canada through its Accreditation Board to evaluate Canadian engineering programs, details twelve graduate attributes, 3.1.1 through 3.1.12, that are used in the assessment of program outcomes [6]. These twelve graduate attributes are similar in most respects to the eleven student outcomes of ABET's Criterion 3. The graduate attributes that relate to *leadership* include:

3.1.2 *Problem analysis:* An ability to use appropriate knowledge and skills to identify, formulate, analyse and solve complex engineering problems in order to reach substantial conclusions.

3.1.6 *Individual and team work:* An ability to work effectively as a member and leader in teams, preferably in a multi-disciplinary setting.

3.1.7 *Communication skills:* An ability to communicate complex engineering concepts within the profession and with society at large. Such ability includes reading, writing, speaking and listening, and the ability to comprehend and write effective reports and design documentation, and to give and effectively respond to clear instructions.

3.1.8 *Professionalism:* An understanding of the roles and responsibilities of the professional engineer in society, especially the primary role of protection of the public and public interest.

3.1.9 *Impact of engineering on society and the environment:* An ability to analyse social and environmental aspects of engineering activities. Such ability includes an understanding of the interactions that engineering has with the economic, social, health, safety, legal, and cultural aspects of society, the uncertainties in the prediction of such interactions; and the concepts of sustainable design and development and environmental stewardship.

3.1.10 *Ethics and equity:* An ability to apply professional ethics, accountability, and equity.

3.1.11 *Economic and project management:* An ability to appropriately incorporate economics and business practices including project, risk, and change management into the practice of engineering and to understand their limitations.

3.1.12 *Life-long learning:* An ability to identify and to address their own educational needs in a changing world in ways sufficient to maintain their competence and to allow them to contribute to the advancement of knowledge.

Bowman and Farr [7] in a cursory review of professional engineering publications (American Society for Civil Engineering, American Society of Engineering Education, American Society for Engineering Management, IEEE) together with rankings from the U.S. News and World Report, identified four primary leadership traits, namely: *communications* (ABET (g); CEAB 3.1.7); *teamwork* (ABET (d); CEAB 3.1.6); *cultural awareness* (ABET (h); CEAB 3.1.9); and *ethics* (ABET (f); CEAB 3.1.10).

Bowman and Farr, in an attempt to identify the attributes of leaders, posed the question, *What is leadership?* In answering this question they concluded that, second to technical competence, leadership is the most important trait needed by young engineers to survive in the competitive engineering profession [3].

They also concluded that leadership comprises the human element of engineering endeavours and that leadership development is a lifelong pursuit tailored to management levels [3]. Based on the writings of Bethel [8], Rost [9] and

Farr et al [10], they define a leader in the following way: *A leader is someone who can influence an organized group toward accomplishing its goals* [3].

Farr et al [10] identified nine specific leadership attributes:

- Big Thinker
- *Ethical* and Courageous
- Masters Change
- Risk Taker
- Mission that Matters
- Decision Maker
- Uses Power Wisely
- *Team Builder*
- *Good Communicator*

Comparing this list with the four primary leadership traits of Bowman and Farr [7], there is no attribute that is even remotely related to *cultural awareness*. This may, in part, be related to the fact that the study by Farr et al [10] was published in 1997 before ABET was using *outcomes assessment* and before globalisation/cultural awareness issues came to the forefront.

Bowman and Farr make the point that as engineers rise to positions of increasing responsibility, the required skill set changes and leadership becomes the essential skill [3].

> *As engineers rise to position of increasing responsibility, they increasingly influence the administration, profit, and direction of an organization. As engineers proceed up the corporate ladder, leadership becomes the essential skill. Senior managing engineers spend less time on traditional engineering detail as they are more concerned with the business aspects of securing and satisfactorily managing projects. Senior engineers typically have also completed their formal college education; they increasingly rely on informal on-the-job training, mentoring, and professional networking* [3].

There are two issues mentioned in this quote that will be addressed briefly at this stage, but returned to later for a fuller discussion. First is the use of *manager* and *leader*: these are different. Second, Bowman and Farr suggested that the development of leadership skills takes place by *informal on-the-job training, mentoring and professional networking* [3]. This is, to a large extent, in agreement with the postulate of Cairnes [1] and Satov [2] that effective leadership training takes place on-the-job.

To conclude this section, we will review the *capabilities of an engineering leader* as identified by the Gordon-MIT Engineering Leadership Program. Housed in MIT's School of Engineering, the Program provides:

> *an integrated set of leadership-oriented, discipline building, hands-on engineering activities, set in the context of the practice of engineering, designed to develop outstanding MIT students as disciplined, future leaders in the world of engineering practice* [11].

The capabilities of an engineering leader are summarised in Table 2 (modified from reference [12]).

Table 2: Capabilities of an Engineering Leader - Gordon-MIT Engineering Leadership Program (adapted from [12]).

Core Values and Character	Initiative and decision making (responsibility, integrity, loyalty, self-awareness, personal vision)
Sense making	Making sense of the world around us (the needs of society, technology, system thinking, solution judgment)
Relating	Developing key relationships and networks (listening and seeking compromise, communicating and advocating, wide connections, enterprise)
Visioning	Creating a compelling image of the future (tapping creativity, defining solutions, creating concepts)
Realising the vision	Getting the job done (building a team, managing a project, innovating, inventing, implementing and operating)
Technical knowledge And critical reasoning	Grounding in the disciplinary fundamentals (problem solving, critical thinking, inquiry)

Although it uses different descriptors, these capabilities are similar to those described by ABET, CEAB and other accrediting bodies and contains both what Bowman and Farr [3] describe as *Leadership criteria* (Table 1 in this paper) and *Technical criteria*. To the writer's mind, no leadership development could take place without *core values and character* being present to a high level.

MEANS OF EFFECTIVELY DEVELOPING LEADERSHIP ATTRIBUTES

Graham et al have commented in their whitepaper on engineering leadership education that there is a dearth of formal networks, events and research programs in engineering leadership education [12]. This is in stark contrast to the parallel educational themes of *engineering entrepreneurship* and *global engineering* for which a number of formal learning communities, resource centres and annual events (e.g. Roundtables, Colloquia) exist. Commenting further on the current situation in engineering leadership education, Graham et al [12] note that:

> *Across the world, the mission statements of many undergraduate engineering degrees include aspirations such as* …to produce engineering leaders for the 21st Century. *However, the majority of programs appear to have no formal or articulated mechanism to deliver the leadership component of this goal, beyond (typically) student involvement in project- or problem-based learning activities.*
>
> *A simple Internet search of* engineering leadership education *will reveal a wide variety of programs currently being offered at undergraduate level, many of which are based in the US. When investigated more closely, however, it appears that many of these are not coherent programs designed for engineering students, but simply pull together a series of pre-existing modules from across the university with perhaps one additional team-based project at the end of the sequence* [12].

It would seem appropriate at this point to comment briefly on project-based learning (PjBL). PjBL lies at the heart of the Gordon-MIT Engineering Leadership program since it is regarded as *the key mechanism for students to develop and reflect on their individual engineering leadership skills* [13]. As such, it can be potentially regarded as a significant component of any engineering leadership education program. If we take Prince and Felder's [14] broad definition of PjBL, namely:

> *Project-based learning begins with an assignment to carry out one or more tasks that lead to the production of a final product - a design, a model, a device or a computer simulation. The culmination of the project is normally a written and/or oral report summarizing the procedure used to produce the product and presenting the outcome* [14],

then the associated activities can take place on campus or *on-the-job* as in an internship or Co-op placement.

Graham et al found that for the majority of *engineering leadership education* programs that were in place, their inception had been motivated by one of two drivers [12], namely:

1. To develop leaders who are able to operate effectively inside and outside the engineering profession.
2. To ensure that their national improves or maintains its globally competitive position [particularly evident in US-based programs].

Graham et al [12] also found that specifically *designed* engineering leadership education programs tended to fit into one or more of four categories:

1. Those based around leadership and management *theory*.
2. Those based on team projects with a global, environmental or service focus.
3. Those involving *coaching* of more junior students, usually in project teams.
4. Those involving industry-based *real-world* projects.

Three related trends were predicted for engineering leadership education in the future [12]:

1. global engineering: *increasing focus on the students' ability to operate in complex, international multi-disciplinary teams, with a stronger awareness of national and cultural differences in their approach to engineering problems.*
2. program collaborations: *greater development of cross-national partnerships between engineering leadership programs, in part to offer students greater* global *exposure.*
3. self-analysis and reflection: *awareness-building of the students' personal skill set, analysis of how this will impact their own leadership ability and provision of a tailored program to accommodate the students' individual development needs.*

A note with respect to *global engineering*: VanderSteen and Mushtaq [15] present a convincing case that local community engagement provides many of the benefits gained from international experience with fewer practical, ethical and pedagogical risks. Such team projects can often have a service or environmental focus.

CONCLUDING REMARKS

As we have noted already in this paper, the terms *manager* and *leader* are sometimes used interchangeably, and management *theory* has been used as the basis for the design of engineering leadership education programs. A cautionary note is in order. As succinctly described by Alec Bruce [16]:

Too often we fail to make the distinction between leaders and managers. Some leaders are managers and the reverse is also true, but not always. Managers have specific, supervisory roles to perform. And, so, they accumulate resources in order to get the job done. Leaders, however, can appear almost anywhere, at every level in an organization. They give things away freely - their time, their ideas, even their personal ambitions – in order to build something bigger than themselves [16].

Let us ensure that we are developing *leadership* and not *management* education programs since, as Alec Bruce notes [16]:

...the world has all the managers it can handle. Now, more than at any other time in recent history, it desperately craves leaders [16].

A similar sentiment was expressed fourteen years ago by Jim Krug in his reflective piece on *Leadership Development: You Can Never Have Too Many Leaders* [17]. When looking at the Gordon-MIT Engineering Leadership Program [11], it can be seen that this program as it progresses through the course of years one and two goes from all to many to few students: This is not consistent with the viewpoint that you can never have too many leaders.

Let us go back now to the original premise of Margot Cairnes [1]:

The leadership development we need helps us become conscious of not only what we do, but why *we do it. This is deep personal development and awareness raising.* It is most effective when done working on live, complex, changing and strategic issues. *There are no formulas for right action, thought or speech. There is only the desire to lift our levels of consciousness, morality, spirit, effectiveness and our capacity to think at even high levels.*

There is a high level of general agreement that working on live, complex, changing and strategic issues is the most effective way of developing leadership skills. However, this can occur not only on-the-job but as part of the formal education through such means as project-based learning (describe by Bowman and Farr [3] as practice-oriented projects). As already mentioned in the Introduction section, Satov [2] argued that engineers must practice intuitive thinking which itself depends on *operative studies of a rich variety of examples and models* [18].

Intuitive experiences must be acquired by the student through his/her own activities – they cannot be learned through verbal instruction [18].

Whitman further noted that …*Students must be stimulated to* reflect *upon their intuitive activities* [18].

It is now over 40 years since Professor W.E. Holland at Purdue University wrote his seminal paper, *The Argument: Engineering Education for Social Leadership* [19]. In this paper one can find many foundation elements of *engineering leadership education*. To Quote Professor Holland:

As builders of bridges between the world of science and the work of man, they (engineers) must become sensitive, far-sighted, responsible and dynamic in joining these two worlds for the purpose of human fulfilment.

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