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Pearson BTEC Levels 5 Higher Nationals in Engineering (RQF)

Unit 35:
Professional Engineering Management

Unit Workbook 1

in a series of 1 for this unit

Learning Outcome LO1 to LO4

Professional Engineering Management

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4 INTRODUCTION TO ENGINEERING MANAGEMENT

Engineering is the application of scientific knowledge and mathematical methods to practical purposes of the design, construction or operation of structures, machines, or systems. The discipline of engineering encompasses a range of more specialized fields of engineering, each with a more specific emphasis on particular areas of applied mathematics, applied science, and types of application. The term engineering is derived from the Latin *ingenium,* meaning "cleverness" and *ingeniare*, meaning "to contrive, devise".

In the engineering design process, engineers apply mathematics and sciences such as physics to find novel solutions to problems or to improve existing solutions. More than ever, engineers are now required to have a proficient knowledge of relevant sciences for their design projects. As a result, many engineers continue to learn new material throughout their career.

If multiple solutions exist, engineers weigh each design choice based on their merit and choose the solution that best matches the requirements. The crucial and unique task of the engineer is to identify, understand, and interpret the constraints on a design in order to yield a successful result. It is generally insufficient to build a technically successful product, rather, it must also meet further requirements.

Constraints may include available resources, physical, imaginative or technical limitations, flexibility for future modifications and additions, and other factors, such as requirements for cost, safety, marketability, productivity, and serviceability. By understanding the constraints, engineers derive specifications for the limits within which a viable object or system may be produced and operated.

4.1 Problem Solving

Engineers use their knowledge of science, mathematics, logic, economics, and appropriate experience or tacit knowledge to find suitable solutions to a problem. Creating an appropriate mathematical model of a problem often allows them to analyse it (sometimes definitively), and to test potential solutions.

Usually, multiple reasonable solutions exist, so engineers must evaluate the different design choices on their merits and choose the solution that best meets their requirements. Engineers typically attempt to predict how well their designs will perform to their specifications prior to full-scale production. They use, among other things: prototypes, scale models, simulations, destructive tests, non-destructive tests, and stress tests. Testing ensures that products will perform as expected.

Engineers take on the responsibility of producing designs that will perform as well as expected and will not cause unintended harm to the public at large. Engineers typically include a factor of safety in their designs to reduce the risk of unexpected failure. However, the greater the safety factor, the less efficient the design may be, as well as being more expensive.

The study of failed products is known as forensic engineering and can help the product designer in evaluating his or her design in the light of real conditions. The discipline is of greatest value after disasters, such as bridge collapses, when careful analysis is needed to establish the cause or causes of the failure.

4.2 Social Context

The engineering profession engages in a wide range of activities, from large collaboration at the societal level, and also smaller individual projects. Almost all engineering projects are obligated to some sort of

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financing agency: a company, a set of investors, or a government. The few types of engineering that are minimally constrained by such issues are pro bono engineering and open-design engineering.

By its very nature engineering has interconnections with society, culture and human behaviour. Every product or construction used by modern society is influenced by engineering. The results of engineering activity influence changes to the environment, society and economies, and its application brings with it a responsibility and public safety.

Engineering projects can be subject to controversy. Examples from different engineering disciplines include the development of nuclear weapons, the design and use of sport utility vehicles and the extraction of oil. In response, some western engineering companies have enacted serious corporate and social responsibility policies.

Engineering is a key driver of innovation and human development. Sub-Saharan Africa, in particular, has a very small engineering capacity which results in many African nations being unable to develop crucial infrastructure without outside aid

All overseas development and relief NGOs make considerable use of engineers to apply solutions in disaster and development scenarios. A number of charitable organisations aim to use engineering directly for the good of mankind:

- Engineers Without Borders
- Engineers Against Poverty
- Registered Engineers for Disaster Relief
- Engineers for a Sustainable World
- Engineering for Change
- Engineering Ministries International

Engineering companies in many established economies are facing significant challenges with regard to the number of professional engineers being trained, compared with the number retiring. This problem is very prominent in the UK where engineering has a poor image and low status. There are many negative economic and political issues that this can cause, as well as ethical issues. It is widely agreed that the engineering profession faces an "image crisis", rather than it being fundamentally an unattractive career. In this regard, much work is needed to avoid a numbers crisis in the UK and other western economies.

4.3 Code of ethics

Many engineering societies have established codes of practice and codes of ethics to guide members and inform the public at large. The National Society of Professional Engineers code of ethics states:

> *Engineering is an important and learned profession. As members of this profession, engineers are expected to exhibit the highest standards of honesty and integrity. Engineering has a direct and vital impact on the quality of life for all people. Accordingly, the services provided by engineers require honesty, impartiality, fairness, and equity, and must be dedicated to the protection of the public health, safety, and welfare. Engineers must perform under a standard of professional behaviour that requires adherence to the highest principles of ethical conduct.*

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4.4 Making it work: Engineering Project Management

Project management has evolved to plan, coordinate and control the complex and diverse activities of modern industrial, IT, commercial and management change. All projects share one common characteristic; the projection of ideas and activities into new endeavours. The ever-present element of risk and uncertainty means that the events and tasks leading to completion can never be foretold with absolute accuracy. Examples abound of projects that have exceeded their costs by enormous amounts, finishing late or even being abandoned before completion. Such failures are far too common, seen in all kinds of projects in industry, commerce and especially, it seems, the public sector.

The purpose of project management is to foresee or predict as many of the dangers and problems as possible and to plan, organize and control activities so that projects are completed successfully in spite of all the risks. This process should start well before any resource is committed and must continue until all work is finished. The primary aim of the project manager is for the result to satisfy the project sponsor or purchaser and all the other principal stakeholders, within the promised timescale and without using more money and other resources than those that were originally set aside or budgeted.

Of course, the aim of a project manager must be to achieve success in all aspects of the project. But it is occasionally necessary to identify one of the three primary objectives, that is, cost, performance (includes quality), and time, as being of special importance. This emphasis can affect the priority given to the allocation of scarce resources and the way in which management attention is concentrated. It can also influence the choice of project organisation structure.

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5 WHO's WHO

We need to be clear about some of the terms we're going to use, especially when it comes to the responsibilities carried by the people involved. Mainly, a project will be organised between three principal parties; Customer, Contractor, and End-user. A few simplified examples are provided in FIG XXX to illustrate that project relationships can extend well beyond the customer-contractor boundaries.

Project Type	***Project example***	***Project customer***	***Principal 'contractor'***	***End user***	***Operated and maintained by:***
1 Civil engineering, construction, petrochemical, mining and quarrying	Local authority housing development	Local authority	Wimply	Housing tenants	Local authority
	Private toll road	Landowner	Tarpack	Road users	Landowner's agent
	Copper mine	Cupric Ltd	Cupric Ltd (head office engineering)	Cupric (Zambia) Ltd	Cupric (Zambia) Ltd
2 Manufacturing	New passenger aircraft	Going Ltd	Going Ltd	Various airlines	Various airlines
	Automatic rifle	Ministry of Defence	Small Arms Ltd	Military units	Military units
	Washing machine development	Hotwash Ltd	Hotwash R&D dept	Domestic users	Domestic users
3 Management	Design and implement new sales procedures	ABC Ltd	ABC Ltd (with external consultant)	ABC staff	ABC Ltd
	Office relocation	Greens of London	Greens' (internal task force)	Greens of Exeter	Greens of Exeter
4 Research	Speculative research for new plastic materials	Chemikl Ltd	Chemikl Ltd (laboratory)	Unknown	Not applicable

Figure 1 Examples of Project Relationships

1. **Customer**: The person or organisation for which the project is being conducted. In this context *client* and *project owner* are loosely synonymous. The project customer is traditionally a person or organisation that pays another organisation money in return for a project. However, in many management change projects the company is, in effect, both customer and contractor, with the board or senior management of the company acting as the customer, whilst the manager or department instructed to carry out the project assumes the role of contractor.
2. **Contractor:** The organisation that is principally responsible for executing the project work to the customer's requirements. It is not restricted to its more common use as used in the contracting industry for construction projects. So, contractor describes any organisation or group that carries out a project, whether or not the project is carried out against a formal sales contract.
3. **End user:** The individual or organisation that will ultimately own and operate the project. This is not always the same person or organisation that paid for the original project. Consider, for example, a research and development project carried out by the Whitewash Company PLC to develop washing machines for sale in the retail sector. The customer for this project would be Whitewash PLC, the main

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contractor would be the design engineering department of Whitewash PLC, and members of the public who bought the machines would be the end users.

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6 PROJECT ORGANISATION STRUCTURE

It should be obvious that, if all the project objectives are to be achieved, the people, communications, jobs and resources must be properly organised. But the form which that organisation should take might not be so obvious.

Every company has its own ideas about how to organise itself and its work. It is highly probable that if three companies doing similar work could be compared, three different organisation structures would be found. Further, all three companies might be equally successful (or equally unsuccessful), implying that it is not always possible to say with any degree of confidence that there is one best organisation solution.

It cannot, therefore, be stated exactly how every project should have its organisation structured. It is possible, though, to set out some of the properties that are essential for efficient organisation;

1) Effective organisation and communication
2) Project Management Organisation
3) Project Matrix Organisation
4) Project Teams and Task Forces
5) Organisation of Central Administration Functions

Challenge

It is recommended at this point that you read Chapters 9 and 10 of the eBook 1. (Ref. 1).

An effective organisation will have clear lines of authority and every member of the project will know what they are expected to do to make the project a success. This is part of the management communication framework needed to motivate all the staff. A well-motivated group can be a joy to work with. A badly informed group, with vague responsibilities and ambiguous levels of status and authority, is likely to be poorly motivated, slow to achieve results, costly to run and extremely frustrating to work with.

The complement of good management communications is the provision of adequate feedback paths through and across the organisation. These facilitate cooperation and coordination. They allow progress to be monitored and difficulties to be reported back to executive management. They should also give all participants access to the relevant experts for advice or instruction on technical and commercial difficulties.

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7 PROJECT SUCCESS OR FAILURE

Three objectives; time, performance and cost, are the traditional, basic parameters used to measure project success or failure. Although they are important, they relate principally to the execution or fulfilment stage of a project, which is the period of most direct interest to the project manager. Other people might have quite different views about the ultimate success or failure of a project. For example, a customer who subsequently discovers that the project fails to live up to its initial promise and does not deliver its expected return on investment will perceive the result as a failure. Other stakeholders might have their own, quite different, parameters for measuring success.

Consider the Gantt chart in Figure 2, where the project life is now compared, not with rates of expenditure, but with some of the factors that determine actual or perceived success or failure as the project life history unfolds.

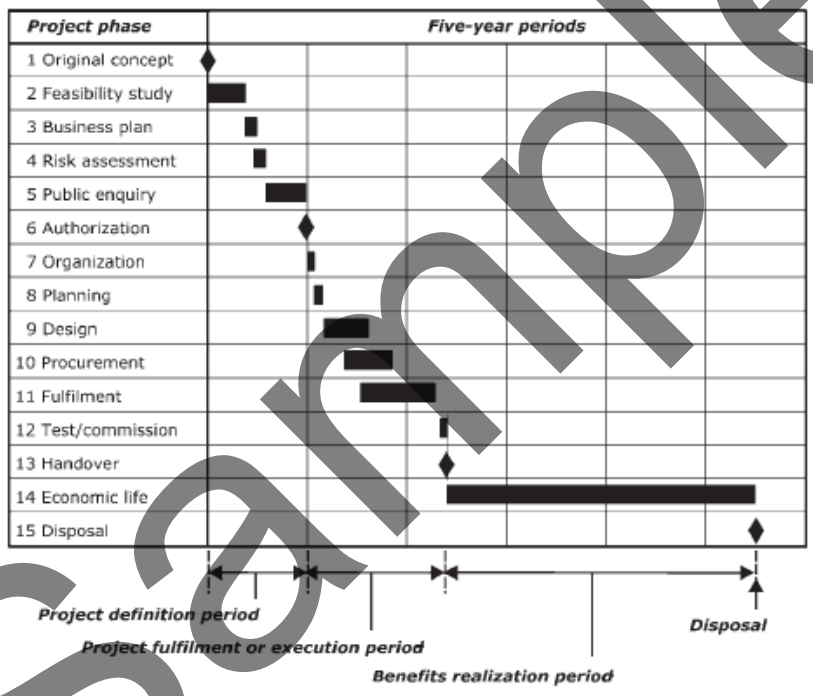

Figure 2 Perception of success or failure during a project life history

The defined periods shown are defined as follows;

1) **Project Definition Period:** Appraisal, strategy and go/no-go decisions set the scene for ultimate project success or failure. If the project is incorrectly or inadequately defined, or if the strategy and risk assessment are wrong, failure is almost certain.
2) **Project fulfilment or execution period:** Success or failure during this period is largely governed by the actions of the Project Manager and the contractor. The contractor of a fixed price project will think it successful if it is finished on time, within budget and to specification. At this stage, the customer can promote failure, for example, by introducing too many changes or by making late payments.
3) **Benefits Realisation period:** Now the true success or failure of the project will be discovered according to the perceptions of the project owner and the stakeholders. Will all the expected operational and

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financial benefits be delivered? How will the wider body of stakeholders perceive the performance of the project or its impact on the environment? Is all the borrowed capital being repaid on time?

4) **Disposal:** Will the project leave chemical or other residues in the ground and pollute the environment? Will decommissioning involve the removal of hazardous materials? Will there be any radioactive residues that will pose a long-term and expensive problem?
   Alternatively, can all or part of the project be sold on to a third party, either as scrap for recycling or for a new period of useful life?

7.1 Factors for Success/Failure during Project Definition

Initial project definition leads to the business case on which the decision to authorise or disallow the project start will principally depend. This initial definition takes during Phases 1 to 6 in the Gantt chart of Figure 2. This is clearly too early for anyone to measure the success or failure of the project, but it is the time in the project's life history when the foundations for success or failure are laid.

Any of the following shortcomings during this period can condemn a project to almost certain failure:

1) The project scope (the extent of work required) is not clearly stated and understood.
2) The technical requirements are vague.
3) Estimates of cost, timescale or benefits are too optimistic.
4) Risk assessment is incomplete or flawed.
5) The intended project strategy is inappropriate.
6) Insufficient regard is paid to cash flows and the provision of funds.
7) The interests and concerns of stakeholders are not taken into account.
8) Undue regard is paid to the motivation and behaviour of people who will execute the project.
9) Particularly in management change projects, insufficient thought is given to how all the managers and people affected by the project will be motivated to adapt to the changes expected of them.
10) Approval to proceed with the project is given for political, personal or intuitive reasons without due consideration to the business plan.

7.2 Factors for Success/Failure during Project Fulfilment

When authorisation has been given for the project to start, it is the contractor and the project manager who take over most of the responsibility for success or failure which will usually be judged according to how well they achieve the three primary objectives of cost, performance and time. Many things need to be in place and many actions taken during the project execution period to help ensure success.

Among other things, these include:

1) good project definition and a sound business case
2) appropriate choice of project strategy
3) strong support for the project and its manager from higher management
4) availability of sufficient funds and other resources
5) firm control of changes to the authorized project
6) technical competence
7) a sound quality culture throughout the organisation
8) a suitable organisational structure

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9) appropriate regard for the health and safety of everyone connected with the project
10) good project communications
11) well-motivated staff
12) quick and fair resolution of conflict.

The primary objectives of cost, performance and time are clear benchmarks against which to judge success or failure when (or soon after) a project is finished and handed over to the customer. The project manager needs to understand what each of these objectives implies and how the three can interrelate with each other.

It must be recognized, also, that many projects have to satisfy more than two primary stakeholders. There will always be people and organisations who, while not being principal stakeholders, nonetheless have an interest in how the outcome of a project might affect them. Subcontractors and suppliers are an obvious example. Staff working on a project have a stake in the outcome because project success or failure can (apart from contributing to job satisfaction) have profound implications for their future employment and careers.

Perceptions of success or failure will differ between the different stakeholders, so a true measure of project success or failure depends on how the project outcome is perceived by all the stakeholders. A project is successful if all the stakeholders are happy. Although that ideal may not always be achievable, it is best project management practice to try to identify all the stakeholders and satisfy their aspirations as far as possible.

7.3 Factors for Success/Failure during Benefits Realisation

In most industrial and manufacturing projects the project owner should start to realize the expected benefits immediately or shortly after the project is successfully finished and handed over (Phase 13 in Figure 2). In business change and IT projects, though, the most significant benefits tend to be realised later in the project life history, during the period shown as Phase 14 in Figure 2.

7.4 Factors for Success/Failure during Disposal

The Disposal phase of a project must not be underestimated. Failure during the disposal phase could have long term consequences for a whole industrial sector. Consider the ramifications the nuclear industry if project failures were to occur during the decommissioning or long-term storage phases of the radioactive fuel life-cycle.

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8 THE VALUE OF STRATEGIC PLANNING

Strategic planning is essentially a step further on than business planning. It is thinking even further ahead into the future, scrutinising with an even sharper eye, and accounting for even further unforeseen organisational challenges and opportunities.

Strategic planning is not a panacea, but it is a pre-cursor to innovative thinking which, for most businesses, is an essential for progress and development. Strategic planning is one of the several components of project management that a high-functioning organisation requires to operate at their maximum operating level.

Project managers that have had success in getting an organisation up and running may feel tempted to apply the same planning principles to their strategies, but this is a no-no. Business plans are designed to get your organisation or new project up and running, while strategic plans are management tools used to communicate your vision to staff, and get projects accomplished with greater efficiency. Here are some of the many key differences between the two:

Business planning; assesses how much funding your project requires, and where to get it.

Strategic planning; determines how and where funding should be spent during the project

Do not apply your business plans for strategic purposes, as they were not meant to be used as such. Business planning gets you up on your feet, whereas strategic planning incorporates everything from your first step to reaching a full sprint.

8.1 Taking project evaluation to the next level

The flow chart presented in Figure 3 shows what strategic planning looks like on paper. As is obvious, a comprehensive strategic plan covers all aspects of project performance and goals so facilitating decision making and enhancing efficiency.

Essentially, strategic planning has a noble and singular purpose; to move you forward, no matter where you are!

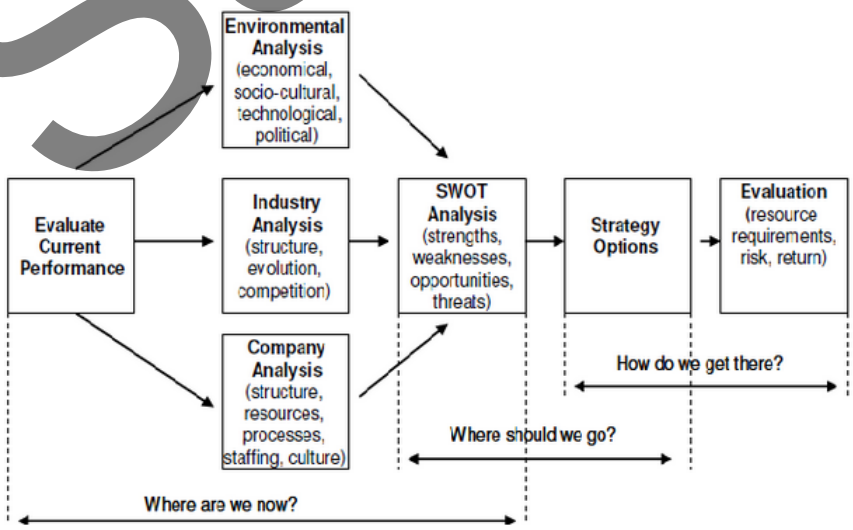

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Figure 3 Strategic Planning Flow Chart

8.2 Increased project communication

Part of strategic planning is opening a dialogue that flows from top to bottom, and back up to the top. 67% of an organisations HR and IT departments have strategies that are not in line with the overall organisational strategy, due to a lack of communication.

Project managers make their team aware that a strategic plan is going to be taking place for the next project (and of course future projects as well) and that they expect to hear ideas and plans from each department, so they can form an overall strategy for the project that each member can adhere to.

85% of executives only spend one hour a month discussing strategy, while the top performing companies spend four to eight hours a month. Communicating project strategy keeps each member on board and builds morale when even low-level staff feel that their voice can be heard.

8.3 Reducing resource misallocation

In the same breath as how, strategic planning enhances communication among all project staff, strategic planning also allows project resources to be managed more effectively. Strategic planning goes in-depth in evaluating the given resources a project has available, and helps project managers make informed decisions by evaluating, monitoring, and adjusting project resource allocation to where they are needed most to propel the project forward. Strategic Planning is the analytical thinking that pays close attention to the details and make informed decisions based on facts, not conjecture.

Strategic planning identifies what you have to work with, and how to assign human and financial resources to ensure that your project avoids any snares that could cripple your project's progress.

8.4 Consistent project team engagement

With a strategic planning methodology in place, staff will be more engaged to contribute all they can throughout the entire duration of the project. Only 23% of companies have a cohesive strategic planning practice in place for their project management, and many still wonder why so many projects run over-budget and/or miss deadlines.

As indicated in Figure 3, strategic planning sets up a comprehensive plan for every step of the way during project planning. It is not the Project Manager who is executing the strategy, it is the lower-level managers and staff. Open dialogue has already been encouraged and demonstrated to them, so communication is encouraged.

Every step of the way, a plan has been put in place. If there is a new idea from any department, they approach upper-management and suggest ideas. However, once a bridge has been crossed during the project's progress, the team already knows what to do next, what to evaluate, and what to aim for and achieve. This keeps the team from guessing what they should do next and saves time in staff seeking out the project manager for instruction.

The project team should be made up of open minded, innovative thinkers, always brewing new ideas throughout the project. By using strategic planning, the Project Manager can take control of their vision

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and turn it into real-life results, making full use of the available resources and operating the project at maximum capacity.

Challenge

It is recommended at this point that you read eBooks 2 and 3. (Ref. 2 and Ref. 3.)

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9 ENGINEERING STRATEGY AND SERVICES DELIVERY PLAN

Challenge

In addition to your own research, reference eBooks 2, 3, 4, and 5 (Refs 2, 3, 4, and 5) provide examples of Engineering Strategy and Services Delivery Plan documents which you may use as supporting material if you so wish.

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10 SUPPLY CHAIN AND SUSTAINABILITY

Supply chain sustainability is a business issue affecting an organisation's supply chain or logistics network in terms of environmental, risk, and waste costs. There is a growing need for integrating environmentally sound choices into supply-chain management. Sustainability in the supply chain is increasingly seen among high-level executives as essential to deliver profitability and has replaced, or at least sidled up alongside, monetary cost, value, and speed as the dominant topics of discussion among purchasing and supply professionals.

10.1 Background

Supply chains are critical links that connect an organisation's inputs to its outputs. Traditional challenges have included lowering costs, ensuring just-in-time delivery, and shrinking transportation times to allow better reaction to business challenges. However, the increasing environmental costs of these networks and growing consumer pressure for eco-friendly products has led many organisations to look at supply chain sustainability as a new measure of profitable logistics management. This shift is reflected by an understanding that sustainable supply chains frequently mean profitable supply chains.

Many companies are limited to measuring the sustainability of their own business operations and are unable to extend this evaluation to their suppliers and customers. This makes determining their true environmental costs highly challenging and reduces their ability to remove waste from the supply chains. However, much progress has been made in defining supply chain sustainability and benchmarking tools are now available that enable sustainability action plans to be developed and implemented.

One of the key requirements of successful sustainable supply chains is collaboration. The practice of collaboration, such as sharing distribution to reduce waste by ensuring that half-empty vehicles do not get sent out and that deliveries to the same address are on the same truck, is not widespread because many companies fear a loss of commercial control by working with others. Investment in alternative modes of transportation, such as the use of canals and airships, can play an important role in helping companies reduce the cost and environmental impact of their deliveries. Collaboration platforms are emerging because of the fear of a loss of commercial control and competitive advantage by working closely with other companies.

10.2 Three Tiers of Sustainability

Tier 1: Getting the basics right

This is the base level and is the stage in which the majority of organisations are at. Companies employ simple measures such as switching lights and PCs off when left idle, recycling paper, and using greener forms of travel with the purpose of reducing the day-to-day carbon footprint. Some companies also employ self-service technologies such as centralized procurement and teleconferencing.

Tier 2: Learning to think sustainably

This is the second level, where companies begin to realize the need to embed sustainability into supply chain operations. Companies tend to achieve this level when they assess their impact across a local range of operations. In terms of the supply chain, this could involve supplier management, product design, manufacturing rationalization, and distribution optimization.

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Tier 3: The science of sustainability

The third tier of supply chain sustainability uses auditing and benchmarks to provide a framework for governing sustainable supply chain operations. This gives clarity around the environmental impact of adjustments to supply chain agility, flexibility, and cost in the supply chain network. Moving towards this level means being driven by the current climate (in which companies recognise cost savings through green operations as being significant) as well as pushing emerging regulations and standards at both an industry and governmental level.

10.3 Application of Sustainability

Companies looking to implement sustainable strategies down its supply chain should also look upstream. To elaborate, if a company is able to choose between various suppliers, it can for example use its purchasing power to get its suppliers in compliance with its green supply chain standards. In managing suppliers, companies must measure that inputs from suppliers are of high quality, and the usage of water and energy is minimised leading to less pollution, defects and over production. They also must audit their supplier base and make sure that they are improving the supply chain metrics.

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11 TOTAL QUALITY MANAGEMENT

Total Quality Management (TQM) describes a management approach to long-term success through customer satisfaction. In a TQM effort, all members of an organisation participate in improving processes, products, services, and the culture in which they work.

TQM can be summarized as a management system for a customer-focused organisation that involves all employees in continual improvement. It uses strategy, data, and effective communications to integrate the quality discipline into the culture and activities of the organisation. Many of these concepts are present in modern Quality Management Systems, the successor to TQM.

Here are the 8 principles of total quality management:

1) **Customer-focused.**
   The customer ultimately determines the level of quality. No matter what an organisation does to foster quality improvement (training employees, integrating quality into the design process, upgrading computers or software, or buying new measuring tools) the customer determines whether the efforts were worthwhile.
2) **Total employee involvement**
   All employees participate in working toward common goals. Total employee commitment can only be obtained after fear has been driven from the workplace, when empowerment has occurred, and management has provided the proper environment. High-performance work systems integrate continuous improvement efforts with normal business operations. Self-managed work teams are one form of empowerment.
3) **Process-centred**
   A fundamental part of TQM is a focus on process thinking. A process is a series of steps that take inputs from suppliers (internal or external) and transforms them into outputs that are delivered to customers (again, either internal or external). The steps required to carry out the process are defined, and performance measures are continuously monitored in order to detect unexpected variation.
4) **Integrated system**
   Although an organisation may consist of many different functional specialties often organized into vertically structured departments, it is the horizontal processes interconnecting these functions that are the focus of TQM.
   Micro-processes add up to larger processes, and all processes aggregate into the business processes required for defining and implementing strategy. Everyone must understand the vision, mission, and guiding principles as well as the quality policies, objectives, and critical processes of the organisation. Business performance must be monitored and communicated continuously.
   Every organisation has a unique work culture, and it is virtually impossible to achieve excellence in its products and services unless a good quality culture has been fostered. Thus, an integrated system connects business improvement elements in an attempt to continually improve and exceed the expectations of customers, employees, and other stakeholders.
5) **Strategic and systematic approach**
   A critical part of the management of quality is the strategic and systematic approach to achieving an

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organisation's vision, mission, and goals. This process, called strategic planning or strategic management, includes the formulation of a strategic plan that integrates quality as a core component.

6) **Continual improvement**
   A major thrust of TQM is continual process improvement. Continual improvement drives an organisation to be both analytical and creative in finding ways to become more competitive and more effective at meeting stakeholder expectations.
7) **Fact-based decision making**
   In order to know how well an organisation is performing, data on performance measures are necessary. TQM requires that an organisation continually collect and analyse data in order to improve decision making accuracy, achieve consensus, and allow prediction based on past history.
8) **Communications**
   During times of organisational change, as well as part of day-to-day operation, effective communications plays a large part in maintaining morale and in motivating employees at all levels. Communications involve strategies, method, and timeliness.

These elements are considered so essential to TQM that many organisations define them, in some format, as a set of core values and principles on which the organisation is to operate.

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12 NEW PRODUCT DEVELOPMENT

In business and engineering, new product development (NPD) covers the complete process of bringing a new product to market. A central aspect of NPD is product design, along with various business considerations. New product development is described broadly as the transformation of a market opportunity into a product available for sale. The product can be tangible (a physical product) or intangible (like a service, for example), though sometimes services and other processes are distinguished from "products." NPD requires an understanding of customer needs and wants, the competitive environment, and the nature of the market. Cost, time and quality are the main variables that drive customer needs. Aiming at these three variables, companies develop continuous practices and strategies to better satisfy customer requirements and to increase their own market share by a regular development of new products. There are many uncertainties and challenges which companies must face throughout the process. The use of best practices and the elimination of barriers to communication are the main concerns for the management of the NPD.

By setting out the steps involved, and sticking to them, product development becomes a more focused and flexible approach activity that can be adapted for all different types of products and services.

1) **Idea Generation**
   The development of a product will start with the concept. The rest of the process will ensure that ideas are tested for their viability, so in the beginning all ideas are good ideas. Ideas can, and will come, from many different directions. The best place to start is with a SWOT analysis, (Strengths, Weaknesses, Opportunities and Threats), which incorporates current market trends. This can be used to analyse your company's position and find a direction that is in line with your business strategy.
   In addition to this business-centred activity, are methods that focus on the customer's needs and wants. This could be:
   a) Under-taking market research
   b) Listening to suggestions from your target audience – including feedback on your current products' strengths and weaknesses.
   c) Encouraging suggestions from employees and partners
   d) Looking at your competitor's successes and failures
2) **Idea Screening**
   This step is crucial to ensure that unsuitable ideas, for whatever reason, are rejected as soon as possible. Ideas need to be considered objectively, ideally by a group or committee.
   Specific screening criteria need to be set for this stage, looking at Return On Investment (ROI), affordability and market potential. These questions need to be considered carefully, to avoid product failure after considerable investment down the line.
3) **Concept Development & Testing**
   You have an idea and it's passed the screening stage. However, internal opinion isn't the most important. You need to ask the people that matter – your customers.
   Using a small group of your true customer base (those that convert) the idea need to be tested to see their reaction. The idea should now be a concept, with enough in-depth information that the consumer can visualise it.
   Do they understand the concept?

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Do they want or need it?
This stage gives you a chance to develop the concept further, considering their feedback, but also to start thinking about what your marketing message will be.

4) **Business Analysis**
Once the concept has been tested and finalised, a business case needs to be put together to assess whether the new product/service will be profitable. This should include a detailed marketing strategy, highlighting the target market, product positioning and the marketing mix that will be used.
This analysis needs to include: whether there is a demand for the product, a full appraisal of the costs, competition and identification of a break-even point.

5) **Product Development**
If the new product is approved, it will be passed to the technical and marketing development stage. This is when a prototype or a limited production model will be created. This means you can investigate exact design & specifications and any manufacturing methods, but also gives something tangible for consumer testing, for feedback on specifics like look, feel and packaging for example.

6) **Test Marketing**
Test marketing (or market testing) is different to concept or consumer testing, in that it introduces the prototype product following the proposed marketing plan as whole rather than individual elements. This process is required to validate the whole concept and is used for further refinement of all elements, from product to marketing message.

7) **Commercialisation**
When the concept has been developed and tested, final decisions need to be made to move the product to its launch into the market. Pricing and marketing plans need to be finalised and the sales teams and distribution briefed, so that the product and company is ready for the final stage.

8) **Launch**
A detailed launch plan is needed for this stage to run smoothly and to have maximum impact. It should include decisions surrounding when and where to launch to target your primary consumer group. Finally, in order to learn from any mistakes made, a review of the market performance is needed to access the success of the project.

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13 ENGINEERING MANAGEMENT TOOLS

13.1 Problem Solving and Decision Making

Much of what people do is solve problems and make decisions. Often, they do so on the spot, when they're stressed and very short for time. Consequently, when they encounter a new problem or decision they must make, they react with a decision that seemed to work before. It's easy with this approach to get stuck in a circle of solving the same problem over and over again. Therefore, it's often useful to get used to an organized approach to problem solving and decision making. Not all problems can be solved, and decisions made by the following, rather rational approach, but it's a good starting point. Sometimes, it even helps to align "problem" with "opportunity"!

1) Define the problem

This is often where people struggle. They react to what they think the problem is. Instead, seek to understand more about why you think there's a problem.

Define the problem: (with input from yourself and others). Ask yourself and others, the following questions:

1. What can you see that causes you to think there's a problem?
2. Where is it happening?
3. How is it happening?
4. When is it happening?
5. With whom is it happening? (Don't jump to "Who is causing the problem?" When we're stressed, blaming others is often one of our first reactions. To be an effective manager, you need to address issues more than people.)
6. Why is it happening?
7. Write down a five-sentence description of the problem in terms of "The following should be happening, but isn't ..." or "The following is happening and should be: ..." As much as possible, be specific in your description, including what is happening, where, how, with whom and why. (It may be helpful at this point to use a variety of research methods.

Defining complex problems:

If the problem still seems overwhelming, break it down by repeating steps a-g until you have descriptions of several related problems.

Verifying your understanding of the problems:

It helps a great deal to verify your problem analysis for conferring with a peer or someone else.

Prioritize the problems:

If you discover that you are looking at several related problems, then prioritize which ones you should address first.

Note the difference between "important" and "urgent" problems. Often, what we consider to be important problems to consider are really just urgent problems. Important problems deserve more attention. For example, if you're continually answering "urgent" phone calls, then you've probably got a more "important" problem and that's to design a system that screens and prioritizes your phone calls.

Understand your role in the problem:

Your role in the problem can greatly influence how you perceive the role of others. For example, if

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you're very stressed out, it'll probably look like others are, too, or, you may resort too quickly to blaming and reprimanding others. Or, you are feel very guilty about your role in the problem, you may ignore the accountabilities of others.

2) Look at potential causes for the problem

a) It's amazing how much you don't know about what you don't know. Therefore, in this phase, it's critical to get input from other people who notice the problem and who are affected by it.
b) It's often useful to collect input from other individuals one at a time (at least at first). Otherwise, people tend to be inhibited about offering their impressions of the real causes of problems.
c) Write down what your opinions and what you've heard from others.
d) Regarding what you think might be performance problems associated with an employee, it's often useful to seek advice from a peer or your supervisor in order to verify your impression of the problem.
e) Write down a description of the cause of the problem and in terms of what is happening, where, when, how, with whom and why.

3) Identify alternatives for approaches to resolve the problem

At this point, it's useful to keep others involved (unless you're facing a personal and/or employee performance problem). Brainstorm for solutions to the problem. Very simply put, brainstorming is collecting as many ideas as possible, then screening them to find the best idea. It's critical when collecting the ideas to not pass any judgment on the ideas -- just write them down as you hear them. (A wonderful set of skills used to identify the underlying cause of issues is Systems Thinking.)

4) Select an approach to resolve the problem

When selecting the best approach, consider:

a) Which approach is the most likely to solve the problem for the long term?
b) Which approach is the most realistic to accomplish for now? Do you have the resources? Are they affordable? Do you have enough time to implement the approach?
c) What is the extent of risk associated with each alternative?

(The nature of this step, in particular, in the problem-solving process is why problem solving and decision making are highly integrated.)

5) Plan the implementation of the best alternative (this is your action plan)

a) Carefully consider "What will the situation look like when the problem is solved?"
b) What steps should be taken to implement the best alternative to solving the problem? What systems or processes should be changed in your organisation, for example, a new policy or procedure? Don't resort to solutions where someone is "just going to try harder".
c) How will you know if the steps are being followed or not? (these are your indicators of the success of your plan)
d) What resources will you need in terms of people, money and facilities?
e) How much time will you need to implement the solution? Write a schedule that includes the start and stop times, and when you expect to see certain indicators of success.
f) Who will primarily be responsible for ensuring implementation of the plan?
g) Write down the answers to the above questions and consider this as your action plan.

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h) Communicate the plan to those who will be involved in implementing it and, at least, to your immediate supervisor.
(An important aspect of this step in the problem-solving process is continual observation and feedback.)

6) Monitor implementation of the plan

Monitor the indicators of success:

a) Are you seeing what you would expect from the indicators?
b) Will the plan be done according to schedule?
c) If the plan is not being followed as expected, then consider: Was the plan realistic? Are there sufficient resources to accomplish the plan on schedule? Should more priority be placed on various aspects of the plan? Should the plan be changed?

7) Verify if the problem has been resolved or not

One of the best ways to verify if a problem has been solved or not is to resume normal operations in the organisation. Still, you should consider:

a) What changes should be made to avoid this type of problem in the future? Consider changes to policies and procedures, training, etc.
b) Lastly, consider "What did you learn from this problem solving?" Consider new knowledge, understanding and/or skills.
c) Consider writing a brief memo that highlights the success of the problem-solving effort, and what you learned as a result. Share it with your supervisor, peers and subordinates.

13.1.1 Rational Versus Organic Approach to Problem Solving

13.1.1.1 Rational

A person with this preference often prefers using a comprehensive and logical approach similar to the guidelines in the above section. For example, the rational approach, described below, is often used when addressing large, complex matters in strategic planning.

1. Define the problem.
2. Examine all potential causes for the problem.
3. Identify all alternatives to resolve the problem.
4. Carefully select an alternative.
5. Develop an orderly implementation plan to implement that best alternative.
6. Carefully monitor implementation of the plan.
7. Verify if the problem has been resolved or not.

A major advantage of this approach is that it gives a strong sense of order in an otherwise chaotic situation and provides a common frame of reference from which people can communicate in the situation. A major disadvantage of this approach is that it can take a long time to finish. Some people might argue, too, that the world is much too chaotic for the rational approach to be useful.

13.1.1.2 Organic

Some people assert that the dynamics of organisations and people are not nearly so mechanistic as to be improved by solving one problem after another. Often, the quality of an organisation or life comes from how one handles being “on the road” itself, rather than the “arriving at the destination.” The quality comes

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from the ongoing process of trying, rather than from having fixed a lot of problems. For many people it is an approach to organisational consulting. The following quote is often used when explaining the organic (or holistic) approach to problem solving.

"All the greatest and most important problems in life are fundamentally insoluble … They can never be solved, but only outgrown. This "outgrowing" proves on further investigation to require a new level of consciousness. Some higher or wider interest appeared on the horizon and through this broadening of outlook, the insoluble lost its urgency. It was not solved logically in its own terms but faded when confronted with a new and stronger life urge."

From Jung, Carl, Psychological Types (Pantheon Books, 1923)

A major advantage of the organic approach is that it is highly adaptable to understanding and explaining the chaotic changes that occur in projects and everyday life. It also suits the nature of people who shun linear and mechanistic approaches to projects. The major disadvantage is that the approach often provides no clear frame of reference around which people can communicate, feel comfortable and measure progress toward solutions to problems.

13.1.2 Tools and Methods for Problem Solving and Decision Making

Challenge

Undertake your own research on the following tools and methods;

Cost Benefit Analysis (for deciding based on costs)
De Bono Hats (for looking at a situation from many perspectives
Decision Trees (for clarifying and depicting which alternative are derived from which)
Delphi Decision Making (to collect the views of experts and distil expert-based solutions)
Dialectic Decision Making (rigorous action planning via examining opposite points of view)
Fishbone Diagram -- 5 Steps to build Fishbone Diagram
Fishbowls (for groups to learn by watching modelled behaviours)
Force-Field Analysis (for identifying opposing forces)
Grid Analysis (for choosing among many choices)
Pareto Principle (for finding the options that will make the most difference -- (20/80 rule")
Polarity Map (for "solving" seemingly unsolvable contradictions)
Rational Decision Making
SWOT Analysis (to analyse from strengths, weaknesses, opportunities and threats)
Voting
Work Breakdown Structure (for organizing and relating many details)

13.2 Project Risk Management

Could your projects use additional risk management? It is generally agreed that Risk Management is one of the most underutilized areas of project management. As engineers, when we're managing a project in our area of expertise we like to think we know the primary risks and we have them under control. But a small

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