Effective Innovation in Practice

A Guide to technology-oriented Innovation for Engineers and Technical Managers

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Chapter 1
Introduction

> I have been impressed with the urgency of doing. Knowing is not enough; we must apply. Being willing is not enough; we must do. (Leonardo da Vinci, 1452–1519)

Nowadays, running a business that has to deal with great internal and external dynamics is a challenging activity. It requires challenging managerial decisions to be made, many simultaneous activities to be carried out, and a complex coordination system for these activities. The main reasons for these dynamic environments are the continuous new demands resulting from the consumer's behavior with regard to buying innovative products. Therefore, organizations within various industry sectors are confronted with a complex environment that is changing rapidly. Product life cycles are becoming shorter and the digital revolution, which is still taking place, has great implications for information and communication systems within organizations.

There are also other strong international and national developments, influencing the primary and secondary processes within organizations. Examples include global economic issues, global climate issues and regional laws relating to corporate governance within companies. All necessitate a clear focus on customer demands (the make to market principle) as well as more effective and efficient business processes to shorten the time to market (TTM). Global and national companies have to innovate continuously with regard to technologies for delivering their products in order to create a sustainable competitive advantage.

With this book we have tried to fulfill the requirements of those readers who need a guide to cope better with technology-oriented innovation within organizational practices from a learning perspective. At the preparatory stage of this book, four key points were uppermost in our plans:

- First, this book must be useful for students, studying abroad at Universities and Universities of Applied Sciences, dealing with technology-oriented learning programs and for lectures involved in the programs;
- Second, this book must be useful for managers interested in, and working on, innovation management issues in organizational practices;
- Third, this book should incorporate theories and methods that are useful for professionals working on innovation questions in a systematic way within innovation teams, process change teams, and product development teams;
- Fourth, this book should not only support knowledge development but should also be helpful for decision making related to innovation questions in practice.

In summary, this book supports learning to innovate in a practical rather than theoretical manner - by doing. It therefore supports a learning process by delivering several learning products such as research plans and reflection reports (what was learned and reflecting on the learning). Further, by doing research in practice, based on the methodological guidelines and concepts in this book, it will be possible to create advice reports that are useful for decision makers.

Innovation is a very broad term; it incorporates many words, ideas and experiences, and depends on specific individuals within specific organizational situations. Nowadays, innovation deals with an enormous amount of internal and external organizational issues. In this book we have tried to present a toolbox of ideas, theories and methods related to innovation and technology. The intention is to give the reader a number of 'pencils' for 'coloring' the technology-oriented innovation world better than you could have done before reading this book. We've also tried to sharpen the reader's ideas and improve the learner's capability to distinguish between head and side issues, considering innovation from a technological perspective. It is like the difference between seeing only the man or seeing more than that (figure 1.1).

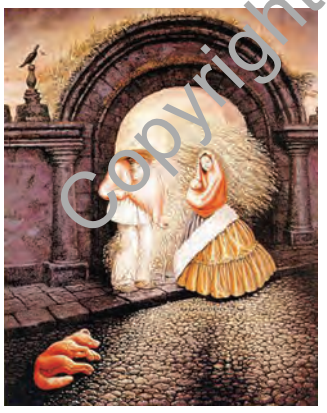


Figure 1.1 Learning to see

It is to be expected that students considering an individual innovation learning trajectory, will experience something similar to Vincent van Gogh (1853-1898). At the beginning of his learning trajectory for painting, he wrote,"I learned to measure and to see, by searching for the main lines. What seems to be in the past an impossible ambition, now step-by-step things are becoming possible." What you should have to do is just start the learning process suggested in section 1.6.

1.1 Structure of the book

Now you have an understanding of the foundations of the book, and our main emphasis of 'learning by doing', it is time to present the structure of this book. It contains seven chapters. Each chapter can be seen as one step of the 'knowledge ladder', see figure 1.2. Every step of the ladder will improve your ability to understand and carry out problem solving activities related to technology-oriented innovation. Every step has been built on the previous one and therefore, reading all chapters will allow you to accumulate your knowledge about technology oriented innovation.

Figure 1.2 The 'knowledge ladder'

Chapter 1 presents the relevance of technology-oriented innovation within today's organizations, including definitions of the main concepts to be used. Chapter 2 deals with the question of how to carry out business management research steps to create the skills to develop a proper design for problem solving research related to innovation. In this part the reader can learn what kind of research activities they ought to be using, and how. It concerns project-based research, that has to be carried out in a methodologically assured way. Chapter 3 presents an overview of some historical and current aspects of technology in relation to technology, science, engineering, innovation and inventions.

Chapters 4 and 5 deal with some successful organizational models recommended for coping with the management of innovation in practice. Chapter 6 focuses on the question of how to create customer value and organizational value in relation to product and process development. It also covers many concepts related to technology management and methods for opportunity identification and selection, and possible ways of reducing the risks and uncertainties associated with innovation. Chapter 7 concludes with a view of possible learning project descriptions and some recommendations to those involved within the innovation process for creating effective technology-oriented innovations in practice.

1.2 Effective innovation within organizations

What could be meant by effective innovation within organizations? Effective innovation here deals with something new that is related to organizational goals. Therefore, innovation is strongly related to the strategy of an organization, i.e. mission, vision, goals and strategy (that is strategy defined in a broad sense). Innovation has its origins in the Latin 'Innovare'. The Romans used Novatio and thus related with our modern word 'new'. Schumpeter (1883-1950) and Usher (1883-1965; Ruttan, 1959; [1]) introduced the word innovation that was more in line with our present use of the term and related to economic activities. They stressed that innovations were creative activities to be seen as an integral part of the process of learning: "innovation is an inescapable necessity for the individual as for the group as a whole." It is interesting that Shumpeter regarded innovation and invention as belonging to different sectors of socio-economic activity. "Innovation belongs to economy, whereas 'invention' belongs to science and technology", he postulated. He defined innovation as Durchsetzung neuer Kombinationen (in English: execution of new combinations) and concluded that real innovations have to be useful in practice. Shumpeter states that organizational innovation includes five possibilities:

- production of new types of goods, or change of properties of the existing goods;
- introduction of a new method of production, based on a new scientific discovery;
- opening of new markets;
- use of the new sources of raw materials and intermediate goods;
- new organization of the means of production.

However, there are lot of others who have questioned innovation (and still do). In the Netherlands, for example, in his oration speech, van der Kooij (Innovare

necessest, 1988; [2]) concluded that during the period 1970-1996 the definition for innovation had being changed. The innovation concepts used before 1970 showed that innovation had been seen as an activity (thus not as an object) that was new at the moment of implementation. During 1970-1980, the concepts showed innovation more as an activity by focusing on products. The definitions after 1980 were dealing with innovation as a process by focusing on products as well as manufacturing processes. It seems to be clear that the term innovation could be considered as a complex word that has evolved over several decades.

In modern innovation literature, we find various definitions of innovation. A number of scholars are expressing the view that innovation is related to concepts such as technology, technique, invention, creativity, product development, value management, strategy and management. Others argue that innovation is mainly concerned with social changing behavior. They are referring to the major impact that innovations can have on society. Innovations such as the T-Ford car and the airplane, but also more recently the Internet are well known examples that express the global impact on our technology driven society. Also, in literature, it is recognized that we have to distinguish between several kinds of innovation. Incremental (step-wise) innovation must be distinguished from radical (often with a major impact) innovation. Often innovation is expressed in terms of disruptive and sustainable technology. Sustainable technologies improve the performance of established products or processes including a small technology step forward. Disruptive technologies deals with innovation, including a great technology step. A disruptive technology often significantly changes the way we do things in our world with regard to our behavior. This is sometimes called a paradigm shift. Paradigm is a broad concept and means the way we perceive and experience our world. A paradigm shift has very often to do with a radical change. Some historical examples of innovations that caused a paradigm shift are: the Internet, the steam machine and electrical power stations; for more examples see chapter 3. Figure 1.3 shows an example

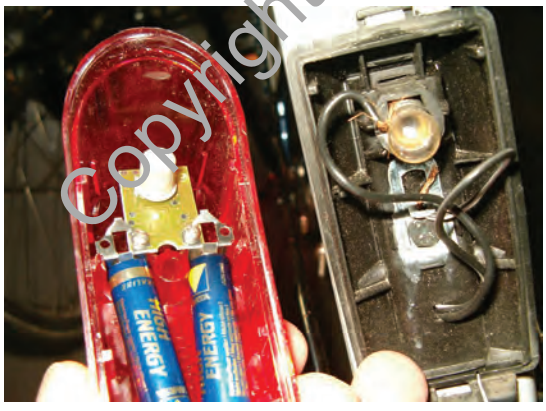


Figure 1.3 Product architecture differences between 'old' and 'new' bicycle backlight

of a disruptive technology on a small scale - a bicycle backlight; this innovation changed our life just a little at the end of twentieth century in the Netherlands.

Increasingly management books are considering more specifically the management issues with regard to innovation. In his book *Innovation management and new product development* Paul Trott (2008; [3]) defined innovation as follows:

Innovation is the management of all activities involved in the process of idea generation, technology, development, manufacturing, and marketing of a new (or improved) product or manufacturing process or equipment.

Kathleen Allen presented in her book *Bringing new technology to market* (Allen, 2003; [4]) an innovation and commercialization process including invention and innovation. She states that innovation can be seen as a manageable process that turns an invention into something useful and having commercial value. She states that "in a broad sense innovation is also about creating ways of doing things". She also pointed out that an invention (solely based on creativity) has to be distinguished from innovation in terms of requiring a plan. An invention has to do with a Eureka phenomenon. "It came up suddenly and could not be expected and planned." Joe Tidd and John Bessant in their great book *Managing Innovation* (Tidd and Bessant, 2009; [5]) perceive innovation as a process of turning ideas into reality and capturing value from them. They identify four phases in the innovation process:

1. *Search*: how can we find opportunities for innovation?
2. *Select*: what are we going to do and why?
3. *Implement*: how are we going to make it happen?
4. *Capture*: how are we going to get the benefits from it?

In his groundbreaking book *The sources of Innovation* von Hippel (1988; [6]) focused on user development of innovation and he defines the following steps: identify need; research and development; build prototype; apply/commercialize.

Narayanan in his impressive book *Managing technology and innovation for competitive value* (Narayanan, 2001; [7]), paid more attention to technology than most others do. He uses the term innovation in two ways: innovation as process and innovation as output. In the first context, the term innovation refers to the process through which individual organizations arrive at a technical solution via a problem solving approach by means of: problem recognition, technology selection, solution development and finally commercialization. In the second context, the term innovation refers to a product or service, i.e. the output of the process of innovation instead of the process itself.
So, as you can see, innovation is a very commonly used word with many dimensions, depending on the context in which it is used.

To make the complex word 'innovation' applicable for modern technological driven organizations, this book pays significant attention to operationalizing the closely related subjects of innovation and technology.
Referring to the four design conditions mentioned earlier, this book concentrates on technology-oriented innovation management and focuses on those organizations in which the technical system plays a big role in the way those innovating organizations deliver and develop products and services (intangible products). In short, we are talking about the management of technology-oriented innovation.

1.3 Relationship between technology and innovation

Protagoras, a Greek philosopher, born 485bc, thinker and teacher, was one of the first Greek Sophists (i.e. travelling teachers). He is well known because of his dictum, "Man is the measure of all things". Probably he tried to express the relativity to the individual of all perceptions and, according to some, of all judgments as well. Nowadays in our technology-driven society, it seems to be necessary to slightly arrange his dictum to: "Man in relationship with technology is the measure of all things". This adjusted dictum expresses the enormous interaction between the activities of individuals and groups of individuals (human activities) and technology (technical system activities). The pictures in figures 1.4 and 1.5 show the relationship between technology and some other important aspects of society.

Figure 1.4 Nature without technology (left), and nature in relationship with technology

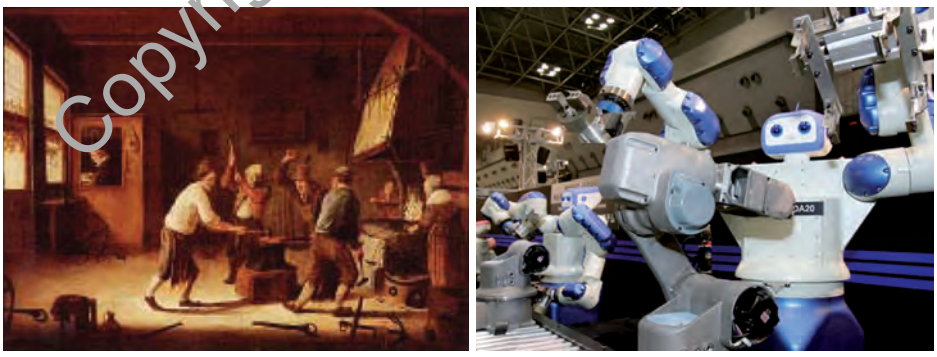


Figure 1.5 Pictures (dated 1700 and 2009) showing a great difference in human-technical system activities within the working environment

1.3.1 What does technology really mean?

In asking young full-time Business Engineering students "what does technology really mean?", the following picture of the perception of the technology concept emerged:

1. Technology is a complex combination of materials, and is a means of making things faster. It deals with the way, how to manufacture. Technology shows us what kind of processes have to be used in manufacturing.
2. Technology means improvements to assist us in our daily lives, that help us to achieve goals and it is a way of improving or inventing products by implementing new ideas and creating new products.
3. Technology means a complex process, which contains a lot of elements to produce something, and to provide us with a service.

Asking a Business Engineering student combining his study with a job as a manager for a company that engineers and manufactures compressor equipments, delivered the following beautiful, clear and short statement: "Technology is the know-how we need to manufacture our products that we sell."

The word technology has its origin in the Greek term 'tekhnologia' meaning systematic treatment of an art, craft, or technique. Originally referring to grammar, from tekhno- + -logia, it means, science of technique. Rogers (1983, [8]) defined the term technology as follows: "Technology is any tool or technique, any product or process, any physical equipment or method of doing or making, by which human capability is extended."

Throughout the twentieth century the uses of the term seem to have increased to a number of 'classes' of technology, such as technology as objects (tools, machines etc.); as knowledge; as a series of activities, including skills, methods, procedures, routines; as a goal-directed process; and as a socio-technical system covering the manufacture and use of objects involving people and other objects.

In his book *Managing Technology* Steele (1989); [9]) defines technology as "The system by which a society satisfies its needs and desires." When applied to an individual firm he postulated it as: "The capability that an enterprise needs in order to provide its customers with the good and services it proposes to offer, both now and in the future."

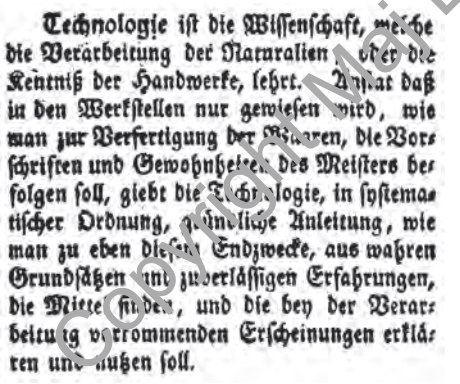
Cybernetica Principia [10] defines technology as:
"An object or sequence of operations created by man to assist in achieving some goal."
Here it is expressing very clearly the artificial status of the meaning of technology.
In some languages, e.g. French, Dutch and German, technology seems to be clearly distinguished from technic (origins: 'technique', 'tecnica', 'technik') which is the

practical skill to use knowledge, methods, and procedures in a particular case in order to resolve a specific practical problem.

1.3.2 Who coined the word 'technology' and when?

The first person who carefully explained the word technology seems to be Johann Beckmann[1] (1738-1811). Beckmann presented the first textbook (1777; [11]) on technology (in a practical way and from a scientific point of view) and coined the term in this. After his appointment as the Professor of the Economy, Beckmann turned to reinforcing the 'craft sciences'. He was a Kameralistic scholar of economy and philosophy and is considered the founder of several branches of science: 'warenkunde' (commodity science), 'landwirtschaftslehre' (agronomics) and technology. Beckmann described in his book (addressed to governmental economic officials) how different raw materials are processed via a systematic approach and for a number of trades.

Beckmann introduced technology as a separate subject into the high school learning program. After a brief introduction to the economics of the manufacturing process, Beckmann describes a natural order of processes, from simple to more complicated one. He describes in detail a large variety of different trades and manufacturing businesses, ranging from the woolen trade to hat-making, dyeing, paper-making, brewing and distilling, tobacco production, pottery, brick production, porcelain-making, glass and mirror production, minting of coins and production of gun powder. He even gives information on different varieties of base products and some historical background information (see figure 1.6).


Technologie iſt die Wiſſenſchaft, welche die Verarbeitung der Naturalien, oder die Kentniß der Handwerke, lehrt. Anſtat daß in den Werkſtellen nur gewieſen wird, wie man zur Verfertigung der Waaren, die Vorſchriften und Gewohnheiten des Meiſters befolgen ſoll, giebt die Technologie, in ſyſtematiſcher Ordnung, gründliche Anleitung, wie man zu eben dieſem Endzwecke, aus wahren Grundſätzen und zuverläſſigen Erfahrungen, die Mittel finden, und die bey der Verarbeitung vorkommenden Erſcheinungen erklären und nutzen ſoll.

Technology is the science which teaches us the processing of natural products, or the knowledge of handicrafts. Compared with the typical situation at places of work where the only discussion in terms of teaching is how one, in order to manufacture products, should follow the instructions and habits of the Masters, technology provides us with a systematically ordered and thorough documentation (including fundamental directives, instructions, descriptions, explanations, manuals) about how one, for the same final purpose (manufacturing products), based on true principles and reliable experiences, should find the means and should explain and use the phenomena that occurs during processing.

Figure 1.6 Beckmann's definition of technology (German/Englisch)

[1] Technologie ist die Wissenschaft, welche die Verarbeitung der Naturalien, oder die Kentniß der Handwerke, lehrt. Anstat daß in den Werkstellen nur gewiesen wird, wie man zur Verfertigung der Waaren, die Vorschriften und Gewohnheiten des Meisters befolgen soll, giebt die Technologie, in systematischer Ordnung, gründliche Anleitung, wie man zu eben diesem Endzwecke, aus wahren Grundsätzen und zuverlässigen Erfahrungen, die Mittel finden, und die bey der Verarbeitung vorkommenden Erscheinungen erklären und nutzen soll.

1.3.3 Use of the word 'technology' in modern times

How is technology nowadays related to the terms such as innovation, invention and technique? By searching Google using advanced searching tools, the following number of search results were discovered (see table 1.1).

Table 1.1 Google hits on innovation, invention, technology, technique and combinations of these words

Innovation	Invention	Technology	Technique	Search results * 1000 (April 2009)	Search results * 1000 (October 2013)
-	-	*	-	737.000	5.740.000
-	-	-	*	135.000	363.000
*	-	-	-	65.400	236.000
-	-	*	*	61.400	329.000
-	*	-	-	35.100	97.300
*	-	*	-	2.700	649.000
-	*	*	-	11.000	71.700
*	-	-	*	3.810	15.500
*	*	*	*	1.550	14.900
-	*	-	*	365	11.000
*	*	*	-	463	44.000
*	*	-	-	341	6.810
-	*	*	*	299	15.700

By looking for the occurrences of several word combinations through including and excluding words (using several search operators) the table above was derived. Based on Google search methods, the term technology seems to be the 'hottest' item in our information-based society. Another conclusion can be derived if we search for -ogy words. For the words finishing with 'ogy' you could also conclude that the word technology is the 'top -ogy word', see Internet 'More words'[2]. Technology related to innovation seems to be a very important issue nowadays.

In this book, that focuses on innovation and technology within organizations, I will stay closely aligned with Beckmann, the founder of the word 'technology', who defined technology as systematic instructional knowledge related to manufacturing processes. In chapter 3 we will deal with the question of what history (based on some aspects) can teach us about technology in terms of innovation, inventions and some other organizational issues. Considering innovation and the importance of technology in

[2] The top ten "ogy words" are technology, psychology, ideology, sociology, theology, biology, methodology, analogy, apology, terminology. Surprisingly methodology, also a main subject in this book, appears in the top 10.

our society, it seems to make sense to concentrate on the issue of technology within innovating organizations, and to focus on innovation from a technological perspective.

1.4 Technology-oriented innovation within organizations

From a business perspective, based on the definitions given earlier, I propose to introduce the modern concepts of customer value and organizational value, leading to the following working definition for innovation:

Innovation is a goal-directed activity process (to be managed) by which product-market-technology ideas (not necessarily inventions) are transformed into new or improved product and/or process concepts, finally resulting in the possibility of producing new or improved products for practical applications, with the intention of generating organization value and customer value.

In this book, the management of technology-oriented innovation is discussed with a focus on managerial questions that are strongly related to innovation problem solving and decision-making. Organization value has to be understood from a broad perspective and includes tangible and intangible values, i.e.: profit, continuity, image, knowledge, etc. Customer value is from the customer's perspective and deals with the trade-off between the benefits received versus the price paid for the products.

To express the innovation definition in more operational terms, we have to deal with issues such as maintaining, improving and innovating existing value chain activities within a business. We also have to deal with questions concerning product and process technology and with the question how to manage all these organizational issues in relation to creating organizational value and creating customer value. This book deals with the main question: 'how to cope with technology-oriented innovation within organizational practices in an effective way?' In agreement with the definition of Beckmann, we are trying to answer the main question: 'how to treat innovation effectively within organizations, in a systematic order (considering knowledge, skills, methods and techniques)?' Alternatively, in shortened terms: 'how to cope with the technology of innovation?'

1.5 Being innovative, don't forget about being a sustainable firm

According to the working definition, innovation can be seen as a transformation process within organizations that has to be managed. Employees (not necessary all, but certainly those with managerial and coordinating tasks) within organizations, who are

dealing with innovation, have to deal with two main kinds of activities. One category of activities concerns goal-related activities for existing situations, e.g. producing and delivering qualified products to customers, contacting customers in order to obtain new orders, undertaking administration tasks, etc. The other kind of activities have to do with changing some or more organizational elements (incremental or radical) of the existing situation, e.g. improving the manufacturing process, redesigning the marketing and sales department, and strategy development. The reasons for changing are related, for example, to quality problems, new customers' wishes, efficiency improvements, etc. To be effective, both kinds of activities have to be coordinated by managers in order to attain the organization's main goals in a sustainable and competitive way.

Because innovation is concerned with the kinds of activities mentioned above, there is a risk that managers involved with innovation will forget to carefully manage the existing organization. After all, innovation is stretching, defiant and new but the existing organization must ensure that it continues to deliver good products, get new orders and achieve stable profits and sales by satisfying its stakeholders: customers, shareholders, employees, etc. After all, innovation has two distinctly different sides: a challenging, creating and diverging side, and a rational, analytical and converging side. Coping with innovation within organizational practices, therefore, is a complex managerial task.

The difficulty of coping with innovation can be very clearly shown by means of the case of the dotcom bubble in recent history. It is instructive to learn from an innovation story that shows the two sides of innovations as discussed previously. It shows very clearly what can happen if decision makers within organizations are too enthusiastic about their innovations, and forget to take account of the needs of the existing business from a long term perspective.

The Internet innovation lifecycle started with the development in the sixties as an experimental military project [12]. 1957 was the year that the Soviet Union successfully launched the first artificial satellite, Sputnik. The United States responded to that with Government-backed R&D development programs intended to close the assumed technology gap, finally resulting in ARPA (US Advanced Research Projects Agency) in 1958. This program was set-up to promote scientific research in all disciplines, and to foster technological advancement on all those fronts that might be connected with defense. This program worked well and stimulated lots of students to join the program. One of them was Leonard Kleinrock who was attracted to computing and had earned a master's degree in electrical engineering at MIT. After getting his master's degree, he decided to carry out PhD research related to computer communications. He foresaw that computer communications would become important and he also recognized that the telephone system for linking computers was not adequate enough to use for

effective communications. He published a book in 1964 about packet switching and other elements that serve as the foundation for today's Internet technology.

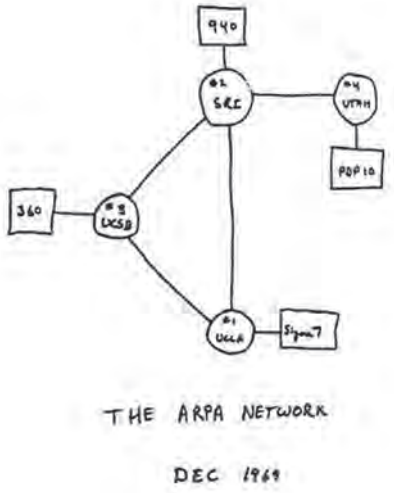


Figure 1.7 Drawing of 4 Node Network (Image: The Computer History Museum)

During the seventies, many people were playing significant roles in the further development of data communications, such as Douglas Englebart (he developed NLS (oNLine System), an online hyper linking system, and also invented the mouse), and Robert Kahn of BBN (engineering consulting company Bolt Beranek and Newman) and Vinton Cerf of Stanford who further developed Kleinrock's concepts.

1969 was the start date for the Internet, for this was the year that four host computers joined ARPANET (see figure 1.7), which had been recently developed by ARPA by using NCP (network control program). Invented by Lick Licklider and Lawrence Roberts among others, ARPANET was the first computer network. ARPANET switched to TCP/IP on Jan. 1st, 1983. Originally designed to connect Universities, ARPANET evolved into the Internet of today.

Tim Berners Lee is often referred to as the inventor of the World Wide Web. In 1990, whilst working at the CERN institute he invented HTTP, the hypertext editor for the World Wide Web. He created a hyperlinked database system for use in connecting databases across a closed network. The Berners-Lee 1989 CERN proposal, 'Information Management: A Proposal' became in effect the original proposal for the World Wide Web. However, there were also some others including Doug Engelbart and Ted Nelson who developed the idea of hypertext and Robert Cailliau who worked for many years with Berners-Lee on developing a system for networking computers at CERN.

The first Web server was developed at CERN in Switzerland in 1991. In April 1993, CERN agreed to have the underlying Web technology put in the general public domain, in effect allowing anyone to use the Web protocol. By the end of 1992, there were about 26 publicly accessible sites available on the World Wide Web and then ... the Internet revolution had begun (see figure 1.8).

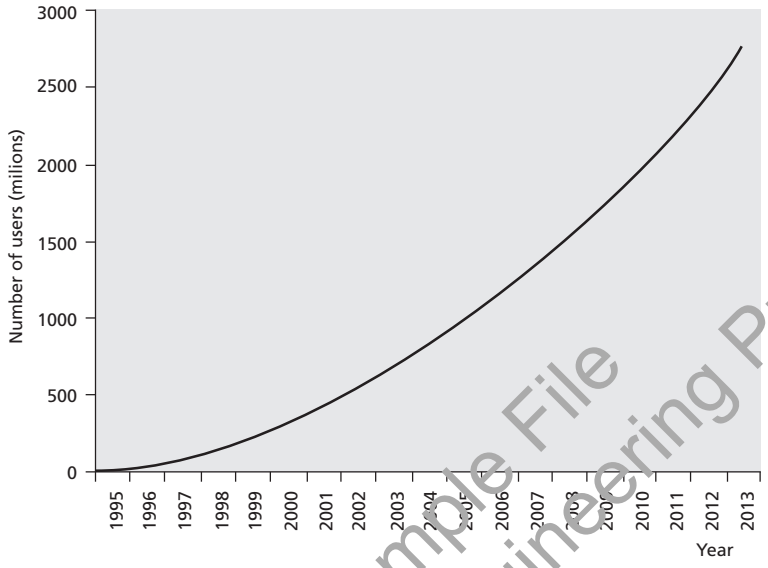


Figure 1.8 The growth in the number of users of the Internet (source: www.internetworldstats.com/emarketing.htm)

On September 14, 2008 (Washington, D.C) Tim Berners-Lee unveiled the World Wide Web Foundation [13] to fulfill a vision of the Web as humanity connected by technology. The World Wide Web Foundation seeks to advance one Web that is free and open, to expand the Web's capability and robustness, and to extend the Web's benefits to all people on the planet. The Web Foundation brings together business leaders, technology innovators, academia, government, NGOs (non-governmental organizations), and experts in many fields to tackle challenges that, like the Web, are global in scale. By funding research, technology development, and outreach, the Web Foundation strives to enable all people to share knowledge, access services, conduct commerce, participate in good governance, and communicate in creative ways.

The Internet development is a good example of the birth and growing use of a technology on a very large scale leading to a paradigm shift. Although nowadays the Internet is an established technology used as a tool for conducting business, we needed the dotcom bubble to understand the negative aspects of the new technology. The dotcom bubble burst on March 10th 2000 and the values of many Internet companies have dropped considerably since then for several years. A lot of fast growing firms

seemed to be too dependent on capital then. Investors were very interested into dotcom start-ups and invested at a far quicker and in a less measured way than they would normally do for regular business companies.

What could we learn from this Internet story? Every time a major change happens in technology, many new companies want to develop new business with technology, but being innovative in the past also has to do with being innovative tomorrow and the day after tomorrow.

Decision makers within innovating organizations have also to take great care about the possible negative consequences of innovations. Focusing on managing innovation, in order to be effective, the managers within innovating organizations have to carefully monitor the existing situation of the organization day after day. On a daily basis managers have to diagnose the existing situation for decision-making purposes based on the 'house in order' principle. At the same time managers have to continuously look for ways to innovate. Both activities have to managed in a proper, balanced way.

To cope with this balance, Lowell W. Steele (1989; 19]) presented a useful concept for creating awareness within organizations of the possible consequences of changing the existing state of organizations too radically.

Figure 1.9 Innovation risk space

He distinguished three axes (figure 1.9) with the following dimensions: technology change, product change and market change and he called this figure, the risk space. Focusing on technology-oriented innovation, I propose to call it the innovation risk space. We have then to consider three axes covering the change into one or more innovation directions. The further along each dimension that change is situated, the greater the organizational risks. Movements along all three dimensions at the same time will, according to Steele, lead to too much serious organizational risks.

This concept is a very first tool available for people involved with innovation problem solving and are considering the possible risks associated with the scale and degree of innovations. Many other tools will follow in next chapters.

1.6 Learning context

This book *Effective innovation in practice* deals with the following subjects: technology-oriented innovation, innovation management, technology management, and business management research. The final goal is to develop the reader's knowledge, skills and attitudes from an experimental learning (learning by doing) perspective. The learning context could either be a formal learning environment (school, university) or the working context of professionals. The reader will acquire:

- An innovation management knowledge base;
- Methodological research skills to cope effectively with a broad spectrum of innovation issues in practice;
- A critical approach to using innovation concepts for problem solving practices in relation to decision-making;
- Advanced experiences with regard to the preparatory activities when organizations have to be redesigned in relation to their innovation processes;
- Stimulants to explore analytical abilities and conceptualizing skills to cope with complex situations related to technology-oriented innovation;
- A systematic approach with regard to problem solving, dealing with it in an interdisciplinary way.

The proposed method is to learn the theories in this book by studying and practicing (learning by doing) based on a learning-research approach. This approach contains two main steps. Firstly, learning the concepts in this book by explaining, using and checking them in the preparation of a research proposal. Secondly, carrying out the research based on that research proposal in a methodological approved and systematic way. In choosing this learning research approach, it is expected that it will possible to learn in a pleasant and efficient way, thus preventing the possible stress that might normally arise when trying to resolve complex problem solving situations. See figure 1.10 that neatly expresses the possible negative consequences of undertaking research in an inefficient way.

Figure 1.10 Carefully designed and executed innovation research can prevent stress

1.6.1 Learning approach in more detail

This book will help you to learn in a practical way to cope with innovation. Assuming that you have a serious interest in learning more about innovation and innovation management and that you want to become more effective in undertaking activities related to solving innovation problems, the question raised is "Could this book help me to learn more of technology-oriented innovation?" David Kolb[3] provides a framework to answer this didactical question. He developed the Experimental Learning Theory (ELT) (1984; [14]) and defines learning as "the process whereby knowledge is created through the transformation of experience". His theory is based upon scientific knowledge of how people learn and develop, and the academic view that knowledge development has to do with "understanding and transforming experience".

Kolb developed a generic model to describe four types of learning styles in relation to personal qualities, educational specialization and jobs. Knowledge results from the combination of the acquisition and transformation of experience. According to Kolb, acquiring experience is concerned with concrete experience and abstract conceptualization. Transforming experiences deals with reflective observation and active experimentation. Concrete experiences are the basis for observations and reflections, these reflections are assimilated and distilled into abstract concepts from which new implications for actions can be drawn, to be actively tested in creating new experiences.

Kolb stated that four learning dimensions (learning styles) are possible. People are always developing preferred ways of selecting one of the following learning styles: Diverging, Assimilating, Converging and Accommodating.

- Diverging style: concrete experiences and reflective observation are combined;
- Assimilating style: reflective observation and abstract conceptualizing are combined;
- Converging: abstract conceptualizing and active experimentation are combined;
- Accommodating: concrete experience and active experimentation are combined.

The learning styles identified by Kolb are explained in more detail below.

Convergers: learner as doer, problem solver, decision maker
Individuals preferring the 'think and do' style enjoy finding practical uses for ideas and theories. They have the ability to solve problems and make decisions based on finding solutions to questions or problems. Applied research shows that students who specialize in Engineering and Physical sciences prefer the 'think and do' converging

[3] David A. Kolb is Professor of Organizational Behavior in the Weatherhead School of Management.

style. The converging learning style tends also to be preferred by professionals in the field of technology (e.g. engineering), economics and environmental science.

Accommodators: learner as doer, entrepreneur working with others
Individuals preferring the 'do and feel' learning style enjoy 'learning by doing', primarily not based on logical analysis, but on active experimentation (hands-on learning). They want to carry out plans, searching for challenging experiences. These individuals prefer to work with others in solving problems. Applied research shows that students who specialize in Business and Management prefer the 'do and feel' learning style. The accommodation learning style tends to be preferred by employees within general management, marketing and sales functions.

Divergers: learner as watcher, information worker, idea generator
Individuals preferring the 'feel and watch' style enjoy viewing concrete situations from different perspectives based on concrete experiences. They like to generate ideas and gather information within groups. People with majors in the Arts, History, Political Science, English and Psychology tend to have diverging learning styles. Professions such as arts, communication and social service (e.g. social work) are favored by persons with this learning style.

Assimilators: learner as watcher, observer thinker
Individuals preferring the 'watch and think' learning style enjoy transforming information into concise, logical forms and focusing on ideas and abstract concepts. Based on reflective observation, these persons assimilate such reflections into abstract concepts. This type of individual likes exploring analytical models. People with educational backgrounds in Economics, Mathematics, Sociology and Chemistry tend to have the assimilation learning style. Typical jobs are information and science careers.

From a learning perspective, it is preferable to take into account the learning styles of the students by starting the learning process without excluding other learning dimensions. It should be noted that teaching activities also give value to other stages of the learning cycle. This book focuses on learners as problem solvers in practices related to innovation decision making. These include those studying Business Engineering and Business Management Sciences, but also individuals whose professional careers involve them in innovation issues, such as members of management teams, innovation teams, R&D teams, and product & technology development teams. As mentioned earlier, the learning research approach covered in this book will provide an effective approach for these groups or individuals.

1.6.2 Suggested learning approach

This book should be seen as an instruction tool. It is proposed to use this book in conjunction with lectures, including meetings between student and lecturer, to learn about technology-oriented innovation, for discussion purposes and for reflecting on the things learned. In combining the styles of Kolb with a structured way of undertaking

Table[4] *1.2*

Proposed learning activities	Main product judgment criteria	Learning activities Kolb	Proposed lecturer role and lecture activities
1a Research design Development of a research plan for carrying out design based research.	1a Research plan quality Quality of research design upon which applied research will be based.	Learner as watcher, observer, thinker concentrating on: knowledge of facts and concepts, problem approach, research skills, principles, abstractions, cognitive schemes.	Teacher for lessons and workshops, working on case assignments to question, to probe and to explore the ideas, concepts, and logic and interrelationships between concepts.
1b Reflection Process and content based written reflection based on research design.	1b Document quality considering: Knowledge development process and knowledge products.	Learner as watcher, information worker, idea generator concentrating on: reflections, monitoring.	Motivator for discussion purposes. Practicing under accompaniment by thinking over and reviewing what has happened.
2 Research steps -Problem signaling -Diagnosis -(Re)Design	2 Advice reports quality Fousing on quality of reports upon which managerial decisions could be based.	Learner as doer, problem solver, decision maker concentrating on properly using: methods, techniques, instruments.	Coach/expert, for practicing techniques with coaching and feedback from an expert (context, process, content). or: Evaluator, for learners carrying out variety of challenging activities, role playing, group simulations, presentations, exercises.
3 Research steps -Intervention -Evaluation	3 Quality of intervention actions If redesign really had taken place, quality of evaluation reports.	Learner as doer, problem solver, decision maker concentrating on properly using: methods, techniques, instruments.	Coach/expert, for practicing techniques with coaching and feedback from an expert (context, process, content). or: Evaluator, for learners carrying out variety of challenging activities, role playing, group simulations, presentations, exercises.

[4] Colomn 1 items are discussed in detail in chapter 2

organizational research for solving innovation problems, table 1.2 could be helpful. Lecturers especially can explore the various suggestions for the kind of teaching products, learning activities and lecture roles that could be helpful in supporting the proposed 'learning by doing' approach. For more details see the Workbook *Effective Innovation in Practice – Opportunities for Hands-on Learning* and the website http://innovationcenter.nl/the-method/

1.7 Summary

Innovation and technology are complex and commonly used words and are applied in many different contexts. In this book we choose to focus on the innovation process from a technological perspective called technology-oriented innovation. This process, in short, has to be seen as a goal directed activity process, through which ideas are transformed into product and/or process concepts, with the intention of generating organization value and customer value.

Johann Beckmann coined the word 'technology' in 1777. He defined technology as the application of systematic instructional knowledge related to manufacturing processes. When considering innovation and the important factor of technology in our society, it seems to be sensible to concentrate on the factor of technology within organizations, to concentrate on innovation from a technologic perspective called technology-oriented innovation. A two-stage activity path is recommended for learning by doing when considering innovation directed problem solving, taking into account the learning styles of Kolb. The first main step is developing a research proposal based on the proposed concepts presented in this book. The second step considers executing innovation research based on this proposal for delivering learning products and advice reports.

Questions

1. What is innovation in your opinion and what does 'new' mean?
2. Considering technology, in your opinion what kind of effects has technology had during the period 1600- 2000?
3. What are great innovations (give five examples) and why?
4. Give your own definition of the concept of technology.
5. Use the Internet to surf on the following terms: innovation, patent and value. What kind of conclusions can you derive from their relationship with technology?
6. What does the technology of innovation mean?

7. Use the Internet to search for two stories describing organizations that had taken (too) great risks regarding innovations. What can you learn from these?
8. Search for two great innovations relating to consumer products in recent history. Describe them and consider the question of whether these are real innovations according to the working definition of innovation presented in this chapter.
9. Think about an organizational problem in your working or learning context. Try to develop a research proposal for undertaking problem solving business research, that is related to innovation.

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