Lean Manufacturing & Business Process Re-Engineering

Contents

Business Process Re-engineering

Business Process re-engineering (BPR) is a management approach aiming at improvements by means of elevating efficiency and effectiveness of the processes that exist within and across organisations. The key to BPR is for organizations to look at their business processes from a "clean slate" perspective and determine how they can best construct these processes to improve how they conduct business.

Business process re-engineering is also known as BPR, Business Process Redesign, Business Transformation, or Business Process Change Management.

History

In 1990, Michael Hammer, a former professor of computer science at the Massachusetts Institute of Technology (MIT), published an article in the Harvard Business Review, in which he claimed that the major challenge for managers is to obliterate non-value adding work, rather than using technology for automating it (Hammer 1990). This statement implicitly accused managers of having focused on the wrong issues, namely that technology in general, and more specifically information technology, has been used primarily for automating existing work rather than using it as an enabler for making non-value adding work obsolete.

Hammer's claim was simple: Most of the work being done does not add any value for customers, and this work should be removed, not accelerated through automation. Instead, companies should reconsider their processes in order to maximize customer value, while minimizing the consumption of resources required for delivering their product or service. A similar idea was advocated by Thomas H. Davenport and J. Short (1990), at that time a member of the Ernst & Young research center, in a paper published in the Sloan Management Review the same year as Hammer published his paper.

This idea, to unbiasedly review a company's business processes, was rapidly adopted by a huge number of firms, which were striving for renewed competitiveness, which they had lost due to the market entrance of foreign competitors, their inability to satisfy customer needs, and their insufficient cost structure. Even well established management thinkers, such as Peter Drucker and Tom Peters, were accepting and advocating BPR as a new tool for (re-)achieving success in a dynamic world. During the following years, a fast growing number of publications, books as well as journal articles, was dedicated to BPR, and many consulting firms embarked on this trend and developed BPR methods. However, the critics were fast to claim that BPR was a way to dehumanize the work place, increase managerial control, and to justify downsizing, i.e. major reductions of the work force (Greenbaum 1995, Industry Week 1994), and a rebirth of Taylorism under a different label.

Despite this critique, reengineering was adopted at an accelerating pace and by 1993, as many as 65% of the Fortune 500 companies claimed to either have initiated reengineering efforts, or to have plans to do so. This trend was fueled by the fast adoption of BPR by the consulting industry, but also by the study *Made in America*, conducted by MIT, that showed how companies in many US industries had lagged behind their foreign counterparts in terms of competitiveness, time-to-market and productivity.

Definition of BPR

Different definitions can be found. This section contains the definition provided in notable publications in the field.

Hammer and Champy (1993) define BPR as

"... '***the fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical contemporary measures of performance, such as cost, quality, service, and speed."***

Thomas H. Davenport (1993), another well-known BPR theorist, uses the term process innovation, which he says

"encompasses the envisioning of new work strategies, the actual process design activity, and the implementation of the change in all its complex technological, human, and organizational dimensions".

Additionally, Davenport (ibid.) points out the major difference between BPR and other approaches to organization development (OD), especially the continuous improvement or TQM movement, when he states:

"Today firms must seek not fractional, but multiplicative levels of improvement – 10x rather than 10%."

Finally, Johansson *et al.* (1993) provide a description of BPR relative to other process-oriented views, such as Total Quality Management (TQM) and Just-in-time (JIT), and state:

"Business Process Re-engineering, although a close relative, seeks radical rather than merely continuous improvement. It escalates the efforts of JIT and TQM to make process orientation a strategic tool and a core competence of the organization. BPR concentrates on core business processes, and uses the specific techniques within the JIT and TQM ”toolboxes” as enablers, while broadening the process vision."

In order to achieve the major improvements BPR is seeking for, the change of structural organizational variables, and other ways of managing and performing work is often considered as being insufficient. For being able to reap the achievable benefits fully, the use of information technology (IT) is conceived as a major contributing factor. While IT traditionally has been used for supporting the existing business functions, i.e. it was used for increasing organizational efficiency, it now plays a role as enabler of new organizational forms, and patterns of collaboration within and between organizations.

BPR derives its existence from different disciplines, and four major areas can be identified as being subjected to change in BPR - organization, technology, strategy, and people - where a process view is used as common framework for considering these dimensions. The approach can be graphically depicted by a modification of "Leavitt’s diamond" (Leavitt 1965).

Business strategy is the primary driver of BPR initiatives and the other dimensions are governed by strategy's encompassing role. The organisation dimension reflects the structural elements of the company, such as hierarchical levels, the composition of organisational units, and the distribution of work between them. Technology is concerned with the use of computer systems and other forms of communication technology in the business. In BPR, information technology is generally considered as playing a role as enabler of new forms of organizing and collaborating, rather than supporting existing business functions. The people / human resources dimension deals with aspects such as education, training, motivation and reward systems. The concept of business processes - interrelated activities aiming at creating a value added output to a customer - is the basic underlying idea of BPR. These processes are characterized by a number of attributes: Process ownership, customer focus, value-adding, and cross-functionality.

The role of information technology

Information technology (IT) has historically played an important role in the re-engineering concept. It is considered by some as a major enabler for new forms of working and collaborating within an organisation and across organisational borders.

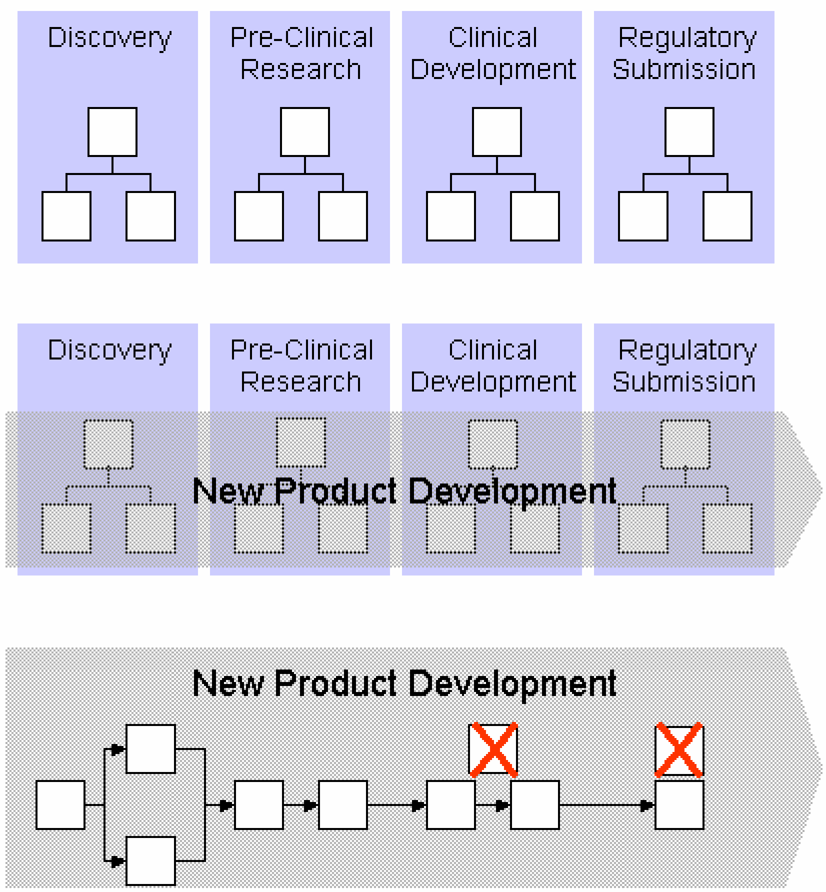
The early BPR literature, e.g. Hammer & Champy (1993), identified several so called *disruptive technologies* that were supposed to challenge traditional wisdom about how work should be performed.

1. Shared databases, making information available at many places
2. Expert systems, allowing generalists to perform specialist tasks
3. Telecommunication networks, allowing organizations to be centralized and decentralized at the same time
4. Decision-support tools, allowing decision-making to be a part of everybody's job
5. Wireless data communication and portable computers, allowing field personnel to work office independent
6. Interactive videodisk, to get in immediate contact with potential buyers
7. Automatic identification and tracking, allowing things to tell where they are, instead of requiring to be found
8. High performance computing, allowing on-the-fly planning and revisioning

In the mid 1990s, especially workflow management systems were considered as a significant contributor to improved process efficiency. Also ERP (Enterprise Resource Planning) vendors, such as SAP, positioned their solutions as vehicles for business process redesign and improvement.

Methodology

Although the labels and steps differ slightly, the early methodologies that were rooted in IT-centric BPR solutions share many of the same basic principles and elements. The following outline is one such model, based on the PRLC (Process Reengineering Life Cycle) approach developed by Guha et.al. (1993).



Simplified schematic outline of using a business process approach, examplified for pharmceutical R&D:

1. Structural organisation with functional units
2. Introduction of New Product Development as cross-functional process
3. Re-structuring and streamlining activities, removal of non-value adding tasks

1. Envision new processes
    1. Secure management support
    2. Identify reengineering opportunities
    3. Identify enabling technologies
    4. Align with corporate strategy
2. Initiating change
    1. Set up reengineering team
    2. Outline performance goals
3. Process diagnosis
    1. Describe existing processes
    2. Uncover pathologies in existing processes

4. Process redesign
    1. Develop alternative process scenarios
    2. Develop new process design
    3. Design HR architecture
    4. Select IT platform
    5. Develop overall blueprint and gather feedback
5. Reconstruction
    1. Develop/install IT solution
    2. Establish process changes
6. Process monitoring
    1. Performance measurement, including time, quality, cost, IT performance
    2. Link to continuous improvement

-> Loop-back to diagnosis

Benefiting from lessons learned from the early adopters, some BPR practitioners advocated a change in emphasis to a customer-centric, as opposed to an IT-centric, methodology. One such methodology, that also incorporated a Risk and Impact Assessment to account for the impact that BPR can have on jobs and operations, was described by Lon Roberts (1994). Roberts also stressed the use of change management tools to proactively address resistance to change—a factor linked to the demise of many reengineering initiatives that looked good on the drawing board.

Also within the management consulting industry, a significant number of methodological approaches have been developed. A set of short papers, outlining and comparing some of them can be found here, followed by some guidelines for companies considering to contract a consultancy for a BPR initiative:

BPR - a rebirth of scientific management?

By its critics, BPR is often accused to be a re-animation of Taylor's principles of scientific management, aiming at increasing productivity to a maximum, but disregarding aspects such as work environment and employee satisfaction. It can be agreed that Taylor's theories, in conjunction with the work of the early administrative scientists have had a considerable impact on the management discipline for more than 50 years. However, it is not self-evident that BPR is a close relative to Taylorism and this proposed relation deserves a closer investigation.

In the late 19th century Frederick Winslow Taylor, a mechanical engineer, started to develop the idea of management as a scientific discipline. He applied the premise that work and its organisational environment could be considered and designed upon scientific principles, i.e. that work processes could be studied in detail using a positivist analytic approach. Upon the basis of this analysis, an optimal organisational structure and way of performing all work tasks could be identified and implemented. However, he was not the one to originally invent the concept. In 1886, a paper entitled *"The Engineer as Economist"*, written by Henry R. Towne for the American Society of Mechanical Engineers, had laid the bedrock for the development of scientific management.

The basic idea of scientific management was that work could be studied from an objective scientific perspective and that the analysis of the gathered information could be used for increasing productivity, especially of blue-collar work, significantly. Taylor (1911) summarized his observations in the following four principles:

- Observation and analysis through time study to set the optimal production rate. In other words, develop a science for each man's task–a One Best Way.
- Scientifically select the best man for the job and train him in the procedures he is expected to follow.
- Cooperate with the man to ensure that the work is done as described. This means establishing a differential rate system of piece work and paying the man on an incentive basis, not according to the position.
- Divide the work between managers and workers so that managers are given the responsibility for planning and preparation of work, rather than the individual worker.

Scientific management's main characteristic is the strict separation of planning and doing, which was implemented by the use of a functional foremanship system. This means that a worker, depending on the task that he or she is performing, can report to different foreman, each of them being responsible for a small, specialized area.

Taylor's ideas had a major impact on manufacturing, but also administration. One of the most well-known examples is Ford Motor Co., which adopted the principles of scientific management at an early stage, and built its assembly line for the T-model based on Taylor's model of work and authority distribution, thereby giving name to Fordism.

Later on, Taylor's ideas were extended by the time and motion studies performed by Frank Gilbreth and his wife Lillian. Henry Gantt, a co-worker of Taylor, developed Taylor's idea further, but placed more emphasis on the worker. He developed a reward system that no longer took into account only the output of the work, but was based on a fixed daily wage, and a bonus for completing the task.

Taylor's work can be, and has been, criticized many times for degrading individuals to become machinelike. One of the most famous critiques of the situation that an application of scientific management could result in, is shown in Charles Chaplin's movie *"Modern Times (film)"*. Despite that fact, Taylor was inspired by the vision of creating a workplace that is beneficial to all members of the organisation, both management and workers.

When looking at Taylor's ideas retrospectively, we can conclude, that they very well fitted the organisations of the early 20th century. The kind of organisation he proposed requires certain pre-conditions, which were satisfied in the technological and socio-economic environment of his time and the heritage from economic individualism and a Protestant view of work. However, despite the good intention of designing organisations where managers and workers could jointly contribute to the common achievements, Taylor missed the fact that he had been building his principles on wrong assumptions. There are some major critical points that can be brought forward against Taylor's concept.

The strict belief in man being totally rational, and the history of Protestant ethic, which considered work as being a manifestation of religious grace, made him disregard the crucial issue of human behaviour and the fact that money is insufficient as the single source of motivation (Tawney 1954).

The lack of considering the organisational environment as a conceivable factor, and the overemphasis on organisational efficiency. As Thompson (1969) notes:

"Scientific management, focusing primarily on manufacturing or similar production activities, clearly employs economic efficiency as its ultimate criterion and achieves conceptual closure of the organisation by assuming that goals are known, tasks are repetitive, output of the production process somehow disappears, and resources in uniform qualities are available."

If accepting Thompson's critique as valid and relevant, it can be concluded that the strict hierarchical organisation seems to be unfit to take on the challenges that are imposed by fierce competition and dynamic market structures. Due to the focus on improvement through repetition and resource uniformity, the applicability on organisations and processes without these characteristics, such as pharmaceutical R&D, can be questioned.

Peter Drucker noted a third problem related to scientific management, namely that there was no real concern about technology, i.e. that Taylor considered his theory as being general, and that it could be applied to any organization, independently of the technology used. Drucker (1972) stated:

"Scientific management was not concerned with technology. It took tools and technology as givens."

This point brings forward a clear argument against the application of Taylor's principles and methodologies for improving today's organisations. Considering that the rapid development in the IT field actually constitutes a driving force in itself, it appears to be unfit to employ organisational concepts that neglect the changing and enabling role of technology. On the other hand we can argue that the application of scientific management in the early 20st century, as we look at it retrospectively, must be considered as the contemporary use of a concept that would look and be applied in a different way today. Taylor did not neglect technology, he considered it as an important contributor to organisational performance, but given the pace of development, he could not consider it as a major driver of change.

Looking at the suggested relationship between BPR and Taylor's principles we can conclude that primarily Thompson's and Drucker's criticism build a strong case against BPR being a successor of Taylorism. An organisational concept that does not take into account changing business environments and rapid technological advancements is not fit for serving as an improvement method today. Also the BPR literature offers a harsh critique of the continuous application of tayloristic principles in the modern business world, thus rejecting the separation of planning and doing and the strict functional division of labor. BPR proponents claim that taking BPR for Taylorism is a major misunderstanding of the concept, and responsible for a considerable number of re-engineering project failures. On the other hand, there is also a similarity which stems from the methodological approach: Both scientific management and BPR have a focus on productivity and efficient use of resources that can be achieved through an optimum process design and its subsequent deployment.

The following quote, referring to scientific management can equally be used to describe the intention of reengineering:

"To conduct the undertaking toward its objectives by seeking to derive optimum advantage from all available resources." (Loyd 1994)

At the same time it cannot be denied, that the implementation of process-based organisations in practice often is accompanied by massive lay-offs and an emphasis on managerial control. A study by CSC Index from 1994 revealed that 73% of the companies applying BPR reduced their workforce with an average of 21%. Thomas Davenport, an early contributor to the BPR-field, provided a harsh critique against labeling substantial workforce reductions re-engineering and in a paper from 1995 he stated that

"Re-engineering didn't start out as a code word for mindless bloodshed ... The [other] thing to remember about the start of re-engineering is that the phrase 'massive layoffs' was never part of the early vocabulary." (Davenport, 1995)

Successes

BPR, if implemented properly, can give huge returns. BPR has helped giants like Procter and Gamble Corporation and General Motors Corporation succeed after financial drawbacks due to competition. It helped American Airlines somewhat get back on track from the bad debt that is currently haunting their business practice. BPR is about the proper method of implementation.

General Motors Corporation implemented a 3-year plan to consolidate their multiple desktop systems into one. It is known internally as "Consistent Office Environment" (Booker, 1994). This reengineering process involved replacing the numerous brands of desktop systems, network operating systems and application development tools into a more manageable number of vendors and technology platforms. According to Donald G. Hedeen, director of desktops and deployment at GM and manager of the upgrade program, he says that the process "lays the foundation for the implementation of a common business communication strategy across General Motors." (Booker, 1994). Lotus Development Corporation and Hewlett-Packard Development Company, formerly Compaq Computer Corporation, received the single largest non-government sales ever from General Motors Corporation. GM also planned to use Novell NetWare as a security client, Microsoft Office and Hewlett-Packard printers. According to Donald G. Hedeen, this saved GM 10% to 25% on support costs, 3% to 5% on hardware, 40% to 60% on software licensing fees, and increased efficiency by overcoming incompatibility issues by using just one platform across the entire company.

Southwest Airlines offers another successful example of re-engineering their company and using Information Technology the way it was meant to be implemented. In 1992, Southwest Airlines had a revenue of $1.7 billion and an after-tax profit of $91 million. American Airlines, the largest U.S. carrier, on the other hand had a revenue of $14.4 billion dollars but lost $475 million and has not made a profit since 1989 (Furey and Diorio, 1994). Companies like Southwest Airlines know that their formula for success is easy to copy by new start-ups like Morris, Reno, and Kiwi Airlines. In order to stay in the game of competitive advantage, they have to continuously re-engineer their strategy. BPR helps them be original.

Michael Dell is the founder and CEO of DELL Incorporated, which has been in business since 1983 and has been the world's fastest growing major PC Company. Michael Dell's idea of a successful business is to keep the smallest inventory possible by having a direct link with the manufacturer. When a customer places an order, the custom parts requested by the customer are automatically sent to the manufacturer for shipment. This reduces the cost for inventory tracking and massive warehouse maintenance. Dell's website is noted for bringing in nearly "$10 million each day in sales."(Smith, 1999). Michael Dell mentions: "If you have a good strategy with sound economics, the real challenge is to get people excited about what you're doing. A lot of businesses get off track because they don't communicate an excitement about being part of a winning team that can achieve big goals. If a company can't motivate its people and it doesn't have a clear compass, it will drift." (Smith, 1999) Dell's stocks have been ranked as the top stock for the decade of the 1990s, when it had a return of 57,282% (Knestout and Ramage, 1999). Michael Dell is now concentrating more on customer service than selling computers since the PC market price has pretty much equalized. Michael Dell notes: "The new frontier in our industry is service, which is a much greater differentiator when price has been equalized. In our industry, there's been a pretty huge gap between what customers want in service and what they can get, so they've come to expect mediocre service. We may be the best in this area, but we can still improve quite a bit—in the quality of the product, the availability of parts, service and delivery time." (Smith, 1999) Michael Dell understands the concept of BPR and really recognizes where and when to re-engineer his business.

Ford re-engineered their business and manufacturing process from just manufacturing cars to manufacturing quality cars, where the number one goal is quality. This helped Ford save millions on recalls and warranty repairs. Ford has accomplished this goal by incorporating barcodes on all their parts and scanners to scan for any missing parts in a completed car coming off of the assembly line. This helped them guarantee a safe and quality car. They have also implemented Voice-over-IP (VoIP) to reduce the cost of having meetings between the branches.

A multi-billion dollar corporation like Procter and Gamble Corporation, which carries 300 brands and growing really has a strong grasp in re-engineering. Procter and Gamble Corporation's chief technology officer, G. Gil Cloyd, explains how a company which carry multiple brands has to contend with the "classic innovator's dilemma — most innovations fail, but companies that don't innovate die. His solution, innovating innovation..." (Teresko, 2004). Cloyd has helped a company like Procter and Gamble grow to $5.1 billion by the fiscal year of 2004. According to Cloyd's scorecard, he was able to raise the volume by 17%, the organic volume by 10%, sales are at $51.4 billion up by 19%, with organic sales up 8%, earnings are at $6.5 billion up 25% and share earnings up 25%. Procter and Gamble also has a free cash flow of $7.3 billion or 113% of earnings, dividends up 13% annually with a total shareholder return of 24%. Cloyd states: "The challenge we face is the competitive need for a very rapid pace of innovation. In the consumer products world, we estimate that the required pace of innovation has double in the last three years. Digital technology is very important in helping us to learn faster." (Teresko, 2004) G. Gil Cloyd also predicts, in the near future, "as much as 90% of P&G's R&D will be done in a virtual world with the remainder being physical validation of results and options." (Teresko, 2004).

Critique

The most frequent and harsh cirtique against BPR concerns the strict focus on efficiency and technology and the disregard of people in the organization that is subjected to a re-engineering initiative. Very often, the label BPR was used for major workforce reductions. Thomas Davenport, an early BPR proponent, stated that

"When I wrote about "business process redesign" in 1990, I explicitly said that using it for cost reduction alone was not a sensible goal. And consultants Michael Hammer and James Champy, the two names most closely associated with reengineering, have insisted all along that layoffs shouldn't be the point.

But the fact is, once out of the bottle, the re-engineering genie quickly turned ugly." (Davenport, 1995)

Michael Hammer similarly admitted that

"I wasn't smart enough about that. I was reflecting my engineering background and was insufficient appreciative of the human dimension. I've learned that's critical." (White, 1996)

Other criticism brought forward against the BPR concept include

- lack of management support for the initiative and thus poor acceptance in the organisation.
- exaggerated expectations regarding the potential benefits from a BPR initiative and consequently failure to achieve the expected results.
- underestimation of the resistance to change within the organisation.
- implementation of generic so-called best-practice processes that do not fit specific company needs.
- overtrust in technology solutions.
- performing BPR as a one-off project with limited strategy alignment and long-term perspective.
- poor project management.

Development after 1995

With the publication of critiques in 1995 and 1996 by some of the early BPR proponents, coupled with abuses and misuses of the concept by others, the re-engineering fervor in the U.S. began to wane. Since then, considering business processes as a starting point for business analysis and redesign has become a widely accepted approach and is a standard part of the change methodology portfolio, but is typically performed in a less radical way as originally proposed.

More recently, the concept of Business Process Management (BPM) has gained major attention in the corporate world and can be considered as a successor to the BPR wave of the 1990s, as it is evenly driven by a striving for process efficiency supported by information technology. Equivalently to the critique brought forward against BPR, BPM is now accused of focusing on technology and disregarding the people aspects of change.

Notes

- Davenport, Thomas & Short, J. (1990), The New Industrial Engineering: Information Technology and Business Process Redesign, in: Sloan Management Review, Summer 1990, pp 11-27
- Davenport, Thomas (1993), Process Innovation: Re-engineering work through information technology, Harvard Business School Press, Boston
- Davenport, Thomas (1995), Re-engineering - The Fad That Forgot People, Fast Company, November 1995
- Drucker, Peter (1972), Work and Tools, in: W. Kranzberg and W.H. Davenport (eds), Technology and Culture, New York
- Greenbaum, Joan (1995), Windows on the workplace, Cornerstone
- Guha, S.; Kettinger, W.J. & Teng, T.C., Business Process Reengineering: Building a Comprehensive Methodology, Information Systems Management, Summer 1993
- Hammer, Michael (1990), Reengineering Work: Don't automate, obliterate, Harvard Business Review, Jul/Aug 1990, pp 104-112
- Hammer, Michael and Champy, James (1993), Reengineering the Corporation: A Manifesto for Business Revolution, Harper Business
- Industry Week (1994), De-engineering the corporation, Industry Week article, 4/18/94
- Johansson, Henry J. et.al. (1993), Business Process Reengineering: BreakPoint Strategies for Market Dominance, John Wiley & Sons
- Leavitt, H.J. (1965), Applied Organizational Change in Industry: Structural, Technological and Humanistic Approaches, in: James March (ed.), Handbook of Organizations, Rand McNally, Chicago
- Loyd, Tom (1994), Giants with Feet of Clay, Financial Times, Dec 5 1994, p 8
- Malhotra, Yogesh (1998), Business Process Redesign: An Overview, IEEE Engineering Management Review, vol. 26, no. 3, Fall 1998.
- Roberts, Lon (1994), Process Reengineering: The Key To Achieving Breakthrough Success, Quality Press, Milwaukee.
- Taylor (1911), Frederick, The principles of scientific management, Harper & Row, New York
- Thompson, James D. (1969), Organizations in Action, MacGraw-Hill, New York

Lean manufacturing

Lean manufacturing is a generic process management philosophy derived mostly from the Toyota Production System (TPS) but also from other sources. It is renowned for its focus on reduction of the original Toyota 'seven wastes' in order to improve overall customer value. Lean is often linked with Six Sigma because of that methodology's emphasis on reduction of process variation (or its converse smoothness) and Toyota's combined usage. Toyota's steady growth from a small player to the most valuable and the biggest car company in the world has focused attention upon how it has achieved this, making "Lean" a hot topic in management science in the first decade of the 21st century.

"Lean" is viewed by many as the latest management fad in the cost-reduction arena. It has for many the advantage of a very descriptive active name and has been, in many cases, used like any other cost-reduction approach. This has meant that the "Lean" word can be found in many places, projects and proposals. This has meant that for many it has hit the same implementation problems as those other approaches which has created a level of cynicism in some quarters about its effectiveness. However, there are enough high-profile high-success implementations (headed by Toyota) that attitudes to it are quite mixed.

For many, Lean is the set of TPS 'tools' that assist in the identification and steady elimination of waste (muda), the improvement of quality, and production time and cost reduction. The Japanese terms from Toyota are quite strongly represented in "Lean". To solve the problem of waste, Lean Manufacturing has several 'tools' at its disposal. These include continuous process improvement (kaizen), the "5 Whys" and mistake-proofing (poka-yoke). In this way it can be seen as taking a very similar approach to other improvement methodologies.

There is a second approach to Lean Manufacturing, which is promoted by Toyota, in which the focus is upon improving the 'flow' or smoothness of work (thereby steadily eliminating mura, unevenness) through the system and not upon 'waste reduction' per se. Techniques to improve flow include production levelling, "pull" production (by means of kanban) and the Heijunka box. This is a fundamentally different approach to most improvement methodologies which may partially account for its lack of popularity.

The difference between these two approaches is not the goal but the prime approach to achieving it. The implementation of smooth flow exposes quality problems which already existed and thus waste reduction naturally happens as a consequence. The advantage claimed for this approach is that it naturally takes a system-wide perspective whereas a 'waste' focus has this perspective, sometimes wrongly, assumed. Some Toyota staff have expressed some surprise at the 'tool' based approach as they see the tools as work-arounds made necessary where flow could not be fully implemented and not as aims in themselves.

Both Lean and TPS can be seen as a loosely connected set of potentially competing principles whose goal is cost reduction by the elimination of waste. These principles include: Pull processing, Perfect first-time quality, Waste minimization, Continuous improvement, Flexibility, Building and maintaining a long term relationship with suppliers, Autonomation, Load levelling and Production flow and Visual control. The disconnected nature of some of these principles perhaps springs from the fact that the TPS has grown pragmatically since 1948 as it responded to the problems it saw within its own production facilities. Thus what one sees today is the result of a 'need' driven learning to improve where each step has built on previous ideas and not something based upon a theoretical framework. Toyota's view is that the methodology is not the tools but the method of application of muda, mura, muri to expose problems systematically and to use the tools where the ideal cannot be achieved. Thus the 'tools' are, in their view, 'workarounds' adapted to different situations which explains any apparent incoherence of the 'principles' above.

The TPS has two pillar concepts: JIT (flow) and autonomation (smart automation). Adherents of the Toyota approach would say that the smooth 'flow'ing delivery of 'value' achieves all these improvements as a side-effect. If production 'flows' perfectly then there is no inventory, if customer valued features are the only ones produced then product design is simplified and effort is only expended on features the customer values. The other of the two TPS pillars is the very human aspect of 'autonomation' whereby automation is achieved with a human touch. This aims to give the machines enough 'intelligence' to recognise when they are working abnormally and flag this for human attention. Thus humans do not have to monitor normal production and only have to focus on abnormal, or fault, conditions. A reduction in human workload that is probably much desired by all involved since it removes much routine and repetitive activity that humans often do not enjoy and where they are therefore not at their most effective.

Lean implementation is therefore focused on getting the right things, to the right place, at the right time, in the right quantity to achieve perfect work flow while minimizing waste and being flexible and able to change. These concepts of flexibility and change are principally required to allow production leveling, but have their analogues in other processes such as R&D. The flexibility and ability to change are not open-ended, and therefore often not expensive capability requirements. More importantly, all of these concepts have to be understood, appreciated, and embraced by the actual employees who build the products and therefore own the processes that deliver the value. The cultural and managerial aspects of Lean are just as, and possibly more, important than the actual tools or methodologies of production itself. There are many examples of Lean tool implementation without sustained benefit and these are often blamed on weak understanding of Lean in the organisation.

Lean aims to make the work simple enough to understand, to do and to manage. To achieve these three at once there is a belief held by some that Toyota's mentoring process (loosely called Senpai and Kohai relationship), so strongly supported in Japan, is one of the best ways to foster Lean Thinking up and down the organizational structure. This is the process undertaken by Toyota as it helps its suppliers to improve their own production. The closest equivalent to Toyota's mentoring process is the concept of Lean Sensei, which encourages companies, organizations, and teams to seek out outside, third-party "Sensei" that can provide unbiased advice and coaching, (see Womack et al, Lean Thinking, 1998).

History of waste reduction thinking

Pre-20th Century

Most of the basic goals of lean manufacturing are common sense and documented examples can be seen back to at least Benjamin Franklin. Poor Richard's Almanack says of wasted time, "He that idly loses 5s. [shillings] worth of time, loses 5s., and might as prudently throw 5s. into the river." He added that avoiding unnecessary costs could be more profitable than increasing sales: "A penny saved is two pence clear. A pin a-day is a groat a-year. Save and have."

Again Franklin's The Way to Wealth says the following about carrying unnecessary inventory. "You call them goods; but, if you do not take care, they will prove evils to some of you. You expect they will be sold cheap, and, perhaps, they may [be bought] for less than they cost; but, if you have no occasion for them, they must be dear to you. Remember what Poor Richard says, 'Buy what thou hast no need of, and ere long thou shalt sell thy necessaries.' In another place he says, 'Many have been ruined by buying good penny worths'." Henry Ford cited Franklin as a major influence on his own business practices, which included Just-in-time manufacturing.

The concept of waste being built into jobs and then taken for granted was noticed by motion efficiency expert Frank Gilbreth, who saw that masons bent over to pick up bricks from the ground. The bricklayer was therefore lowering and raising his entire upper body to get a 5 pound (2.3 kg) brick but this inefficiency had been built into the job through long practice. Introduction of a non-stooping scaffold, which delivered the bricks at waist level, allowed masons to work about three times as quickly, and with less effort.

20th Century

Frederick Winslow Taylor, the father of scientific management, introduced what are now called standardization and best practice deployment: "And whenever a workman proposes an improvement, it should be the policy of the management to make a careful analysis of the new method, and if necessary conduct a series of experiments to determine accurately the relative merit of the new suggestion and of the old standard. And whenever the new method is found to be markedly superior to the old, it should be adopted as the standard for the whole establishment" (Principles of Scientific Management, 1911).

Taylor also warned explicitly against cutting piece rates (or, by implication, cutting wages or discharging workers) when efficiency improvements reduce the need for raw labor: "...after a workman has had the price per piece of the work he is doing lowered two or three times as a result of his having worked harder and increased his output, he is likely entirely to lose sight of his employer's side of the case and become imbued with a grim determination to have no more cuts if soldiering [marking time, just doing what he is told] can prevent it." This is now a foundation of lean manufacturing, because it is obvious that workers will not drive improvements they think will put them out of work. Shigeo Shingo, the best-known exponent of single-minute exchange of die (SMED) and error-proofing or poka-yoke, cites Principles of Scientific Management as his inspiration (Andrew Dillon, translator, 1987. The Sayings of Shigeo Shingo: Key Strategies for Plant Improvement).

American industrialists recognized the threat of cheap offshore labor to American workers during the 1910s, and explicitly stated the goal of what is now called lean manufacturing as a countermeasure. Henry Towne, past President of the American Society of Mechanical Engineers, wrote in the Foreword to Frederick Winslow Taylor's Shop Management (1911), "We are justly proud of the high wage rates which prevail throughout our country, and jealous of any interference with them by the products of the cheaper labor of other countries. To maintain this condition, to strengthen our control of home markets, and, above all, to broaden our opportunities in foreign markets where we must compete with the products of other industrial nations, we should welcome and encourage every influence tending to increase the efficiency of our productive processes."

Ford starts the ball rolling

Henry Ford continued this focus on waste while developing his mass assembly manufacturing system. "Ford's success has startled the country, almost the world, financially, industrially, mechanically. It exhibits in higher degree than most persons would have thought possible the seemingly contradictory requirements of true efficiency, which are: constant increase of quality, great increase of pay to the workers, repeated reduction in cost to the consumer. And with these appears, as at once cause and effect, an absolutely incredible enlargement of output reaching something like one hundredfold in less than ten years, and an enormous profit to the manufacturer".

Ford (1922, My Life and Work) provided a single-paragraph description that encompasses the entire concept of waste. "I believe that the average farmer puts to a really useful purpose only about 5%. of the energy he expends. ... Not only is everything done by hand, but seldom is a thought given to a logical arrangement. A farmer doing his chores will walk up and down a rickety ladder a dozen times. He will carry water for years instead of putting in a few lengths of pipe. His whole idea, when there is extra work to do, is to hire extra men. He thinks of putting money into improvements as an expense. ... It is waste motion— waste effort— that makes farm prices high and profits low." Poor arrangement of the workplace-- a major focus of the modern kaizen-- and doing a job inefficiently out of habit-- are major forms of waste even in modern workplaces.

Ford also pointed out how easy it was to overlook material waste. As described by Harry Bennett, "One day when Mr. Ford and I were together he spotted some rust in the slag that ballasted the right of way of the D. T. & I [railroad]. This slag had been dumped there from our own furnaces. 'You know,' Mr. Ford said to me, 'there's iron in that slag. You make the crane crews who put it out there sort it over, and take it back to the plant.'" In other words, Ford saw the rust and realized that the steel plant was not recovering all of the iron.

Design for Manufacture (DFM) also is a Ford concept. Per My Life and Work, "Start with an article that suits and then study to find some way of eliminating the entirely useless parts. This applies to everything— a shoe, a dress, a house, a piece of machinery, a railroad, a steamship, an airplane. As we cut out useless parts and simplify necessary ones, we also cut down the cost of making. ...But also it is to be remembered that all the parts are designed so that they can be most easily made." The same reference describes Just in time manufacturing very explicitly.

Whilst Ford is renowned for his production line it is often not recognised how much effort he put into removing the 'fitters' work in order to make the production line possible. Until Ford a car's components always had to be 'fitted' or reshaped by a skilled engineer at the point of use so that they would connect properly. By enforcing very strict specification and quality criteria on component manufacture he eliminated this work almost entirely, this reduced manufacturing effort by between 60-90%. However Ford's mass production system failed to incorporate the notion of Pull and thus often suffered from over production.

Toyota develops Lean thinking

Toyota's development of ideas that later became Lean may have started at the turn of the 20th century with Sakichi Toyoda in their textile business with looms that stopped themselves when a thread broke, this became the seed of "Autonomation" and "Jidoka". Toyota's journey with JIT may have started back in 1934 when it moved from textiles to produce its first car. Kiichiro Toyoda, founder of Toyota Motor Corp., directed the engine casting work and discovered many problems in their manufacture. He decided he must stop the repairing of poor quality by intense study of each stage of the process. In 1936 Toyota won its first truck contract with the Japanese government his processes hit new problems and developed the "Kaizen" improvement teams.

Levels of demand in the Post War economy of Japan were low and the focus of mass production on lowest cost per item via economies of scale therefore had little application. Having visited and seen supermarkets in the US Taiichi Ohno recognised the scheduling of work should not be driven by sales or production targets but by actual sales. Given the financial situation during this period over-production was not an option and thus the notion of Pull (build to order rather than target driven Push) came to underpin production scheduling.

It was with Taiichi Ohno at Toyota that these themes came together. He built on the already existing internal schools of thought and spread its breadth and use into what has now become the Toyota Production System (TPS). It is principally from the TPS, but now including many other sources, that Lean production is developing. Norman Bodek wrote the following in his foreword to a reprint of Ford's (1926) Today and Tomorrow: "I was first introduced to the concepts of just-in-time (JIT) and the Toyota production system in 1980. Subsequently I had the opportunity to witness its actual application at Toyota on one of our numerous Japanese study missions. There I met Mr. Taiichi Ohno, the system's creator. When bombarded with questions from our group on what inspired his thinking, he just laughed and said he learned it all from Henry Ford's book." It is the scale, rigour and continuous learning aspects of the TPS which have made it a core of Lean.

Types of waste

Whilst the elimination of waste may seem like a simple and clear subject it is noticable that waste is often very conservatively identified. This then hugely reduces the potential of such an aim. The elimination of waste is the goal of

Lean, Toyota defined three types of waste: muda or nonvalue-added work, muri or overburden and mura or unevenness.

To illustrate the state of this thinking Shigeo Shingo observed that it's only the last turn of a bolt that tightens it - the rest is just movement. This ever finer clarification of waste is key to establishing distinctions between value-adding activity, waste and non-value adding work. Non-value adding work is waste that must be done under the present work conditions. It is key to measure, or estimate, the size of these wastes in order to demonstrate the effect of the changes achieved and therefore the movement towards the goal.

The 'flow' (or smoothness) based approach aims to achieve JIT by removing the variation caused by work scheduling and thereby provide a driver, rationale or target and priorities for implementation, using a variety of techniques. The effort to achieve JIT exposes many quality problems that had been hidden by buffer stocks, by forcing smooth flow of only value-adding steps these problems become visible and must be dealt with explicitly.

Muri is all the unreasonable work that management imposes on workers and machines because of poor organisation, such as carrying heavy weights, moving things around, dangerous tasks, even working significantly faster than usual, etc. It is pushing a person or a machine beyond its natural limits. This may simply be asking a greater level of performance from a process than it can handle without taking shortcuts and informally modifying decision criteria. Unreasonable work is almost always a cause of multiple variations.

To link these three concepts is straight forward. Firstly, Muri focuses on the preparation and planning of the process, or what work can be avoided proactively by design. Next, Mura then focuses on implementation and the elimination of fluctuation at the scheduling or operations level, such as quality and volume. The third — Muda — is discovered after the process is in place and is dealt with reactively. It is seen through variation in output. It is the role of management to examine the Muda, or waste, in the processes and eliminate the deeper causes by considering the connections to the Muri and Mura of the system. The Muda – waste – and Mura – inconsistencies – must be fed back to the Muri, or planning, stage for the next project.

A typical example of the interplay of these wastes is the corporate behaviour of "making the numbers" as the end of a reporting period approaches. Demand is raised, increasing (mura), when the "numbers" are low which causes production to try to squeeze extra capacity from the process which causes routines and standards to be modified or stretched. This stretch and improvisation leads to muri style waste which leads to downtime, mistakes and backflows and waiting, thus the muda of waiting, correction and movement.

Observers who have toured Toyota plants have described their aim as 'learning to see' these wastes in order to carry back a new vision of 'ideal' to their parent companies.

The original seven muda 'deadly wastes' are:

- Overproduction (production ahead of demand)
- Transportation (moving products that is not actually required to perform the processing)
- Waiting (waiting for the next production step)
- Inventory (all components, work-in-progress and finished product not being processed)
- Motion (people or equipment moving or walking more than is required to perform the processing)
- Over Processing (due to poor tool or product design creating activity)
- Defects (the effort involved in inspecting for and fixing defects)

Some of these definitions may seem rather 'idealist' but this tough definition is seen as important. The clear identification of 'non-value adding work', as distinct from waste or work, is critical to identifying the assumptions behind the current work process and to challenging them in due course. In the words of Taiichi Ohno "eliminate muda, mura, muri completely". Breakthroughs in SMED and other process changing techniques rely upon clear identification of where untapped opportunities may lie if the processing assumptions are challenged.

Lean implementation

System engineering
Lean is about more than just cutting costs in the factory. One crucial insight is that most costs are assigned when a product is designed. Often an engineer will specify familiar, safe materials and processes rather than inexpensive, efficient ones. This reduces project risk, that is, the cost to the engineer, while increasing financial risks, and decreasing profits. Good organizations develop and review checklists to review product designs.

Companies must often look beyond the shop-floor to find opportunities for improving overall company cost and performance. At the system engineering level, requirements are reviewed with marketing and customer representatives to eliminate costly requirements. Shared modules may be developed, such as multipurpose power-supplies or shared mechanical components or fasteners. Requirements are assigned to the cheapest discipline. For example, adjustments may be moved into software, and measurements away from a mechanical solution to an electronic solution. Another approach is to choose connection or power-transport methods that are cheap or that used standardized components that become available in a competitive market.

An example program

In summary, an example of a lean implementation program could be:-

With a tools based approach Senior management to agree and discuss their lean vision Management brainstorm to identify project leader and set objectives Communicate plan and vision to the workforce Ask for volunteers to form the Lean Implementation team (5-7 works best, all from different departments) Appoint members of the Lean Manufacturing Implementation Team Train the Implementation Team in the various lean tools - make a point of trying to visit other non competing businesses which have implemented lean Select a Pilot Project – 5S is a good place to start Run the pilot for 2-3 months - evaluate, review and learn from your mistakes Roll out pilot to other factory areas Evaluate results, encourage feedback Stabilize the positive results by teaching supervisors how to train the new standards you've developed with TWI methodology (Training Within Industry) Once you are satisfied that you have a habitual program, consider introducing the next lean tool. Select the one which will give you the biggest return for your business.	With a muri or flow based approach Sort out as many of the visible quality problems as you can, as well as downtime and other instability problems, and get the internal scrap acknowledged and its management started. make the flow of parts through the system/process as continuous as possible using workcells and market locations where necessary and avoiding variations in the operators work cycle introduce standard work and stabilise the work pace through the system start pulling work through the system, look at the production scheduling and move towards daily orders with kanban cards even out the production flow by reducing batch sizes, increase delivery frequency internally and if possible externally, level internal demand improve exposed quality issues using the tools remove some people and go through this work again

Lean Leadership

The role of the leaders within the organisation is the fundamental element of sustaining the progress of lean thinking. Experienced kaizen members at Toyota, for example, often bring up the concept of "Senpai, Kohai," and "Sensei," because they strongly feel that transferring of Toyota culture down and across the Toyota can only happen when more experienced Toyota Sensei continuously coach and guide the less experienced lean champions. Unfortunately, most lean practitioners in North America focus on the tools and methodologies of lean, versus the philosophy and culture of lean. Some exceptions include Shingijitsu Consulting out of Japan, which is made up of ex-Toyota managers, and Lean Sensei International based in North America, which coaches lean through Toyota-style cultural experience.

One of the dislocative effects of Lean is in the area of KPIs (Key Process Indicators). The KPIs by which a plant/facility are judged will often be driving behaviour by leadership within it, e.g. Production against forecast, because the KPIs themselves assume a particular approach to the work being done. This can be an issue where for example a truly Lean, FRS and JIT approach is planned to be adopted because these KPIs will no longer reflect performance since the assumptions on which they are based become invalid. It is a key leadership challenge to manage the impact of this KPI chaos within the organisation.

Lean services

Lean, as a concept or brand, has captured the imagination of many in different spheres of activity. Examples of these from many sectors are listed below.
A study conducted on behalf of the Scottish Executive, by Warwick University, in 2005/06 found that Lean methods were applicable to the public sector, but that most results had been achieved using a much more restricted range of techniques than Lean provides.

The challenge in moving Lean to services is the lack of widely available reference implementations to allow people to see how it can work and the impact it does have. This makes it more difficult to build the level of belief seen as necessary for strong implementation. It is also the case that the manufacturing examples of 'techniques' or 'tools' need to be 'translated' into a service context which has not yet received the level of work or publicity that would give starting points for implementors. The upshot of this is that each implementation often 'feels its way' along as must the early industrial engineers of Toyota. This places huge importance upon sponsorship to encourage and protect these experimental developments. On the positive side there are many examples in service industries accessible through the Lean Enterprise Academy (car servicing, hospital admissions, administrative processes etc) of Lean delivering important results. At this time, however, they are not well publicised.

Kaizen

.
Kaizen, Japanese for "change for the better" or "improvement"; (the English translation is "continuous improvement" or "continual improvement").
In the context of this article, Kaizen refers to a workplace 'quality' strategy and is often associated with the Toyota Production System and related to various quality-control systems, including methods of W. Edwards Deming.

Kaizen aims to eliminate waste (as defined by Joshua Isaac Walters "activities that add cost but do not add value"). It is often the case that this means "to take it apart and put back together in a better way." This is then followed by standardization of this 'better way' with others, through standardized work.

Introduction

Kaizen is a daily activity whose purpose goes beyond simple productivity improvement. It is also a process that, when done correctly, humanizes the workplace, eliminates overly hard work (both mental and physical) "muri", and teaches people how to perform experiments on their work using the scientific method and how to learn to spot and eliminate waste in business processes.

To be most effective Kaizen must operate with three principles in place:

- consider the process and the results (not results-only);
- systemic thinking of the whole process and not just that immediately in view (i.e. big picture, not solely the narrow view); and
- a learning, non-judgmental, non-blaming (because blaming is wasteful) approach and intent.
-

People at all levels of an organization participate in kaizen, from the CEO down, as well as external stakeholders when applicable. The format for kaizen can be individual, suggestion system, small group, or large group. In Toyota it is usually a local improvement within a workstation or local area and involves a small group in improving their own work environment and productivity. This group is often guided through the Kaizen process by a line supervisor, indeed, sometimes this is the line supervisors key role.

Whilst Kaizen (in Toyota) usually delivers small improvements, the culture of continual aligned small improvements and standardisation yields large results in the form of compound productivity improvement. Hence the English translation of Kaizen can be: "continuous improvement", or "continual improvement."

This philosophy differs from the "command-and-control" improvement programs of the mid-twentieth century. Kaizen methodology includes making changes and monitoring results, then adjusting. Large-scale pre-planning and extensive project scheduling are replaced by smaller experiments, which can be rapidly adapted as new improvements are suggested.

History

In Japan, after World War II, American occupation forces brought in American experts in statistical control methods and who were familiar with the War Department's Training Within Industry (TWI) training programs to restore a war-torn nation. TWI programs included Job Instruction (standard work) and Job Methods (process improvement). In conjunction with the Shewhart cycle taught by W. Edwards Deming, and other statistics-based methods taught by Joseph M. Juran, these became the basis of the kaizen revolution in Japan that took place in the 1950s.

Implementation

The Toyota Production System is known for kaizen, where all line personnel are expected to stop their moving production line in case of any abnormality and, along with their supervisor, suggest an improvement to resolve the abnormality which may initiate a kaizen.

The cycle of kaizen activity can be defined as: standardize an operation -> measure the standardized operation (find cycle time and amount of in-process inventory) -> gauge measurements against requirements -> innovate to meet requirements and increase productivity -> standardize the new, improved operations -> continue cycle ad infinitum. This is also known as the Shewhart cycle, Deming cycle, or PDCA.

Masaaki Imai made the term famous in his book, Kaizen: The Key to Japan's Competitive Success.

Some further reading

Imai, Masaaki (1986), Kaizen: The Key to Japan's Competitive Success, McGraw-Hill/Irwin, ISBN 0-07-554332-X
Imai, Masaaki, Gemba Kaizen: A Commonsense, Low-Cost Approach to Management McGraw-Hill; 1 edition (March 1, 1997) ISBN 0-07-031446-2

Six Sigma

6σ

The often-used six sigma symbol.

Six Sigma is a set of practices originally developed by Motorola to systematically improve processes by eliminating defects. A defect is defined as nonconformity of a product or service to its specifications.
While the particulars of the methodology were originally formulated by Bill Smith at Motorola in 1986, Six Sigma was heavily inspired by six preceding decades of quality improvement methodologies such as quality control, TQM, and Zero Defects.

Like its predecessors, Six Sigma asserts the following:

- Continuous efforts to reduce variation in process outputs is key to business success
- Manufacturing and business processes can be measured, analyzed, improved and controlled
- Succeeding at achieving sustained quality improvement requires commitment from the entire organization, particularly from top-level management

The term "Six Sigma" refers to the ability of highly capable processes to produce output within specification. In particular, processes that operate with six sigma quality produce at defect levels below 3.4 defects per (one) million opportunities (DPMO). Six Sigma's implicit goal is to improve all processes to that level of quality or better.

Six Sigma is a registered service mark and trademark of Motorola, Inc. Motorola has reported over US$17 billion in savings from Six Sigma as of 2006.
In addition to Motorola, companies that also adopted Six Sigma methodologies early-on and continue to practice it today include Bank of America, Caterpillar, Honeywell International (previously known as Allied Signal), Raytheon, Merrill Lynch and General Electric.

There have been a few retail companies that have attempted to adapt this methodology to their business with mixed success. Perhaps the most notable was former CEO Bob Nardelli's attempt to adapt his systems from his former employer, General Electric, to the retail industry. There is one inherent problem with attempting to apply Six Sigma to retail. Retail=people, Six Sigma=defects. So, you have to look at your lacking areas as defects by your employees. Home Depot attempted to solve this by thinning out their workforce and implementing training programs for the remaining employees in order to reduce defects. On paper, this may work well but once the human factor was applied it led to massive frustration from the employees and the customers due to the lack of salespeople on the floor at any one time. Although the employees were better trained, they were now required to help 22.8 customers per hour rather than the previous 13.4. Other retailers are learning from these mistakes of the first big box retailers to attempt this and are tweaking the methodology to better suit their company goals.

Methodology

Six Sigma has two key methodologies: DMAIC and DMADV, both inspired by W. Edwards Deming's Plan-Do-Check-Act Cycle: DMAIC is used to improve an existing business process, and DMADV is used to create new product or process designs for predictable, defect-free performance.

DMAIC

Basic methodology consists of the following five steps:

- Define the process improvement goals that are consistent with customer demands and enterprise strategy.
- Measure the current process and collect relevant data for future comparison.
- Analyze to verify relationship and causality of factors. Determine what the relationship is, and attempt to ensure that all factors have been considered.
- Improve or optimize the process based upon the analysis using techniques like Design of Experiments.
- Control to ensure that any variances are corrected before they result in defects. Set up pilot runs to establish process capability, transition to production and thereafter continuously measure the process and institute control mechanisms.

DMADV

Basic methodology consists of the following five steps:

- Define the goals of the design activity that are consistent with customer demands and enterprise strategy.
- Measure and identify CTQs (critical to qualities), product capabilities, production process capability, and risk assessments.
- Analyze to develop and design alternatives, create high-level design and evaluate design capability to select the best design.
- Design details, optimize the design, and plan for design verification. This phase may require simulations.
- Verify the design, set up pilot runs, implement production process and handover to process owners.

Some people have used DMAICR (Realize). Others contend that focusing on the financial gains realized through Six Sigma is counter-productive and that said financial gains are simply byproducts of a good process improvement.

Statistics and robustness

The core of the Six Sigma methodology is a data-driven, systematic approach to problem solving, with a focus on customer impact. Statistical tools and analysis are often useful in the process. However, it is a mistake to view the core of the Six Sigma methodology as statistics; an acceptable Six Sigma project can be started with only rudimentary statistical tools.
Still, some professional statisticians criticize Six Sigma because practitioners have highly varied levels of understanding of the statistics involved.
Six Sigma as a problem-solving approach has traditionally been used in fields such as business, engineering, and production processes.

Implementation roles

One of the key innovations of Six Sigma is the professionalizing of quality management functions. Prior to Six Sigma, Quality Management in practice was largely relegated to the production floor and to statisticians in a separate quality department. Six Sigma borrows martial arts ranking terminology to define a hierarchy (and career path) that cuts across all business functions and a promotion path straight into the executive suite.
Six Sigma identifies several key roles for its successful implementation.

Executive Leadership includes CEO and other key top management team members. They are responsible for setting up a vision for Six Sigma implementation. They also empower the other role holders with the freedom and resources to explore new ideas for breakthrough improvements.

Champions are responsible for the Six Sigma implementation across the organization in an integrated manner. The Executive Leadership draws them from the upper management. Champions also act as mentors to Black Belts. At GE this level of certification is now called "Quality Leader".

Master Black Belts, identified by champions, act as in-house expert coaches for the organization on Six Sigma. They devote 100% of their time to Six Sigma. They assist champions and guide Black Belts and Green Belts. Apart from the usual rigor of statistics, their time is spent on ensuring integrated deployment of Six Sigma across various functions and departments.

Experts This level of skill is used primarily within Aerospace and Defense Business Sectors. Experts work across company boundaries, improving services, processes, and products for their suppliers, their entire campuses, and for their customers. Raytheon Incorporated was one of the first companies to introduce Experts to their organizations. At Raytheon, Experts work not only across multiple sites, but across business divisions, incorporating lessons learned throughout the company.

Black Belts operate under Master Black Belts to apply Six Sigma methodology to specific projects. They devote 100% of their time to Six Sigma. They primarily focus on Six Sigma project execution, whereas Champions and Master Black Belts focus on identifying projects/functions for Six Sigma.

Green Belts are the employees who take up Six Sigma implementation along with their other job responsibilities. They operate under the guidance of Black Belts and support them in achieving the overall results.

Yellow Belts are employees who have been trained in Six Sigma techniques as part of a corporate-wide initiative, but have not completed a Six Sigma project and are not expected to actively engage in quality improvement activities.
In many recent programs, Green Belts and Black Belts are empowered to initiate, expand, and lead projects in their area of responsibility. The roles as defined above, therefore, conform to the older Mikel Harry/Richard Schroeder model, which is not universally accepted.

Origin

Bill Smith did not really "invent" Six Sigma in the 1980s; rather, he applied methodologies that had been available since the 1920s developed by luminaries like Shewhart, Deming, Juran, Ishikawa, Ohno, Shingo, Taguchi and Shainin. All tools used in Six Sigma programs are actually a subset of the Quality Engineering discipline and can be considered a part of the ASQ Certified Quality Engineer body of knowledge. The goal of Six Sigma, then, is to use the old tools in concert, for a greater effect than a sum-of-parts approach.

The use of "Black Belts" as itinerant change agents is controversial as it has created a cottage industry of training and certification. This relieves management of accountability for change; pre-Six Sigma implementations, exemplified by the Toyota Production System and Japan's industrial ascension, simply used the technical talent at hand—Design, Manufacturing and Quality Engineers, Toolmakers, Maintenance and Production workers—to optimize the processes. The expansion of the various "Belts" to include "Green Belt", "Master Black Belt" and "Gold Belt" is commonly seen as a parallel to the various "Belt Factories" that exist in martial arts.

Poka-yoke

Poka-yoke - pronounced "POH-kah YOH-keh", means "fail-safing" or "mistake-proofing" — avoiding (yokeru) inadvertent errors (poka)) is a behavior-shaping constraint, or a method of preventing errors by putting limits on how an operation can be performed in order to force the correct completion of the operation. The concept was originated by Shigeo Shingo as part of the Toyota Production System. Originally described as Baka-yoke, but as this means "fool-proofing" (or "idiot proofing") the name was changed to the milder Poka-yoke.

An example of this in general experience is the inability to remove a car key from the ignition switch of an automobile if the automatic transmission is not first put in the "Park" position, so that the driver cannot leave the car in an unsafe parking condition where the wheels are not locked against movement. In the IT world another example can be found in a normal 3.5" floppy disk: the top-right corner is shaped in a certain way so that the disk cannot be inserted upside-down. In the manufacturing world an example might be that the jig for holding pieces for processing only allows pieces to be held in one orientation, or has switches on the jig to detect whether a hole has been previously cut or not, or it might count the number of spot welds created to ensure that, say, four have been executed by the operator.

Implementation

Shigeo Shingo recognises three types of Poka-Yoke:

- The contact method identifies defects by whether or not contact is established between the device and the product. Colour detection and other product property techniques are considered extensions of this.
- The fixed-value method determines whether a given number of movements have been made.
- The motion-step method determines whether the prescribed steps or motions of the process have been followed.

Poka-yoke either give warnings or can prevent, or control, the wrong action. It is suggested that the choice between these two should be made based on the behaviours in the process, occasional errors may warrant warnings whereas frequent errors, or those impossible to correct, may warrant a control poka-yoke.

Scientific method

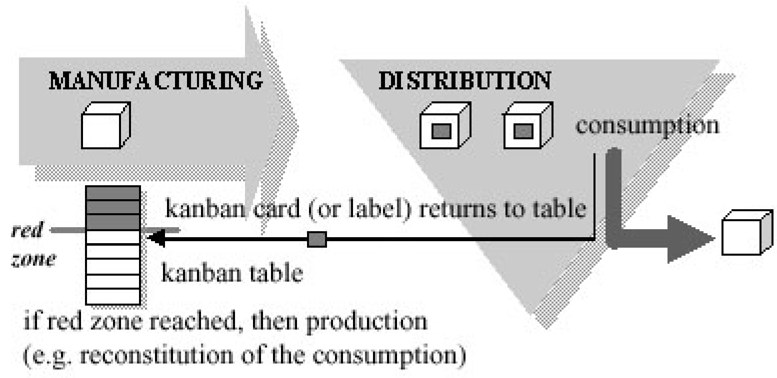
Scientific method is a body of techniques for investigating phenomena, acquiring new knowledge, or correcting and integrating previous knowledge. It is based on gathering observable, empirical and measurable evidence subject to specific principles of reasoning, the collection of data through observation and experimentation, and the formulation and testing of hypotheses.

Although procedures vary from one field of inquiry to another, identifiable features distinguish scientific inquiry from other methodologies of knowledge.

Scientific researchers propose hypotheses as explanations of phenomena, and design experimental studies to test these hypotheses. These steps must be repeatable in order to predict dependably any future results. Theories that encompass wider domains of inquiry may bind many hypotheses together in a coherent structure. This in turn may help form new hypotheses or place groups of hypotheses into context.

Among other facets shared by the various fields of inquiry is the conviction that the process must be objective to reduce a biased interpretation of the results. Another basic expectation is to document, archive and share all data and methodology so it is available for careful scrutiny by other scientists, thereby allowing other researchers the opportunity to verify results by attempting to reproduce them. This practice, called full disclosure, also allows statistical measures of the reliability of these data to be established.

Kanban



Source : "CIM: Principles of Computer Integrated Manufacturing", Jean-Baptiste Waldner, John Wiley & Sons, 1992. Reproduced with author's authorization

Kanban maintains inventory levels; a signal is sent to produce and deliver a new shipment as material is consumed. These signals are tracked through the replenishment cycle and bring extraordinary visibility to suppliers and buyers.

Kanban is a concept related to Lean or Just In Time (JIT) production, but these two concepts are not the same. (The Japanese word "kanban" is a common everyday term meaning "signboard" or "billboard" and utterly lacks the specialized meaning which this loanword has acquired in English.) According to Taiichi Ohno, the man credited with developing JIT, kanban is a means through which JIT is achieved.

Kanban is a signaling system. As its name suggests, Kanban historically uses cards to signal the need for an item. However, other devices such as plastic markers (Kanban squares) or balls (often golf balls) or an empty part-transport trolley can also be used to trigger the movement, production, or supply of a unit in a factory.

It was out of a need to maintain the level of improvements that the kanban system was devised by Toyota. Kanban became an effective tool to support the running of the production system as a whole. In addition, it proved to be an excellent way for promoting improvements because restricting the number of kanban in circulation highlighted problem areas.

Origins

The term kanban describes an embellished wooden or metal sign which has often been reduced to become a trade mark or seal. Since the 17th century, this expression in the Japanese mercantile system has been as important to the merchants of Japan as military banners have been to the samurai. Visual puns, calligraphy and ingenious shapes, or Kanban, define the trade and class of a business or tradesman. Often produced within rigid Confucian restrictions on size and color, the signs and seals are masterpieces of logo and symbol design. For example, a sumo wrestler, symbol of strength, may be used as kanban on a pharmacy sign to advertise a treatment for anemia.

In the late 1940s Toyota was studying US supermarkets with a view to applying some of their management techniques to their work. This interest came about because in a supermarket the customer can get what is needed at the time needed in the amount needed. The supermarket only stocks what it believes it will sell and the customer only takes what they need because their supply is assured. This led Toyota to view earlier processes, to that in focus, as a kind of store. The process goes to this store to get its needed components and the store then replenishes those components. It is the rate of this replenishment which is controlled by kanban which give permission to produce. In 1953 Toyota applied this logic in their main plant machine shop.

Implementation

With this in mind, it is not surprising that an important determinant of the relative merits of "push" and "pull" production scheduling is the quality of the demand forecast. Kanban is a pull system that determines the supply, or production, according to the actual demand of the customers. In contexts where demand is difficult to forecast the best one can do is to quickly respond to observed demand. This is exactly what a kanban system does, it acts as a demand signal which immediately propagates through the entire chain. "Push" systems often encounter serious difficulties when demand forecasts turn out to be inaccurate. Where the response cannot be quick enough, e.g. significant lost sales/downstream production, then stock building may be appropriate by issuing more kanban. Taiichi Ohno states that kanban must follow strict rules of use.

Toyota have six simple rules, and that close monitoring of these rules is a never ending problem to ensure that kanban does what is required.

A simple example of the Kanban system implementation might be a "three bin system" for the brought out parts (where there is no inhouse manufacturing) -- one bin on the factory floor, one bin in the factory store and one bin at the suppliers' store. The bins usually have a removable card that contains the product details and other relevant information -- the Kanban card. When the bin on the shop floor is empty, the bin and Kanban card are returned to the store. The store then replaces the bin on the factory floor with a full bin which also contains a Kanban card. The store then contacts the supplier and returns the now empty bin with its Kanban card. The suppliers inbound product bin with its

Kanban card is then delivered into the factory store completing the final step to the system. Thus the process will never run out of product and could also be described as a "loop", providing the exact amount required, with only "one" spare so there will never be an issue of "over-supply". This 'spare' bin allows for the uncertainty in supply, use and transport that are inherent in the system. The secret to a good Kanban system is to calculate how many Kanban cards are required for each product. Most factories using kanban use the coloured board system (Heijunka Box). This consists of a board created especially for the purpose of holding the Kanban cards.

Another example of kanban thinking: in the production of a widget, the operator has two shelves, one on either side of their workplace. The raw materials can be designated to arrive on one shelf and the finished articles placed on the other. These shelves can then be designated to act as kanbans. The outgoing kanban signals the customer's need so that when it is empty, the operator must produce one more widget.

The Kanban is sized so that it can only hold a fixed number of items decided by the customer needs (usually one). When the operator begins work, he takes the raw material from the incoming kanban, which when seen by the supplier, signals that the customer needs one more.