Quality management – history and trends

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Abstract

Purpose – The continuous development of quality management in organizations was driven on the one hand by competition and on the other hand by growing requirements of the customers. Mass production with a pure push strategy changed to a more and more pull strategy with higher customer and market orientation. To satisfy the requirements of the triangle quality, cost and time the field of view of quality management has continuously been widened from considering "what" is done to "how" it is done. Nowadays the complexity and interrelations inside and outside of organizations increased with their global orientation. To face these global challenges, the purpose of this paper is to do a detailed analysis of the history of quality management that can support the initial position in development of specific tools and methods for quality improvement in organizations.

Design/methodology/approach – For the historic analysis a well-founded literature review has been performed. After presenting the historical development of quality management, the current situation described. Finally an outlook for upcoming trends in quality management is provided by extrapolating current developments.

Findings – Four different paradigm shifts in quality management are up to now identified and described, accompanied by a high number of smaller development steps. Current efforts for the further development of quality management encompass "perceived quality", "human-focused quality management" and "intelligent quality management".

Originality/value – The paper gives a survey on the development of quality management and delivers a forecast on future requirements and trends in structuring the quality management in technical enterprises.

Keywords Quality management, History of quality, Paradigm shifts

Paper type Research paper

1. Introduction

In a market economy, each organization is competing with others providing the same product. This principle is valid independent of the type of offer, including material goods as well as immaterial services or their combination. Thus, the survival of an enterprise depends on its ability to gain, bind and enthuse customers. This can be done either by securing a large enough share of customers from a limited group in direct competition with other providers or by gaining new target groups as potential customers. Which option is more important depends on the provided product and the existing market structure as well as the strategy and capability of the specific enterprise.

To assure the fitness of an organization in this competition by providing products of high quality, i.e. a high "degree to which a set of inherent characteristics fulfils requirements"(ISO 9000, 2005), is the core task of quality management. Although the underlying idea and the overall aim remains the same, the paradigms established for the development and implementation of tools and methods in quality management have changed several times. A paradigm is defined as a model to describe the concerned matter in a certain discipline (Ferguson, 1980). It usually contains typical examples which are considered to be of special importance as well as a certain way to look at them and a set of methods for further treatment and research. Thus, a paradigm

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is indispensable for communication and cooperation among interested parties, but also limits the ways how to solve a given problem (Kuhn, 1996).

The change of a paradigm in any scientific discipline marks the steps of important developments and is often caused by changing conditions like globalization, increasing competitive pressure or increasing customer demands (Weckenmann *et al.*, 2012b). Thus, understanding how and why paradigm changes occurred is an essential precondition to discover major trends and developments in the field of view. Solving these already noticed problems certainly enables improvements and consolidation and must not be neglected, but major innovation is only possible by identifying and targeting such issues that are not yet fully evident. Especially when considering the competitive market situation, it is important for a company to be among the ones leading in a new direction, not only to follow up together with many others.

The analysis of paradigm shifts is not just of academic interest, but is of high practical relevance – especially in a scientific area like quality management with its empirical-heuristic and inductive rather than theoretical-analytic and deductive approach. In order to develop methods and tools to support quality under long-term perspectives and enable innovation by identifying future needs, a historic analysis of paradigm shift in quality management will be performed. Based on the results and underlying mega-trends identified there, the outline of upcoming demands has to be sketched in order to provide a general orientation for further work.

2. Analysis of paradigms in quality management

The idea to meet requirements of potential customers in order to maximize economic success is as old as the establishment of economic trading in humankind. Yet, for the longest time it has been an issue between an individual, personally known provider, e.g. a merchant or a craftsman, and the customer. Thus, the fulfilment of basic demands concerning the society was guaranteed and enforced by laws and "crafts' honour" based on the personal responsibility of the provider, handing out strong punishments for deviations considered as fraud or insufficient quality. Beyond this basic protection, the customer was on his own and due to limited offers usually bound to take a local provider.

This craft-oriented concept changed drastically with the upcoming of manufactures, bringing along division of labour as well as an increased allotment of machine labour, since the responsibility for the quality of a product could not any longer be accounted towards a specific person (Womack *et al.*, 1991). From this situation the demand resulted to establish activities to be considered as the origin of quality management in a modern sense. During that period, many developments were taken inducing also several changes in the naming, from product-oriented quality inspection via process-oriented quality control and quality assurance to system-oriented quality management in the nowadays used sense and Total Quality Management (Figure 1).

2.1 Product quality – quality inspection

The first paradigm of quality management to be noticed came up during the period of mass production. At that time, i.e. ca. 1900-1940, activities of quality inspection focused only on the delivery of manufactured products without known failures. The central aim was to assure a merely sufficient quality of delivered products and thus avoid complaints and recourse claims from customers.

As a main method to achieve this, final products were inspected and waste was filtered out. Subsequently, the activities were introduced as quality inspection as an

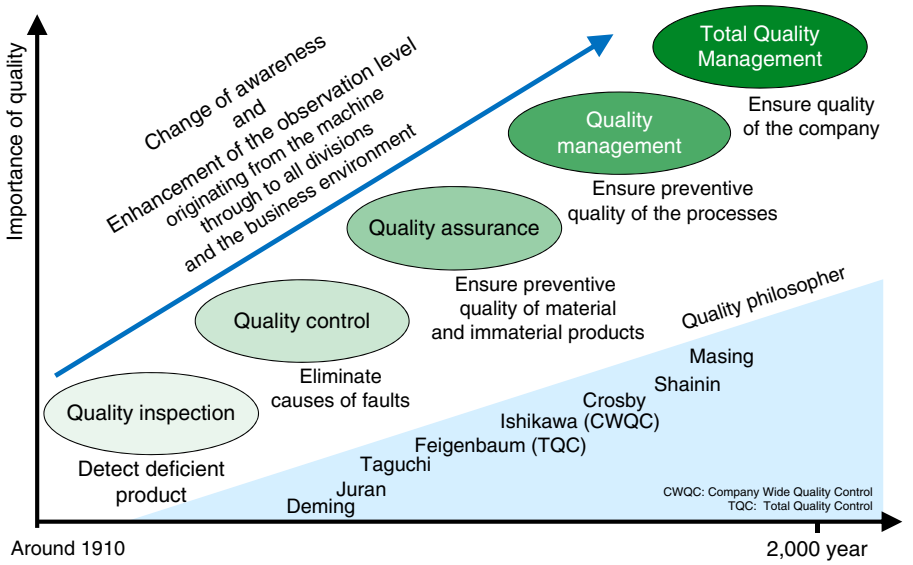


Figure 1.
Overview of concepts in quality management

additional, final working step. This was facilitated by advances in manufacturing metrology and testing, which further carried on taylorism and supported the interchangeability of parts, thus enabling the replacement of insufficient components by other (Weckenmann *et al.*, 2012a).

The necessity for capacious inspections resulted in high costs, both for the detection and the repair or replacement of erroneous parts, including also high waste rates. Also, the necessary correction steps induced a loss of time since many tasks of production had to be first done, then correctly redone. In extreme cases this resulted in a "hidden factory", bound for correction of the output of the obvious factory (Womack *et al.*, 1991). As an effort to reduce the resulting costs, it was tried to maximize the benefits of mass production, meaning less product variety with high product volume. Customer needs – besides basic requirements protected by laws or standards – were hardly considered. Instead product properties and portfolio were mainly defined by the will of the organizations. The T-Model of Ford is a typical example for this period.

In this area, the competition on the market was marked by the effort to provide products of sufficient quality as fast and cheap as possible in order to triumph over competitors or increase the own gaining. Thus, as a main way to describe optimization problems, the three requirements considering products (high quality, low costs, low-delivery time) were summarized within the triangle of "Quality, Cost and Time" (Figure 2), indicating that they were seen as hardly compatible.

Yet, increasing customer demands together with increasing economic pressure indicated the necessity for a first paradigm shift where organizations had to move on from a focus on product quality limited due to the "magic triangle" towards "how" to fulfil these requirements efficiently.

2.2 Process quality

The necessity to combine ever increasing requirements on delivery time, production costs and expected quality resulted in a first major paradigm shift, widening the focus

from product quality to process quality. Some basic approaches to monitor the manufacturing processes had already been established during tayloristic labour division, but they were limited to the observation of time needed for the various working steps. So far, process analysis had only aimed for a systematic, time-optimized separation of the workflow in single bits, whereas quality aspects had not been considered. Under increasing economic pressure ca. 1940 the manufacturing processes were taken into consideration to enable a control of production, especially in order to reduce the high loss and waste resulting from the so far established inspection concept.

With the widening in focus for quality, now the triangle of "Quality, Cost and Time" was applied not only on products but also on processes and thus could be solved from its contradictory relationship – based on the idea, that it is possible to manufacture customer required products at low costs and fast only by capable and efficient processes. Thus, by controlling and optimizing the manufacturing processes, quality, time and costs could be positively affected at the same time (Figure 3).

2.2.1 Quality control. The widened focus on the whole process came along with the understanding that the looking for errors and their subsequent correction was much less efficient than to find the source of the errors and remove that. Resulting, it was no longer aimed to merely inspect quality and react, but to control quality. Consequently, the idea of just filtering out waste was replaced by the model of a control circle (Figure 4).

To support this, a variety of methods like the seven tools of quality management (Q7), the PDCA-cycle by Deming or the "Five-times-Why" strategy came up, which supported the identification and correction of errors. Additionally, the consideration of a whole production process with many entities enabled the utilization of statistical methods on practical problems. This resulted in the definition and wide-spread use of Statistical Process Control (SPC) to react on changes in time to avoid the production of waste. Complementary, statistical Design of Experiments (DoE) came up, facilitating

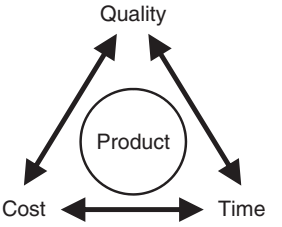


Figure 2.
Quality, cost and time relating products

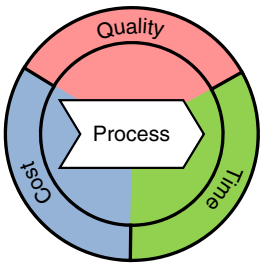


Figure 3.
Quality, cost and time by a process-oriented view

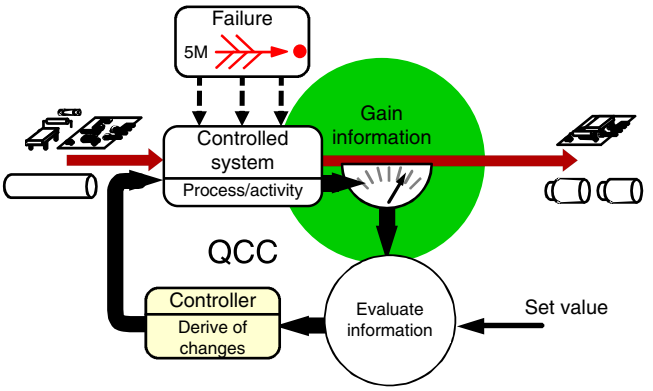


Figure 4.
Quality control circle for manufacturing

the efficient identification and adjustment of significant input parameters to gain optimal output results regarding product quality.

2.2.2 Quality assurance. A further widening of process analysis was triggered by a fundamental change in the logical perspective on process and product quality. So far, still the product properties as final output were observed and the input parameters were subsequently changed, if a deviation from the desired quality came up – thus installing a correction procedure. Starting from around 1960s, the idea was implemented to not just control the quality of products and processes and react a posteriori, but assure quality a priori by identifying possible risks and problems and preventing them before they came up.

At first, the orientation of these preventive actions was still guided from within, following a one-directed push-strategy from enterprise to the customer – starting with directions about the future product from management to be translated to actual products as efficiently as possible and then sold to the customer. Thus, distribution of market shares between enterprises was dependent on variety defined by the vendors, not driven by the customer. Only at about 1980, the concept of costumer focus in development – instead of the previous enterprise focused view – started to be commonly established (Geiger, 1994; Pfeifer, 2001). By this addition of planning quality customer-oriented, prevention of the most crucial problem, i.e. producing technically good products nobody wanted, was possible (Juran, 1988). This development was strongly driven by the increasingly narrow competition due to starting internationalization and the resulting enlarged number of vendors on national markets as opposed to the former, less open and therefore quite stable situation (Womack *et al.*, 1991).

Along with this increased range of applicability, activities of quality assurance started to consider the whole road of a product through the enterprise instead of only the production. As it was noticed that especially early phases like construction and development influenced strongly the three factors quality, costs and time, quality design and planning efforts based on experiences in production increased and more comprehensive control circles were established (Figure 5).

The fundamental change in logical reasoning from reactive control to preventive assurance went along with overcoming the demand for reliable, number-based data as used in statistical methods. More and more, "softer" information and their logical relations had to be used as they were more easily available, especially for the use in an a

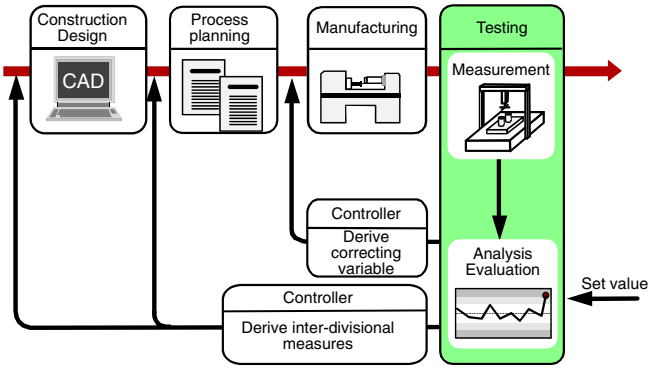


Figure 5.
Combined control circle of various processes

priori analysis. To this end, ideas of system theory so far used to describe models in physics or nature science were included.

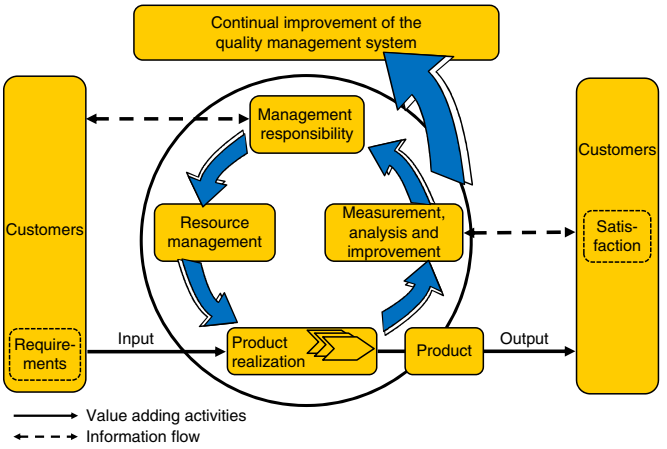
This evolution to preventive quality assurance was enhanced by a number of new methods using logical reasoning for preventive analysis, e.g. the Failure Mode and Effects Analysis (FMEA), respectively Fault or Event Tree Analysis (FTA, ETA). Subsequently, a second tool set, the New Seven Tools (N7), was defined, complementing the well-established Q7 with a methodical kit meant for logic-based information.

2.3 System quality

Through the two paradigm shifts encountered so far, the perspective on quality-related issues has been continuously widened, but still remained on the product-related processes. These were considered as value-creating and thus important, whereas other processes and tasks inside the organization were neglected. But along with the rising demands of customers enabled by the competition, complexity of products increased dramatically. Thus, on the one hand interdependencies with suppliers had to be considered. Their reliability became crucial as the purchased parts often were so complex now, that a rapid change of supplier became impossible. On the other hand, also interdependencies inside an organization had to be considered due to increased product variety and the following demand for flexibility, e.g. if a department was producing parts for several internal customers, delivery had to be managed efficiently.

Overall, the need for information increased resulting from the stronger involvement of customers and the necessity for ever more complex advance planning activities. Thus, problems often were caused by inefficiencies in the so far neglected non-value-creating processes. Following, the idea of a mainly linear process as base for quality was widened towards a system-oriented view including not only the linear dimension of a value-creation process but also, as a second dimension, its connections and interdependencies with all other processes and activities in the organization. Thus, besides the process-oriented consideration of workflow, a system-oriented view was introduced (Figure 6).

2.3.1 Quality management. With the increased complexity of entities and their relationships being considered in quality management, documentation and activities for mutual trust between partners became needed. This finally resulted in the issuing of the series ISO 9000 seq., defining basic requirements for quality management. Together with this standardization, the possibility and demand for certification came up,



Source: (ISO 9001, 2008)

Figure 6. Model of a process-based quality management system

allowing a system of suppliers and industrial customers to trust on the quality-oriented performance of a partner. It has to be stated that the major advances of quality management over former paradigms have not been achieved by issuing new techniques or methods, but by creating a common harmonized and internationally accepted framework of standards and accredited certification agencies, enabling mutual trust and better partnerships of enterprises. Thus, the increasingly high effort to control the quality of a supplier could be reduced.

Subsequently, perspective has been widened from manufacturing processes and material products to the more and more becoming important service processes and immaterial products. To incorporate this new field of application, many existing tools and methods of quality management have been adapted to the needs of service quality, especially considering the difficulty of reproducible data.

2.3.2 Total quality management. The fourth and currently last paradigm shift is fully visible only in the last ten years. Due to the vicinity of the widened application to public or social tasks and the laying of a common requirement for quality in standards, the idea of quality management finally has evolved from being driven mainly by market pressure to being implemented because of the general importance to deliver high-quality results. Thus, concepts of quality management nowadays are used also in areas with no direct competition but an urge for own improvement, such as education, health care or public administration. Together with this notion, the influence of employees as opposed to machines or other technical components plays an ever more important role.

Thus, the need for commitment of all employees in an organization to high quality leads to the paradigm of Total Quality Management after recognizing the relationships between leadership, employee, processes, customer satisfaction and business results. Due to this identified correlations the Total Quality Management and Business Excellence Models, e.g. the European Foundation for Quality Management Model (EFQM Model) raised up. These include also typical aspects for the well-being of employees which have not generally been recognized formerly due to the machine-influenced view.

The resulting demand to consider the employees as human beings and the company not only as an economical, but also as a social actor is facilitated by demands to consider not only financial results, but also employee- or society-related results, being prompted by EFQM Model as well as other tools like Balanced Scorecard. Yet, as this is the last paradigm to be fully recognized, the underlying ideas may be well-known but it will need more time for them to be implemented in a sufficient way to consider them as standard. Taking into consideration that first ideas of a more social layout of quality management can be found as early as 1986, e.g. in Deming's (1986) 14 points, this highlights both the need for continuous improvement and innovation in quality management as well as the time delay until a well-understood concept actually is brought to full application.

3. Analysis of current situation

Nowadays, globalization and resulting complex cross-linked supply chains put new requirements on quality management, demanding not only a technical-oriented quality but also the consideration of social responsibility and sustainability. When organizations want to satisfy customer requirements, they have to act beyond the actual product, and thus even have to implement a worldwide fair employee policy and to consider environmental challenges like shortage of resources to retain their image (Figure 7). Furthermore many companies have to face by now the challenges of global collaborations in development, purchase, manufacturing and sales to resist the increasing competitive pressure. In this challenging situation, three aspects of special importance can be identified which describe major fields where further developments in quality management are needed.

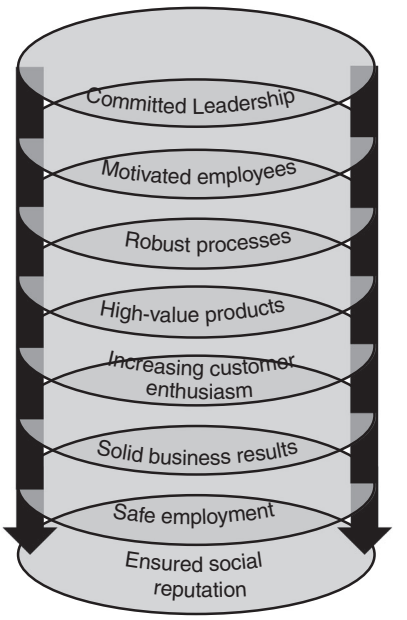


Figure 7.
Holistic view on quality management including manifold dimensions of work and results

3.1 Perceived quality

Product quality historically was considered as something to be inspected and controlled by the producing enterprise. Although this idea as single point of quality management has long since been abandoned, the concept of absolutely measurable quality is still strongly noticeable. Yet, it becomes more and more obvious that final customers in the consumer market often think about quality in various categories strongly differing from the view on a product inside a providing enterprise. Thus, a current challenge in quality management is the determination and consideration of quality as it is perceived by the customer.

This is a difficult task, since first of all the perception of what is a "good" product may vary with the needs and basic attitude of a customer. With international markets and increasing changeability and plurality in society, the group of potential customers is extremely inhomogeneous. Although still it is possible to identify subgroups of people similar in their perception and demands, a focusing on such a well-described target group may result in a very limited customer scope.

Second, the perception of a product by human beings is not even controlled only by objective judgments of the entity in question but also by former experiences and general ideas. Thus, the general fame of a company may easily outweigh small drawbacks of a product (as compared to the customers' wishes of an ideal product), whereas a bad reputation of former product generations or even of the company itself results in an unfavourable judgement of the product at hand or even a complete boycott. As a reaction on this, on the one hand market research to learn about customers' wishes becomes increasingly important as well as complex. On the other hand, marketing and advertising to create a positive image of the specific product and the enterprise in general and thus a certain customer enthusiasm, by forming a picture of product and company in the public mind, are to be seen as important as the actual product. This aspect highlights the importance of all employees for an organization, as they are acting as a kind of representative for their employer, influencing the public image by sharing their experiences about professional life with others.

3.2 Human-focused quality management

The most crucial point in order to remain competitive in the fast evolving economic environment is the management of development processes for new products and accordingly for new manufacturing-related processes in the company (Weckenmann *et al.*, 2012b; Weckenmann and Akkasoglu, 2010).

Yet, the possibility to actually implement improved processes or develop innovative new products depends strongly on the capability and willingness of the employees in a given company to perform their tasks correctly and efficiently. A one-sided focus of development on technical aspects will accordingly lead to dissatisfying results (Weinert, 1998). Moreover, far from being a mere obstacle to technological development, the creativity and ideas of the employees form the most important resource of development and success for a company (Lubit, 2001). Activities of quality management and development accordingly have to consider not only technical aspects but have to focus on the human beings involved with their specific needs and requirements, thus truly implementing the idea of Total Quality Management which includes all elements and areas of a company (Wilkinson and Brown, 2007).

3.3 Intelligent quality management

Increasing computer capacities and performances through advancements in the field of information and communication technologies promote also their use in the field of quality management. The existing and gained organization knowledge has to be secured, provided and cross-linked for a more efficient usability. One of the main tasks of researches in quality management and engineering will certainly be the use of data mining and knowledge discovery technologies in Total Quality Management (Wang, 2009). This leads already today to the so called intelligent quality management which focuses on use of data mining to create new knowledge by recognizing so far unknown cause-effect relationships. In so doing the data quality will become more and more important (Wang, 1998). Information and expert systems are therefore also necessary to provide a high level of user support. Additionally employees have to be included more intensively by using on the one hand ideas of informal learning or other methods of Life Long Learning to develop employees and use them as the important resource they are (Werner and Weckenmann, 2010, 2012; Weckenmann and Werner, 2010), on the other hand activities to support development processes in the company have to be implemented, the most important being the introduction of customized maturity analysis into development phases with consideration of information uncertainty (Weckenmann and Akkasoglu, 2012a, b).

3.4 Resulting demands

Thus, regarding modern engineering two major challenges can be identified that have to be met in quality management to establish a base for success of any other related activities: On the one hand, the assurance of employee competence as a base for high-quality products and continuous innovation; on the other hand, the control of innovation and development processes for enthusing products to enable a healthy growth and a focused, sustainable improvement of the enterprise.

Considering both aspects together, the increasing of subjectively perceived over objectively measured quality, the current shift in paradigm might be a drastic one – changing from a perspective on quality mainly controlled by engineering activities and techniques to a more universal view integrating ideas from psychology, pedagogy, linguistics or other social sciences.

4. Identification of trends – responsibility in quality

The analysis of paradigm shifts in quality management shows clearly, that for a certain time there are pressing challenges which have to be solved by the establishment of adequate methods. Yet, once a certain standard is met or driven by changes in constraints, new challenges will come into focus, resulting in a further paradigm shift. These issues always have been there before, but often have been neglected due to other, more pressing problems or because no need has been felt to cover them. For example, the consideration of employee demands has been marked as strongly important already by many early thinkers in quality management – nevertheless it has taken roughly a century for corresponding ideas to be established in Total Quality Management.

A paradigm change does not happen due to a single event or invention but usually occurs over a series of – sometimes small – changes and contribution. A certain detection and analysis thus is only possible from a historic distance. Nevertheless, major changes reveal themselves in anomalies or other exceptions or "outliers" from existing rules. As a research topic and starting point for innovation, beyond currently

necessary work also long-term developments have to be considered. These can be identified by extrapolating trends in the analysis of paradigm shifts.

Considering the overall development described above, it seems very likely that the complexity of processes in production and development will increase further. At the same time, the demands of customers will raise, covering not only usability aspects of the product but more and more overall perception of the organization. With information being easily available to customers, they can be expected to look more closely on the performance of a company in aspects related to overall society. Regarding constraints from outside, it is likely that globalization and internalization will increase. But at the same time, availability of basic materials will come up as a serious problem, as materials are limited but the demand is increasing with further industrialization.

Taking these two aspects together, the need for a sustainable organization of manufacturing, but also of all other activities, shows up. Even nowadays we notice that environment-friendliness and low need of energy is an increasingly important aspect of technical product quality. But also the organization itself will be assessed for its way of acting, covering not only sustainability but also honesty, reliability or treatment of employees.

Thus, overall a main aspect to come up in quality management could be responsibility – a concept which nowadays seems to be considered by only a few "idealistic" companies, sometimes smiled at by others with higher profit margins. Yet, if the next paradigm shift will tend towards the expected direction, these will be the lucky ones. And even if not, they have a high chance to profit on long term from their highly motivated employees and their increased loyalty towards the enterprise.

5. Conclusion and outlook

The history of quality management shows a constant development towards a more comprehensive and efficient realization of quality for all delivered products. Over the period of roughly 100 years since the introduction of mass production resulted in activities to be considered under the label of quality management, the perspective on quality-related issues has widened continuously, starting with a narrow focus on the final product and standing currently at a holistic view on the organization as a complex system, to be managed and improved by caring for the equally complex entities therein, i.e. products, processes, partners, suppliers, customers and employees, under consideration of their mutual relationships.

This development of the view on quality resulted in – so far – four major paradigm shifts, accompanied by a high number of smaller development steps. Along with the changing of current paradigms, innovative methods and tools for quality management were established and continuously improved. And often the ability to understand and influence an issue formerly beyond control of management finally resulted in the preparation of the next shift in paradigm by removing existing obstacles and clearing the view on the overall system. Thus, quality management has facilitated innovation and the raising of standards in various ways.

Yet, although a stringent history of this development can be described with an easily understandable logic behind, there are still organizations or individuals which did not follow these ideas and have stayed on a former level, already overcome by general development. The analysis shows that it needs an awakening to overcome such hardened habits, as also paradigm shifts are always driven by pressure in competition. On the other hand, there have always been visionary ideas in organizations or

individuals that have been performing and thinking on a level far beyond the usual and thus have been an inspiration to others when the above mentioned crisis demands change.

Consequently, the task of quality management will stay twofold: on the one hand to find solutions to evident problems, e.g. currently the reduction of risks for companies and customers during the introduction of new products and processes by maturity analyses or the continuous qualification of employees for their ever changing tasks. On the other hand it is necessary to identify future problems and thus to find a way to an overall higher level performance, e.g. facing major problems of society like environmental responsibility or demands of social change. Thus, quality management will remain the key factor of success for each individual company as well as the whole society as the one final customer common for all organizations.

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