

Project Management – The key to turn Engineer in to Project Leader: Review

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Abstract

This paper includes the co-relation between management skill and engineering skills along with the management aspects for the engineering disciplines discussed in various research papers. It also includes important non-engineering skills that could be expected of engineers within the first five years of commencement of their careers. As management education has often been viewed as secondary to technical skills and hence does not comprehend the integrated range of skills needed, this paper illustrates basic management principles to be included in the modern literature on teaching management to engineers. Some ideas are discussed outlining possible research which will be carried out and reported by the authors, aimed at documenting current deficiencies with a view of developing a more effective future strategy for engineering management education.

Index Terms— Project Management, Engineering management skill, non-technical skills for engineers

I. PROJECT MANAGEMENT – A VIEW FROM THE LITERATURE

Previous works have identified the importance of transferable skills in the education of engineers. This point was echoed at a recent meeting of the Parliamentary and Scientific Committee in the House of Commons that explored the question 'Do we need more multi-skilled scientists and engineers to manage economic recovery and change?' The consensus of the meeting was yes, and the multi-skilled element received much support, although the concern of time in the curriculum was highlighted. In terms of project management, the literature is limited when it comes to exploring perceptions of project management, whether by students or other potential stakeholders. A common view of project management across an organization is often not reality, neither is the notion that working to standards suggests that a broader view of project management education is an important step to take.

Focusing on project success, influence has been identified as an important characteristic of the project manager/team member relationship. By effectively employing influence, project success becomes more likely. This argument is typical of many in the literature that suggest it is the so-called 'softer' skills that need emphasis in developing the project management skill base. Relying on tried and tested Iron Triangle cost, quality and time, with the underlying techniques for planning and control is no longer acceptable. A survey of practice in project management reported in 2002

The teaching of transferable skills is discussed widely in the literature. Although acknowledge as important for an adaptable workforce, there is often an incoherent approach to the development and assessment of the skills. They are often perceived by students as add-ons or gap-fillers and consequently do not receive the required level of student attention. On graduation though, research suggest that students value transferable skills more highly, yet believe their ability is below that needed. This can be viewed as a missed opportunity. The context of the transferable skills needs to be clearly explained for student mastery to be achieved and an approach to achieving this is through group

work. A critical feature of the group work, along with a robust and aligned design, is the need to provide feedback opportunities throughout the work such that the participants can capitalize on them and improve their transferable skills. As an engineering faculty work towards more project and problem based curricula, the scope for developing transferable skills, especially in areas such as project management, is greatly increased. The problem provides the context and the justification, the faculty and the learning environment to support. [1]

II. THE ENGINEERING ADVANTAGE

Engineers (and also scientists, to some extent) bring to their management jobs a very special set of capabilities. These capabilities are different from those of managers from other backgrounds and should be used to advantage in the management environment. Engineers typically have:

- A strong mathematical background
- Knowledge and understanding of generic conceptual tools (e.g. optimization, dynamics, control, probability)
- Problem solving training and attitude
- Modeling know-how and associated conceptual insight
- Technological knowledge about the functional business they will be managing.

Engineers should not stop being engineers when they become

managers, but should rather apply their engineering knowledge in this new environment also. However, new engineering managers seldom capitalize on these strong points - they need some encouragement. This requirement was taken in account in the development of the engineering management program; students are also introduced to the "engineering of management". [2]

III. IS ENGINEERING MANAGEMENT DIFFERENT FROM OTHER MANAGEMENT?

This paper justifies this assertion with the following observations by author:

- Since high-technology enterprises make a business out of doing things that have not been done before, extensive planning is essential to assure things are done right the first time. And since the critical factors in new systems are often (certainly not always) technological, the engineer is especially qualified to recognize them and manage their resolution.
- The organizational structure must assure that the functions essential to the success of the enterprise have sufficient visibility and clout to be effective. In the nontechnical enterprise, marketing and finance tend to have the highest profile. In the high-technology organization, research, engineering design, and quality assurance are often accorded equal stature.
- The key staff in a high-technology enterprise is largely technical specialists, and their selection, training, and evaluation require technical insight.
- Leading and motivating high-technology effort requires that the manager understand the nature of the technical specialist and of the engineering process.
- Although the manager of a high-technology project or enterprise of any complexity cannot expect to understand more than one or two technical specialties as well as the specialists supporting him, he must have the broad technical background to absorb the critical factors of a new technology from his specialists quickly enough to use this understanding in decision making.
- Effective control has many dimensions. Most of them have a significant technical component when applied to a high-technology project or enterprise, and require technical judgment if they are to be successful. [3]

IV. ENGINEERING MANAGEMENT PHASE

This is the phase of the engineer's career in which we are most interested for the purpose of this paper. This is the phase that represents the transition from the reduction approach to problem-solving to the practice of management problem-solving, which generally requires knowledge that is more holistic and integrative. For many engineers, this is a difficult transition, but many have also discovered that it can also be a very rewarding experience.

In this period, engineers need engineering management skills.

Engineers become involved in large projects and more complex designs requiring interdisciplinary skills. In this phase, engineers discover that success will depend not only on technical expertise, but also on other factors, such as organizational and people issues. The knowledge and skills required in this phase of development are primarily such things as project management, interpersonal and communication skills, interdisciplinary skills in finance and marketing, and other organizational skills. [4]

V. MANAGEMENT OF ENGINEERING PROCESSES

A thorough understanding of the development and engineering processes is necessary to assess the applicability of production management principles; hence, a generic reference model has been developed for products based on systems theories. The primary engineering process can be divided into different stages, which transform market demand and customer requirements into instructions and specifications for products, processes or systems. The higher process and evaluation level layers, i.e. R&D management, correspond with a higher degree of novelty, which implies potentially more iterations and requires more creativity. As a result, these layers will not be considered any further in this paper, and the generic reference model of the primary engineering process and the information flow to manufacturing will only serve as the basis for this study.

In addition to the information flow from engineering to material supply, manufacturing and deployment, a feedback loop connects these processes. The creation of a product or service starts with the supply of materials and progresses to the product lifecycle, including service, and finally ends with disposal. During all these stages, observations may be made that result in feedback to the processes and may ultimately initiate engineering activities. The feedback loops consist of four tiered layers and follow the evaluation mechanisms of the steady-state model in. Hence, engineering processes not only transform customer requirements into information for the primary production and development process, but they also cover the incorporation of internal feedback into existing products and processes.

Based on the generic reference model, it is now possible to compare engineering and manufacturing processes. Engineering processes are more comparable to job shops than flow shops. Due to the specialization of engineers, engineering departments are often functionally organized. This type of organization fosters the flexibility necessary for the fulfillment of individual customer requirements. However, job shops are known to have a complex planning process but limited productivity, which contradicts the efficiency and productivity objectives of production and engineering. Hence, it might be expected that the traditional organization encourages the flexibility necessary for dealing with a wide range of customer requirements but at the same time does not offer the productivity necessary to deal with a scarcity of engineering resources. To improve productivity and control of engineering activities, solutions have been put forward in industry. An initial condition for productivity and control seems to be the existence of a structured engineering process. Several authors and organizations have developed ideal types of engineering processes.

This inference also implies that efficiency might only be achieved through adequate control and planning. Planning within the production process can be differentiated into three levels: operational, tactical and short-term planning, similar to engineering. The control of the production process focuses usually on the timely fulfillment of customer requirements. To meet these, throughput time and process speed are important factors. Assuming the similarity between both production and engineering processes (both viewed as a job shop), it must be investigated, whether

production management principles can be adopted for engineering management problems, while accounting for differences (iteration, creativity and novelty). [5]

VI. PROJECT MANAGEMENT AND PROJECT COCKPITS/DASHBOARDS

Project monitoring and management is an accompanying key activity of project managers along the project course to (a) keep track of the project progress and (b) to take counter measures in case of deviations with respect to time, budget, and quality. Thus, measuring and analyzing project data is the foundation for process observation and decision making processes. A main task of a project cockpit is to provide the current project state if required by the project management. In business IT software development software cockpits (or software project control centers) have been developed to enable a comprehensive view on the project focusing on individual roles, e.g., project and quality managers, and selected data sets, e.g., temporal project data, defect data, and issues. Traditional software cockpits focus on (a) collecting data, (b) interpreting them, and (c) visualizing the data according to requirements derived pre-defined roles to support project monitoring in pre-defined time intervals or on demand. In addition, project information, e.g., project organization or time schedules, can be included in the project cockpit. Based on discussions with our industry partners we identified the need for an engineering cockpit approach in the automation systems domain. Nevertheless, after analyzing current software cockpit applications we observed limitations regarding collaboration across disciplines, team awareness, and interaction which hinder efficient implementation in heterogeneous engineering environments.

- *Collaboration.* In automation systems development multiple engineers from different disciplines applying various tools and data models have to collaborate. Thus, an engineering cockpit is a promising approach to bring together the individual disciplines within one single platform
- *Team awareness.* Lessons learned from social networks can help to improve communication and team work by integrating valuable features within the engineering cockpit, e.g., messaging, visibility of available team members. Depending on the context and role different information sets can be presented, e.g., project overview presentation for project managers and detailed change request information for engineers in assigned disciplines.
- *Interaction.* Traditional software cockpits are used for information purposes with limited interaction capabilities. As we see the engineering cockpit as single entry point to engineering data and the current project, contextual and role-specific tasks can be used to drive project managers and engineers to related activities, e.g., navigating to a certain message or retrieving detailed information after a change request was displayed in the cockpit view.[6]

VII. 3- STATE OF INDUSTRIAL PRACTICES AND MOTIVATIONS

In the field of the extended enterprise, it becomes increasingly complex to conduct systems engineering projects given the numerous participants and stakeholders, from the design to the retirement stage. Systems development involves many disciplines, i.e. organizational, financial, human decision-making, logistics, environmental. Thus, in order to manage the projects effectively, many companies rely on standards and PLM (Product Lifecycle Management) tools to guide the industrial processes. However, according to a study by Pierre Audoin consulting PLM tools only help in the collaboration of technical activities. Likewise they do not offer decision support mechanisms to monitor the project; it will thus be necessary to develop a tool in the near future to implement and coordinate cooperation between the processes of SE (System Engineering) and PM (Project Management) and help the project manager in his decisions during the SE project. Our objective is thus to provide the project manager with a standards-compliant method and tool that support cooperation between systems engineers and managers and their respective processes, to control the project and optimize cooperation between processes. To do this, a first step consists in identifying and modeling SE and PM processes, and then finding the relevant indicators to monitor them. The goal is multiple: 1) to support management by coordinating processes; 2) to offer a method to stakeholders to monitor progress at any time, and at any level, from different points of view, and 3) to provide tools to help them take decisions and explore several directions to guide the project. [7]

VIII. THE FUNCTIONAL ANALYSES OF ENTERPRISE'S INNOVATION MANAGEMENT

Functional analysis is the core of value engineering. Value engineering is an organized creative activity with the lowest life cycle cost to achieve reliably the essential function; it attaches great importance to the functional analysis of things, including the function definition, function rearrangement and function evaluation.

The role of function definition is to establish a new starting point for thinking - starting from the function, rather than starting from the concrete structure, thus providing the basis for an open idea. The functions of enterprise's innovation management include the following:

- To meet market demand. One of the objectives of enterprise is to meet market demand, to provide people a variety of products and services. People need various products and services, such as the use function of goods, performance quality, appearance design, maintenance, after-sales service and so on. Due to the constantly changing demand, we must constantly introduce new products and new models. We can achieve this, of course, by copying other people's products or the introducing technology from others, but the fundamental point of view, enterprise's own innovation is very important.
- To reduce operating costs. Through innovation management, we can not only improve the process flow but also reduce raw material consumption and energy consumption, thereby reducing the production cost of

enterprise. At the same time, enterprises which use advanced production technique, can improve the organization and management of enterprises, improve management efficiency and reduce management costs.

- To enhance economic benefit. Economic benefit is a key factor to long-term survival and development of enterprises, therefore, profit maximization to be every enterprise goals. To obtain the most economic benefit, enterprise usually starts from the expansion of sales and the abatement of costs, these two aspects can be achieved through innovation management.

- To maintain leading-edge technology. Another function of innovation management is that enterprise maintains leading-edge technology in the industry, especially high-tech industry. Many industry standards are set by the technology leader. Therefore, the technology leader has more power to set the ruler and has greater superiority in the competition, and can better lead the market and more effectively is the key to the market even monopolize the market.

- Continuing ability to innovate. The enterprise's Innovation management is a long-term activities but not a short-term behavior. It is a problem that every enterprise how to maintain continuous business ability to innovate. Therefore, in each enterprise's innovation activities, we should consider the possibility that this innovation management provide potential for the next innovation management. This requires companies to constantly follow the trend of today's scientific and technological development, and to predict correctly the potential of innovation, so that innovation can be moving in the right direction. [8]

IX. A LEARNING CRITERION FOR BUSINESS AND MANAGEMENT COMPETENCY

Drawing on the discussion of the previous sections, the proposed learning criterion for the business and management Competency of engineering students is as follows:

Through course instruction and participation, students will acquire the knowledge, ability, and mindset to design economic engineering solutions efficiently and effectively with market and customer orientation.

Learning criteria are broad statements that guide the development of learning outcomes, which then guide the creation and assessment of courses and curricula that are designed to help students satisfy the criteria. The words economic and efficient mean minimizing resource waste or cost input while meeting the target goals for scheduling and performance. Unlike the traditional cost-plus pricing method where materials, labor and overhead costs are measured and a desired profit is added to determine a selling price, an acceptable price for a new product or service is determined based on market information. Then, a target cost is the maximum cost that can be incurred on a product while the firm can still earn the required profit margin given the particular selling price. Thus engineers should be able to reduce the overall cost of a product over its entire life-cycle. Engineers also need to view the financial statements of their company and determine how the engineering division could

help improve the financial performance of the company. The word effective is closely tied to the capability to manage engineering teams successfully. Engineers must communicate with all the stakeholders involved in a project as to what actions are to be taken, by when and how much money can be spent on each activity. The engineers and related members get together regularly throughout the project to check the progress and to deal with any issues that may come up. Thus good project management, which also necessitates leadership and strategic employment of technical human resources, is the key to success in any engineering work. Finally, market and customer orientation leads to the capability to design new systems to meet the needs of the customers and to have market power in order to generate significant revenue. Engineers should care about how new products and services will be marketed to target customer groups and increase sales. Engineers should also utilize their R&D results to generate revenue in a variety of other ways. The revenues sources include not just final products and services but also patents, licenses and other interim results of the R&D work. In today's open innovation era where market and customer groups quickly expand as firms look to advance their technology through the use of external ideas and knowledge, it is vital for engineers to seize every opportunity to make profits from their R&D work. The proposed learning outcomes for the business and management competency of engineers are:

- Students will demonstrate substantial knowledge of the business operations (R&D, manufacturing, and marketing) as well as financial data (revenues, costs, and profits)
- Students will demonstrate substantial ability to manage R&D teams, analyze customer needs and apply economic analysis.
- Students will display a mindset to care about efficiency and value maximization in R&D work and to continue to make the engineering solutions evolve to fit the market demands.

The learning outcomes point to the importance of learning about delivering innovative engineering solutions efficiently and effectively and linking engineering work with market demands. The first component of the criterion and proposed learning outcome focuses on knowledge. A successful learning experience in business and management enables students to gain a factual understanding of how engineers in the real world deal with non-technical issues such as managerial, financial, and marketing issues and the ways in which such non-technical considerations impact their engineering work.

The second component of the learning outcomes is ability. An engineer with business and management competency is someone who has progressed beyond "awareness skills" to achieve "process skills," which combine the new form of knowledge into day-to-day practices of engineering work. The process skills, which are gained through practice, indicate the ability to apply various methods of economic engineering design and organizational management skills in engineering work. The third component/outcome is mindset, which is more difficult to identify and assess, yet it is as equally important as the previous two. The term, "mindset" does not indicate inherent features of character or personality, but refers to

learnable tendencies or patterned actions that are observable by others. It is the mind to treat engineering work as an integral business function and an object of management in order to create winning products and services in the market. As a result, engineers gain a macroscopic view on all corporate functions where engineering work is aligned to meeting business goals.

The Accreditation Board of Engineering and Technology (ABET) provides only a general program outcome related to the business and management competency of engineering students. One of the ABET program outcomes states, "Graduates have a respect for diversity and a knowledge of contemporary professional, societal and global issues." The Accreditation Board of Engineering Education in Korea (ABEEK) realized the need to make this statement more specific toward the non-technical competency of engineering students as it says, "Graduates have a broad education which is necessary to understand the impact of engineering solutions in global and societal context knowledge of contemporary issues in the society, economy, environment, and law." However, neither one clearly states the competency in business and management for engineers.

In this context, it is now necessary to articulate what business and management competency is required of engineers. The key element in this learning criterion is the descriptive image of engineers who bring out innovative engineering solutions in the most efficient and effective way with market and customer demands in mind. The learning outcomes accept the view that acquiring knowledge and experience in business operations, financial analyses and technology management skills leads to the achievement of the business and management competency required of engineers.

The engineers with business and management competency then design products and services that best respond to customer needs and therefore maximize the probability of success in the market. [9]

X. THE TEAM COOPERATION MANAGEMENT OF ENGINEERING PROJECT MANAGEMENT

A. The trust management

The well trust relation could reduce complexity and avoid uncertainty and reduce business cost and promote cooperation effect. In the engineering project management, we should form the trust relation of engineering project team by institution restraint, communication mechanism and organization authorization. Firstly, we could build the mutual benefit mechanism of profit and risk sharing of engineering project team to prevent the mutual cheat and opportunism behavior among the team members, and then ensure to form the team trust relation based on institution. Secondly, we should establish an interaction communication pattern among members to encourage unofficial touch and mutual study among members, and then enhance the transparency of members' behaviors strategy to reduce estrangement and strangeness among members. Thirdly, we should strengthen the trust of members and team by organization authorization. In addition to this, the engineering project manager had a very important role in the trust of team, so we should strengthen the management

attainments and morals accomplishment of engineering project manager.

B. The conflict management

According to investigation of the USA management association, manager should spend 20% time average disposing all manner of conflicts, so we could think that the conflict was a common phenomenon. Therefore whether could solve engineering project team cooperation efficiency or not depended on how to deal with conflict management. As all we known, the low level of conflict to the disadvantage of making innovations and the overtop level of conflict also could create negative influence. Just as Amason said that conflict was a double rapier, it would have advantageous and disadvantageous influence at the same time.

In the engineering project management, firstly we should establish a conflict management beforehand mechanism to monitor and estimate the inner and outside environment of conflict, and then analyze the conflict state which the team was faced with by monitoring, distinguishing, diagnosing, evaluating and so on and take steps to control the state in time. Secondly, we should construct a communication terrace of team. We could build an effective inner communication mechanism to improve communication channel and pattern and form a formal communication terrace of project members.

Thirdly, we should establish a reasonable authority structure in order to change the information agency costing which was brought by excessive concentration of powers and overtop agency costing which was brought by excessive separation of powers, and then we could put knowledge management into practice and remission inner conflict in team to defuse the disadvantageous which from conflict.

C. The study management

The study of engineering project team did not emerge without reasons but influenced and restricted by many factors. It was some knowledge which was obtained, stored, employed and created in the engineering project management. The engineering project team should create on them own initiative the "courtyard" which could encourage members to study and build common wishes to lead members to continually study and promote members to interchange and share knowledge among members.

In the engineering project management, firstly, we should form encouraged restraint measures which could promote team study by building institution terrace to form better study atmosphere. Secondly, we should provide study opportunity and condition such as established project management website based on internet by establishing study terrace to provide exchange opportunity and carry out workshop and lectures for project members to augment the members' knowledge store.

D. The encouragement management

The engineering project team was a complex body. If we wanted effectively stimulate team proficiency and promote team performance, we should encourage engineering project team. The team encouragement included material and spirit encouragement. In the engineering project management, the core of material encouragement was reward. The reward design not only accepted contribution from the team members, but also concentrated on enhancing personal capability. The spirit encouragement satisfied demand of

team members above the demand average by creating certain working condition to achieve deep administrative levels, timeless and enduring encouragement for team members. The specific content included under content.

Firstly, we should foster better team atmosphere and set up the value view which was that if I help everybody, then everybody would help me. Secondly, we should build inner emotion ligament of team to enhance sense of belonging of team members. Thirdly, we should design reasonable authority structure and build corresponding team behavior standards to promote team members mutual assistance and encouragement and stimulate working enthusiasm and create capability of team members. [10]

XI. CONCLUSION

An engineer plays an important role in nation's development, which requires more than just technical skills. The non-technical skill makes him more versatile and help him to deal with professionals in various discipline in today's knowledge-based economy. Based on the above details from the different researchers it is quite clear that engineer must have excellent integration between both the skills. However, we also accept that apart from graduate studies non-technical skills are life-long learning, an engineer can learn this skill when he will work for the industry with different cultured people and while communicating with his higher authorities. But the skill as a part of the curriculum has a profound impact in shaping the engineering profession in the rapidly changing technology, corporate downsizing, out-sourcing and globalization and prepare him for the future. It is hoped that such target skills must incorporated within the engineering curriculum.

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