AC 2007-549: ATTRIBUTES OF TECHNOLOGY LEADERS

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Attributes of technology leaders

Abstract

A consortium of companies and universities has developed a certificate to help prepare senior engineers to become technology executives. One of the learning outcomes is that the target jobs are very diverse and demanding. To qualify that outcome, the participating groups have prepared a list of the attributes they consider to be essential in a technical leader. The desired attributes can be broadly considered in four groups: personal features, communication ability, operational (management) capabilities and technical skills. The paper concentrates on personal attributes since they are essential to the successful application of the other skills. A simple process has been identified to develop the personal skills in early industry training and in academic technology programs.

Introduction and scope

Over the past 30 years, most high-technology companies have developed dual paths to technology leadership. One route is for technical specialists. It is often called a 'Technical Ladder' and it is a way to retain and recognize the depth of expertise needed for the business. The other path is through project management which requires broad experience in many contributing functions. The paths are represented in figure 1 which shows the trade-off between breadth and depth. New engineering or technology graduates enter the job market with specific discipline skills and would normally stay with that specialization unless they make a deliberate move into project management.

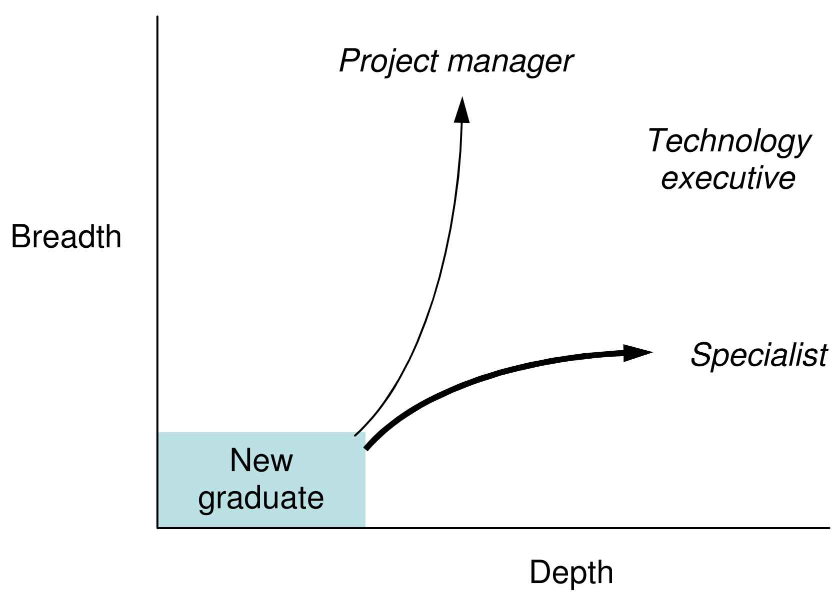

Figure 1. Technical career path options

However, no solution is static and as advanced technology has allowed development of more complex systems, the technical roles have evolved too. Large systems companies have steadily moved away from being the monolithic provider of all components to focus on specific capabilities. As a result, a global and massively interconnected supply chain has evolved to produce and sustain complex systems. At the top are the system integrators who are in turn fed by layers of specialist sub-system and components producers. Management of such a process requires a high level of business skill and there is a supply of eager MBA graduates ready to fill the role. At the specialist end of the spectrum, more sophisticated computer-based tools for design, simulation and analysis drive more technical depth at the expense of breadth.

In response to these changes, many companies have evolved a greater role for technical executives or chief engineers. [Note: companies use different titles - technical executives, chief engineers, lead engineers – to denote the key technical decision-makers.] As a group, they have the last word in determining the technical characteristics of the functional systems. However, very little has been done to study their role or the attributes needed for personal and business success. Courses and books are readily available on how to be a better project manager or even an engineering specialist but almost nothing exists on how to be a chief engineer. The purpose of this paper is to report outcomes from a training program for technology executives. It concentrates on the *personal* attributes that successful practitioners need. These are deep traits of personality, values and culture which are formed long before the individual reaches a leadership position. They should therefore be embedded and developed throughout the whole education and life-long learning process.

Drivers for change

We are all familiar with the changes that computing and integrated electronics have brought to consumer products. However, their impact on the business and professional infrastructure has been even more far-reaching. The application of networked computing, control and communications (C3) functions dominates the changes that are being implemented in sectors as diverse as defense, energy management, manufacturing, health care and transportation. Ever-widening scope and complexity are made manageable by the enhanced productivity offered by C3 capabilities. When higher functional performance and reduced cost of ownership are added to the mix, it is not surprising that system complexity continues to grow and find wider application.

With rapidly changing technology, considerable creative energy has been expended by professional organizations such as the IEEE and ASEE to determine how the educational system can best meet the market needs both in numbers of graduates and in their skills and competencies. This is the input supply side of the manpower demand equation.

Less attention has been given to the other side of the manpower equation – how to reduce the numbers leaving the profession. As long ago as 1983, Landis and Svestka [1] indicated that movement of engineers out of the profession was the strongest driver for recruitment. The position is similar today with more than 50% of engineering degree holders not in engineering jobs [2]. The equation is not a simple 'recruit to balance loss' calculation. Those leaving are experienced and have unique individual knowledge that a new recruit may (or may not) acquire after some years in the job. Some of those who leave do so because of the poor leadership skills of their technical managers. This is a waste that can be reduced. In addition to the traditional high exit mobility of engineers, many industry sectors have to face the implications of an aging workforce. The statistical employment picture shows a workforce that is reasonably balanced in age [2]. However, it hides the rapid erosion being caused by retirement of the technical leaders. These are the professionals who have learned on the job how to manage the process to design, produce and sustain complex systems. As a result, most of their expertise can be classed as 'tribal knowledge'. Their combination of management techniques with engineering practice has not been systematically studied and has little visibility anywhere in higher education programs.

The features of complex systems and the design of training programs to prepare future technology executives have been described elsewhere [3, 4]. This paper considers a complementary outcome. From observations of successful practitioners, what conclusions can be drawn about the personal attributes required for the job? With that information, we can then determine how students can be better advised and prepared.

Industry solutions

In 2002, the question of how to prepare the next generation of technology leaders was raised by a member of the industry-led training consortium that has provided the information base for this paper. The other members agreed that they faced the same issues of pending retirements and other losses of experienced engineers. The response of the consortium was to set up a certificate training program with pooled resources available to all members. The certificate was designed by a team of industry and academic experts and since 2004 the program has been delivered to 10 groups and over 160 participants [4]. The certificate covers:

- Role and scope of the technical executive
- Systems engineering
- Decision-oriented risk management
- Requirements specification
- How to make a business case
- Root cause analysis
- Failure analysis
- An individual case study

The main outcomes have been:

- A majority (75%) of the participants believe the program significantly improved their capacity to do their job and advance to the next level.
- The course participants have fully demonstrated the scope and richness of the lead engineer's function.

- The original course titles have not changed but in the light of feedback from the participants, almost all the content, examples and dialog formats are now significantly different from their initial versions.
- The issues are remarkably consistent across the business sectors represented by the consortium (aerospace, defense and communications).
- It has proved to be a very effective platform for peer-to-peer learning.

Although there are no entrance qualifications beyond the normal management approval for fees and time, it has become clear that personal experience and maturity are the strongest indicators of the likely benefit to the participants. This is partly because the examples analyzed are very wide-ranging and participants with most experience not only contribute most but are also quickest to see personal learning opportunities in every case. A more subtle outcome is that the most experienced technologists understand the rules of operation (written and unwritten) within their organization and are therefore much more flexible in their responses to challenges and new technologies.

Parameters of technology leadership

The participants in the certificate courses are mostly senior engineers who are expected to progress to leadership roles. They already have the personal capabilities to do the next job. Although the courses dealt with the skills for the job, they also provided a unique insight into the participants themselves, their thinking processes and their ways of working. This insight was not anticipated when the program was established but it has given some fascinating results that are the main point of this paper.

It soon emerged that one of the most common capabilities of a technology leader is an ability to impose order on a jumble of results or abstract concepts. It showed up in two forms.

1. How new problems are tackled. It didn't matter if it was an individual or a team; the task was quickly broken down into component parts that each had more readily accessible solutions. The process by which this sub-division was accomplished did not have to be explained or justified; it was simply done quickly, concisely and instinctively.
2. A systematic activity to analyze the attributes of a successful technology leader. The process started with individual lists based on personal knowledge. Some group filtering was then used to classify the main features. Although the detailed lists varied (mostly according to how much time was devoted to the task), the classification from each group of participants consistently pointed to four basic categories of capability:

1. Personal	2. Communication
3. Technical	4. Business

Good communication skills, technical expertise and effective business operations are familiar requirements and will not be considered further in this paper.

The personal attributes, though obvious, are of interest because they refer to skills that are rarely deliberately taught or measured. When each class generated its list of skills and they were grouped under the above four headings, the personal list was always significantly longer than the others and also generated more strong views and discussion. It was also clear from the discussion that without a strong demonstration of positive personal attributes, the value of any capabilities in the other three categories was much diminished. That conclusion should be no surprise but given its importance, the concern is that we do so little about it either in industry or in academia.

An example of the list of personal attributes compiled from three course groups is shown in table 1 (with apologies for inconsistent syntax).

Good mentor	Independent	Experience
Organized	Insatiable curiosity	Passion
Objective reviewer	Thirst for knowledge	Vision
Use influence	Clear what's needed	Don't humiliate
Detail-oriented	Learn fast	Listen but confront
Self-confident	Manage ambiguity	Multi-task
Stubborn	See the gaps	Be patient
Eccentric	Be proactive	Direct
Personable	Results by influence	Not arrogant
Decisive	Disciplined process	Standards + integrity
Good coach	Fly high or low	Commitment
Teachable	Know the difference	Follow-through
Humble	Learn from the job	Motivator
Sense of humor	Professional	Consistent priorities
Patient	Goal advocate	Build relationships
Create expectations	Honest	Team player
Handle bad news	Shoot straight	Approachable but ..
Focused	Calm in crisis	Delegate

Table 1. Desired personal attributes of a technology executive

Although the list was derived from the outcomes from only three courses, the other seven course groups all generated similar lists It is also possible to give the negative version of the list. Technology leaders in the negative category were seen as major contributors to the loss of good engineering talent. There is therefore a clear bottom line advantage in recognizing and developing individuals who have the attributes shown in table 1.

The challenge is to determine the combination of nature and nurture that leads to an approximation of these personal attributes. Which features are best suited to some type of training or educational activity? To that end, we have settled on four actions.

1. Work continuously to hone the skills that do not change: effective communication of all kinds and the self-discipline that comes with good time management.
2. Develop the higher level educational competencies such as critical thinking, troubleshooting, analysis of constraints and receptiveness to new concepts.
3. Develop a process for career planning at all levels. Its business and technical components are readily available but there also needs to be a broad awareness of the factors that drive change and impact competitiveness [5]. We have used a simple 2 x 2 grid to guide the process. As an example, the individual would collect evidence of ways in which local technology initiatives are creating changes and then assess their likely continuation and personal impact. The same steps can be followed for the other three combinations.

	Local	Global
Technology		
Business		

4. Increase awareness of the list of personal attributes and their importance in any job. In each of the above three activities, keep asking how the attributes in table 1 contribute to better outcomes. It is then largely up to the individual to take the appropriate development steps.

It is interesting that all four techniques can be started – indeed they should be started – early in a career. They can be incorporated into company induction and early training courses. However, they also have a place in academic programs.

Academic implications

One of the spin-off advantages of delivering courses through an industry-academic consortium is that there is a natural 'trickle-down' process that can quickly take the appropriate outcomes into academic courses [6]. In this case, it is a simple transition that is in line with ABET outcomes criteria and (for the author) with the goals of the Department and Institution.

The most significant aspect of the list of personal attributes is that it can be understood with little further explanation by any student. There is a natural hesitation to believe that one individual can display so many positive features but the list is readily accepted as desirable. The four actions given above to help develop the personal attributes can be readily accepted too. Student enthusiasm rises further when they realize that no additional course-work is involved. The burden for faculty is, however, a little greater. Most significantly, the personal attributes for technology leaders shown in table 1 also apply to faculty. Although students may look for some of the personal attributes in their peers, it is much better sport to assess the faculty. The fact that students are well able to do this appraisal attests to the ease with which the concept of a list of personal attributes can be accepted and applied. As faculty, we may not be comfortable with the application but we should welcome student acceptance and use of a new tool.

Implementation of the four development activities - hone the skills that don't change, develop higher educational competencies, understand the drivers for change and topics on the personal attributes list – is best done in small doses by treating at least one feature in every class. An easy classroom demonstration is to discuss personal attributes with a visiting industry speaker. It requires no extensive preparation and in 5 minutes, the class can receive an individual example that is specific and also reinforces the generality of the concept. It is a good way to initiate a lively discussion that can flow on to more technical issues where students are normally more reticent in asking questions.

A parallel activity is to make sure that every class session includes at least one example of the higher level educational skills (critical thinking, troubleshooting, analysis of constraints or receptiveness to new concepts) and it is identified clearly as such. In almost all cases, the facility to apply these higher-level skills can be directly linked to the personal attribute list of table 1. It is a good demonstration that the purpose of education in its technology context is not to demonstrate shortcomings but to find better solutions under new conditions.

Conclusions

An industry-based training program for technology executives has given a succinct list of personal qualities required for engineering leaders. Without these personal qualities, the effectiveness of the individuals and their supporting teams is seriously limited. There is little that is surprising in the attributes themselves but given the strength of their validation in this work, it is surprising that they are not fostered more actively in career development activities. To remedy that deficiency, a number of simple steps are being taken to bolster the company-based training of the consortium. Some activities that can readily be incorporated into degree programs have also been initiated.

Acknowledgements

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