Six Sigma and Total Quality Management: different day, same soup?

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Abstract: For decades now TQM has been a dominant management concept for improving competitiveness and financial results. In recent years, however, TQM seems to have lost some of its nimbus with other concepts and approaches such as Lean Enterprise and Six Sigma launched and increasingly in vogue. The aim of this paper is to look at TQM and Six Sigma, their backgrounds, definitions and ingredients, and their similarities and differences to see whether the two concepts really are different dishes or contain the same ingredients in different proportions.

Keywords: quality; Quality Management; Six Sigma; Total Quality Management (TQM).

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1 Background

The concept of TQM has dominated the management scene for some decades. Many organisations all over the world have tried to use TQM to achieve increased competitiveness and improved financial results. Some organisations have succeeded. For instance, quality award recipients show better financial results than comparable 'average companies'; see Hendricks and Singhal (1997) and Eriksson and Hansson (2003). However, without doubt, many organisations have also failed; see e.g., discussions in Allen and Kilmann (2001), Brah et al. (2002) and Cao et al. (2000).

Although there are several reasons for these mixed results, the failures have tarnished the TQM star and have intensified the search for new and efficient means of navigating the increasing competitiveness of a borderless world. Six Sigma and other concepts, have grown in popularity and many organisations have shifted their strategies and practices towards these concepts. That view is supported by Pande et al. (2000), who assert that "TQM is less visible now than in the early 1990s due to problems including lack of integration, leadership apathy, a fuzzy concept, unclear quality goals and a failure to break down internal barriers" and conclude that Six Sigma can overcome these deficiencies, stating that Six Sigma's expansion heralds a 'rebirth' of the quality movement. Furthermore, Harry (2000) claims that "Six Sigma represents a new holistic, multidimensional systems approach to quality that replaces the 'form, fit and function' specification of the past" and *the Financial Times* wrote in October 1997 that "Six Sigma is a program aimed at the near elimination of defects from every product, process, and transaction".

In the list of books at ASQ Quality Press, probably the largest book store in the world on quality literature, we found 73 books with Six Sigma included in the title (August 2005) but just seven with TQM. On the other hand, *USA Today* wrote on July 21, 1998:

> "Today, depending on whom you listen to, Six Sigma is either a revolution slashing trillions of dollars from corporate inefficiency, or it is the most maddening management fad yet devised to keep front-line workers too busy collecting data to do their jobs."

Whatever the truth is, it seems important to reflect on the reasons for this development, and try to dissect the TQM and Six Sigma concepts and analyse their composition. What is true and what is not? Are TQM and Six Sigma in fact two sides of the same coin – two

versions of the same dish? We will scrutinise the two concepts, compare them and present some reflections related to this issue.

2 Total Quality Management (TQM)

2.1 TQM: background, definitions and ingredients

2.1.1 Background

The quality movement has a long history. Often, its development is described in terms of a four phase model consisting of quality inspection, quality control, quality assurance and (total) Quality Management; see Bergman and Klefsjö (2003), Dale (1999) and Kanji and Ascher (1993). However other, maybe more realistic, descriptions of the development can also be found. One of these is using two schools of thought, called the Deterministic School of Thought and the Continuous Improvement School of Thought; see Kroslid (1999). According to Kroslid (1999), "the Deterministic School of Thought is specified as evolving … around a deterministic view of reality with a belief in the existence of one best way". This means that conformance to standards is the best way to meet customer requirements. On the other hand "the Continuous School of Thought is specified as being … founded on a reality full of variation, with an awareness of improvement potential in every aspect of work". Continuous improvements are used to reduce the impact of environmental changes and other variations. The Deterministic School has its origin in Taylorism (Taylor, 1911) and was developed roughly via Philip Crosby and the international ISO 9000 series of standards. The Continuous Improvement School has Walter A. Shewhart, Armand Feigenbaum and Edwards W. Deming as some of its figure heads. According to Bergman and Klefsjö (2003), the two schools are currently converging.

The basics of what we today call TQM, may be dated to the early 1950s and are often referred to as based on fundaments from people like Edwards W. Deming, Joseph M. Juran and Kaoru Ishikawa.[1] Learning the basics from Deming and Juran, Japanese companies extended and customised the integrated approach and culture of TQM. Arguably, the economic growth and manufacturing dominance of Japanese industries in the 1980s can be attributed to the successful application of TQM in Japan (Basu, 2004). Much of the Japanese success was based on the three fundamental tenets of Juran's view of quality programmes: firstly, upper management leadership of quality, secondly, continuous education on quality for all, thirdly, an annual plan for quality improvement and cost reduction – foundations that, by the way, still are valid today (Basu, 2004).

The origin of the name TQM is, by the way, disputed; discussions can be found in Martinez-Lorente et al. (1998) and Bergman and Klefsjö (2003). However, the late American professor and consultant William Golomski has told one of the authors of this paper that Koji Kobayashi, former executive at NEC, was the first one to use the term TQM in his speech when receiving the Deming Prize in 1974.

2.1.2 Definitions

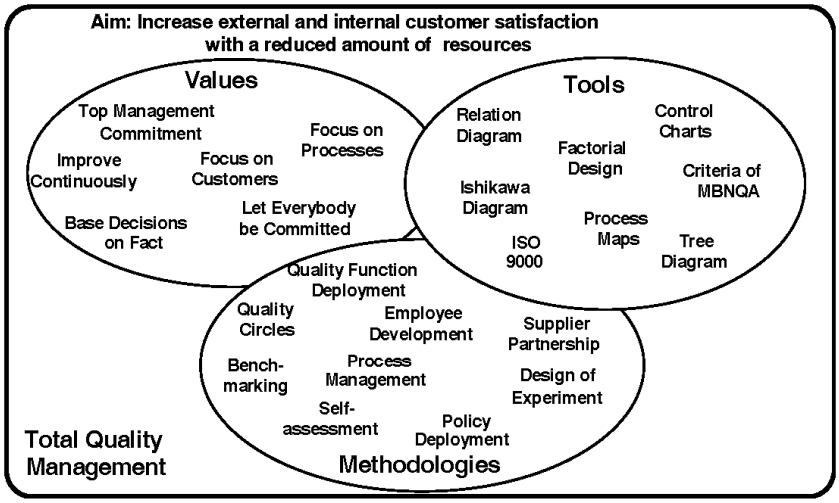
Different definitions and descriptions of TQM have been presented over the years; see e.g., Oakland (1993), Dahlgaard et al. (1998) and Dale (1999). Several of these are, in our opinion, more vague descriptions than definitions and contain terms as "… a philosophy,

which …", "… a culture, that …", "… an approach for …". As just an example, Dale (1999) defines TQM, in accordance with ISO 8402, as

> "a management approach of an organization, centred on quality, based on the participation of all its members and aiming at long-term success through customer satisfaction, and benefits to all members of the organization and to society."

In recent years some definitions with a system emphasis have been suggested. These are based on a kernel of core values that seems to have converged (Sila and Ebrahimpour, 2002). One of these definitions is from Hellsten and Klefsjö (2000), who define TQM "as a continuously evolving management system consisting of values, methodologies and tools, the aim of which is to increase external and internal customer satisfaction with a reduced amount of resources", see Figure 1. They argue that the methodologies (or "ways to work consisting of a sequence of activities") and tools (that is, "more concrete diagrams or matrices, sometimes with a statistical base") should consequently and continuously be chosen to support the values to be part of the culture. The three units together form in that way the whole.

Figure 1 Total Quality Management (TQM) seen as a management system consisting of values, methodologies and tools. The methodologies and tools in the figure are just examples and not a complete list



Source: Hellsten and Klefsjö (2000)

2.1.3 Important ingredients of TQM

Although the system view is not always as clear as in Hellsten and Klefsjö (2000), many definitions of TQM of today contain the ingredient values (sometimes called core values, principles or cornerstones as well) and ways to work (also called methods, methodologies or techniques). TQM can, in most descriptions, be characterised by a number of values, illustrating how we should act in our profession. These focus on the six values mentioned in Figure 1, i.e., on continuous improvements, fact based decisions, participation of all the staff, process focus and, last but not least, a customer perspective in what we do. TQM is also seen as permeating the entire organisation. Another characteristic of TQM is

that it encompasses all the organisation, and preferably suppliers and customers as well. Tobin (1990) has stated that TQM is a totally integrated programme for gaining competitive advantages by continuously improving every facet of organisational culture.

2.2 Some comments

We are, however, fully aware that the TQM concept and its definition are not without controversy. Boaden (1997) claimed that "attempting to define TQM is like shooting at a moving target. As it became more widely practiced, and other initiatives emerge, the emphases on different aspects change". Furthermore, van der Wiele et al. (2000) discuss whether TQM is a fad, fashion, or fit. The fieldwork by van der Wiele et al. (2000) shows that a change to a fit of TQM to other management theories will only occur when there is a strong internal motivation for and emotional involvement in the implementation of TQM. Foley (2004) summarises some of the criticism against TQM and claims, in particular, that it does not have a generally accepted definition and has failed to deliver promised results. He further claims that, due to the criticism, consultants and quality promotion institutions are trying to expunge 'quality' from their lexicon, and that TQM now appears under a different guise, often with new 'catchy' slogans – but that its substance remains the same. Foley (2004) also means that in order to extend the scope of TQM theory it is necessary to incorporate management theories into its development. These ideas are further discussed in Foley et al. (2006). Dale et al. (2001) explore the position of TQM with respect to theory and argue that TQM is still in an early stage of theory development. On the other hand, both Dean and Bowen (1994) and Boaden (1996) contend that TQM already has incorporated many insights from other management theories.

2.3 Strengths and deficiencies of TQM

Investigations show that organisations that have implemented TQM successfully have better financial results than the average company'. Well-known investigations of this issue include Hendricks and Singhal (1997) and Eriksson and Hansson (2003), who both, over two time periods, compare financial indicators of quality award recipients with comparable 'average companies'. The period consisting of a number of years before these companies earned the quality award is called the implementation period[2] while another time period of the same length following the implementation period, is called the post-implementation period. Roughly, both investigations found that quality award recipients have better results during the post-implementation period than the 'average company', but no difference was found during the implementation period. An explanation might be that in the beginning, the investment is roughly of the same size as the short-time benefit, but after some time of successful work the benefit of implementation is high. Similar results are also obtained in a recent study of European quality award recipients performed by Boulter et al. (2006). Lemak and Reed (1997) also claim that TQM leads to an improved profit margin, after studying 60 companies that had demonstrated a commitment to TQM for at least five years. In recent years, research has also shown that one goal of TQM, customer satisfaction has a significant positive impact on market value as well as accounting returns; see e.g., Andersson et al. (1994) and Eklöf et al. (1999).

On the other hand, it is without doubt that many companies have failed to implement TQM successfully; see Brown et al. (1994), Cao et al. (2000) and Foley (2004). Several explanations for this have been offered. Some people blame the TQM concept itself for being vague (Knights and McCabe, 1997). Others believe that failure is more due to poor planning and implementation than to a vague management concept. Implementation of TQM is a complex process since all employees starting with top management need to accept a fundamental organisational change (Shin et al., 1998; McAdam and Bannister, 2001). Awareness of the fact that TQM implementation really means a thorough organisational development and cultural change too seldom exist (Reed et al., 2000). Accordingly, the time, resources and work needed during the implementation are underestimated. These issues are discussed by Hansson (2003) and Hansson and Klefsjö (2003). Furthermore, Lau and Anderson (1998) indicate that blame can often be laid at the feet of 'partial Quality Management' – less than full implementation. Our own experiences in both Sweden and the USA are congruent with the perspective of Lau and Anderson (1998).

3 Six Sigma

3.1 Six Sigma: background, definitions and ingredients

3.1.1 Background

Around 1980 Robert Galvin, at that time CEO at Motorola, realised the importance of working systematically with variance reduction as the Japanese had done for a prolonged period (Bergman and Klefsjö, 2003). Together with Bill Smith, Mikel Harry and Richard Schroeder, he created an improvement program that was given the name Six Sigma. According to Basu (2004), Bill Smith came up with the idea of "inserting hard-nosed statistics into the blurred philosophy of quality". The program was inspired by Japanese work, but also strongly influenced by Juran's thoughts. Due to Six Sigma, Motorola managed to reduce their costs and variation in many processes and were an inaugural winner of America's Malcolm Baldrige National Quality Award in 1988. They reported a profit from the program of USD 700 million for 1991 alone (Bergman and Klefsjö, 2003). Another example is the Volvo Car Corporation in Sweden who claim that their Six Sigma programme has contributed with more than 55 million Euro to the bottom line between 2000 and 2002 (Magnusson et al., 2003).

The Six Sigma results by Motorola impressed Jack Welsh, then CEO at General Electric (GE), and Welch launched Six Sigma in late 1995 as one of four strategic initiatives. After 200 projects and intensive training GE moved to 3,000 projects and more training in 1996 and undertook 6,000 projects and still more training in 1997 (Pyzdek, 2001). According to Byrne (1998), Six Sigma delivered USD 320 million in productivity gains and profits in 1997, more than double Welsh's goal of USD 150 million. In the annual report of 1999 GE was able to report savings of USD 2 billion for that year alone. The success of Six Sigma at GE under Welsh's leadership is undisputed. In the 2000 GE Annual Report Welsh said: "Six Sigma has galvanised our company with an intensity the likes of which I have never seen in my 40 years at GE". The enormous savings reported from Six Sigma in GE certainly interested many leaders, who had difficulties to get TQM working in their organisations. As a result the interest in Six Sigma accelerated during the late 1990s.

3.1.2 Definitions

The name Six Sigma refers to the capability of the process to deliver units within the set limits. The Greek letter σ or 'sigma', corresponding to our 's', is a notation of variation in the sense of standard deviation. For a stable process the distance from the process mean to the nearest tolerance limit should, according to the Six Sigma approach, be at least six times the standard deviation σ of the process output. However, the process mean is also allowed to vary somewhat over time. If the process mean varies at most 1.5 σ from the target value, then on average at most 3.4 Defectives Per Million Opportunities (DPMO) will occur if the output is normally distributed; see Table 1. A 6 σ-process corresponds in a sense to a value of 2.0 of the capability index C_p or 1.5 for C_{pk} when allowing for a 1.5 σ drift in process mean (see Table 1).

Table 1 The correspondence between 'sigma', capability index $C_p = (T_U - T_L)/\sigma$, the number of defective units with process average on the target value, and the number of defective units when allowing a variation of the process average up to +/– 1.5 σ from the target value

Process σ	$(T_U - T_L)/\sigma$	*Value of* C_p	*DPMO when perfectly centred*	*DPMO with a 1.5* σ*-shift, that is, when* $C_{pk} = 1.5$
2	4	0.67	46,000	308,537
3	6	1.00	2,700	66,807
4	8	1.33	60	6,210
5	10	1.67	0.6	233
6	12	2.00	0.002	3.4

Source: Bergman and Klefsjö (2003)

Six Sigma is seen by many people as a process oriented way to reach improvements through reducing variation and measuring the financial output of each driven project. It is supported by an infrastructure of specialists called Master Black Belts, Black Belts, Green Belts and Yellow Belts.[3] Master Black Belts are strategic improvement leaders, often working full-time as trainers and improvement leaders. Often a Champion is also appointed, with the overall responsibility at the top management level. These people have received education in statistical methodologies and different quality tools – Black Belts even more than Green and Yellow. All the activities, as well as the selection of projects, are in most cases strongly supported or even determined by top management – which often functions as a critical success factor.

The TQM concept has been blamed for being vague – let us therefore briefly look at some definitions found in recent literature of Six Sigma. Do we really have a consistent picture of what it means or is the definition of Six Sigma also vague?

> "*Six Sigma is a business improvement approach that seeks to find and eliminate causes of mistakes or defects in business processes by focusing on process outputs that are of critical importance to customers.*" (Snee, 2004)

> "*Six Sigma is a useful management philosophy and problem-solving methodology but it is not a comprehensive management system.*" (McAdam and Evans, 2004)

> "*A Six Sigma initiative is designed to change the culture in an organisation by way of breakthrough improvement in all aspects of the business.*" (Breyfogle et al., 2001)
>
> "*Six Sigma is a programme that combines the most effective statistical and non-statistical methods to make overall business*." (Pearson, 2001)
>
> "*Six Sigma is a highly disciplined process that helps us focus on developing and delivering near-perfect products and services. The central idea behind Six Sigma is that you can measure how many defects you have in a process, you can systematically figure out how to eliminate them and get as close to 'zero defects' as possible. Six Sigma has changed the DNA of GE – it is the way we work - in everything we do in every product we design.*" (General Electric at www.ge.com)

To that list we want to add our own definition that we believe acknowledges its structures for both innovation, improvement and design (Design for Six Sigma or DFSS) along with its goals and flexibility:

> "*Six Sigma is a methodology with accompanying highly structured processes using efficient statistical approaches for acquiring, assessing, and applying the customer, competitor, enterprise, and market intelligence to produce superior product, process and enterprise innovations and designs with the goal of creating a sustainable competitive advantage.*"

We can see that Six Sigma is also described by many different keywords including strategy, methodology, philosophy, approach and so on, exactly as in the case with TQM. Herold et al. (2003) add a list of 'some common descriptions' to our list with formulations such as "… a statistical way of measuring quality control", "… a high-performance, data-driven approach to analysing the root causes of business problems and solving them", "… first and foremost a philosophical approach that demands the effective use of data to analyse business issues" and "… attempts to insert the science of hard-nosed statistics into the foggy philosophy of quality". To sum up, there is, as Goodman and Theuerkauf (2005) say, certainly no common definition of Six Sigma.

3.1.3 Important ingredients of Six Sigma

An important part of Six Sigma is the DMAIC procedure: Define – Measure – Analyse – Improve – Control. Conceptually DMAIC is a highly structured and rigorous problem-solving approach, but one that offers a good deal of freedom within each step so long as the Six Sigma team holds true to the intent of each step and the goals of each step are accomplished. In many aspects, however, DMAIC is simply a more polished version of a more 'ancient' and very familiar improvement cycle: Plan – Do – Study – Act or PDSA. This PDSA cycle, which was popularised by Deming, especially with his presentation in Japan in 1950, was adopted by Deming from an earlier version developed by his mentor Walter A. Shewhart.

3.2 Some comments

Six Sigma has from its beginning had a focus on reducing 'costs of poor quality' or, more generally, the 'costs of poorly performing processes' (CP^3), which means that Six Sigma – at least at its outset – was used reactively to eliminate customer dissatisfaction.

Today, steps have been taken also to use Six Sigma for progressive purposes to avoid failures and mistakes, through DFSS approaches, and hence to attract potential customers and create customer satisfaction which depends largely on the resident experience inside a given company.

Those companies practicing Six Sigma from a true Customers – Outputs – Processes – Inputs – Suppliers (COPIS) perspective are more apt to employ Six Sigma proactively – that is, to actively and rigorously solicit the Voice Of the Customer (VOC) to determine not only the 'wrongs' of a particular product, or service – but also to identify important necessary or innovative 'missing' elements; then to determine what the needed outputs are; optimally configure their processes to deliver those outputs; determine the necessary inputs to the processes and hence chose the suppliers with which they should partner … those are the companies making proactive use of Six Sigma … and we believe those to be relatively rare. There are, however, an increasing number of companies – companies such as GE and IKON – that are said to apply DFSS approaches to every new product or service they provide. It should be noted, however, that while DMAIC is regarded as the Six Sigma approach for significant improvement of innovation in existing products and processes, DFSS is still young enough that a variety of competing structured design approaches are in use, the most popular of which is probably Define – Measure – Analyse – Design – Verify (DMADV).

It can be noted here that new variants (or, maybe, just the same concept marketed under a different name?) have already appeared. Some are FIT SIGMA (Basu and Wright, 2003),[4] Lean Sigma,[5] Ultimate Six Sigma,[6] and Strategic Six Sigma.[7] More humorously, quality expert John Dalrymple of the Centre for Management Quality Research at RMIT University in Australia, when asked what Six Sigma might be called in the future is quoted as saying 'hubri-doobri-doobri', an expression from his native Scotland. When asked to expand on this name his response was brief, he said "it means that it will be called whatever it will be called" (Edgeman and Bigio, 2004). Fundamentally, we echo that opinion – it is not the name that matters, but the fruit of its application. Edgeman and Bigio (2004) went on to speculate that in the future Six Sigma will be used in an increasing number of non-traditional areas, lending to and borrowing from approaches in those fields so that, ultimately, the portfolio of Six Sigma ingredients will be an enlarged one and may come to be known by any number of 'names', of which Six Sigma is only one.

3.3 Some strengths and deficiencies in the Six Sigma concept

Why has Six Sigma become so popular? Without doubt, Six Sigma emphasises the importance of linking financial gains to projects undertaken. That financial aspect attracts top managers, who like the 'money talk'. The published success stories about savings are probably the main reason for the popularity of Six Sigma. The average benefit reported per Six Sigma project varies, but is according to Herold et al. (2003) about 175,000 USD. According to Wise and Stephens (2003) the return on Black Belt projects is between 100,000 USD and 500,000 USD.

Furthermore, Six Sigma focuses on reducing defects as a top priority for quality improvements (Hong and Goh, 2004). It is important here to note that often the large savings obtained from Six Sigma efforts are, savings from reducing the costs of poor quality – obtained by 'extracting gold in the mine', as Juran had already said 50 years ago. It is fundamentally important to understand what the customer wants and needs and

to use this information to guide R&D efforts on existing products or design of new ones (Klefsjö et al., 2001). While an increasing number of organisations are engaging in DFSS, it must be stressed that DFSS is hard work, requiring a relatively imposing amount of expertise – and it is still relatively new – so that there is probably 'more talk than work' done with respect to DFSS application.

The focus on processes and on eliminating variation has certainly increased knowledge about variation. This is excellent – and an important part of Deming's Profound Knowledge system (Deming, 1993). In recent years also a focus on reducing lead times is emphasised.

Hoerl (2004) states that "perhaps the most critical question about the future of Six Sigma is when it will begin to wind down and perhaps morph into something else". We feel that while Six Sigma will evolve over time, as certainly TQM has and will,[8] there are some core strengths of Six Sigma that will be maintained so whatever 'the next big thing' is, it will look at least vaguely familiar to Six Sigma. Some of these core strengths are the use of infrastructure to supply the needed people, money and other resources, freeing top talent to work on new initiatives and, of course, reliance on senior leadership commitment.

4 Comparison of TQM and Six Sigma

There are few studies that directly compare TQM with Six Sigma. In the limited studies that do exist, conclusions on the relationship differ significantly. That is not, in our opinion, surprising since a comparison between two fairly vague concepts relies to a great extent on the definitions used. Ricondo and Viles (2005) compare Six Sigma and its link to TQM, BPR, lean and learning organisation, paying attention to their origins, values, methodologies and tools. Yang (2004) presents an interesting comparison between TQM and Six Sigma based on twelve dimensions: development, principles, features, operation, focus, practices, techniques, leadership, rewards, training, change, and culture. He concludes, among other things, that the core values differ and suggests an integration of TQM and Six Sigma. We agree with Yang (2004) at several points.

Like Basu (2004), we think that the key success factors differentiating Six Sigma from TQM, is the clear project-by-project focus, which in fact was emphasised by Juran a long time ago, and reinforcement of Juran's tenets (Top Management Leadership, continuous education, and annual saving plans). Another important factor is the highly data-driven approach.

According to Snee (2004), there are four aspects of Six Sigma that are not emphasised sufficiently in TQM. First, Six Sigma places a clear focus on bottom line financial results. No Six Sigma project is approved unless the bottom line impact has been identified. Many projects have reported saving between USD 175,000 up to USD 1 million. This bottom line focus is central to strong management leadership and support. However, it is in our opinion a bit peculiar that, in many cases, only projects referred to as 'Six Sigma projects' are investigated from a financial point of view. An investigation of successful Swedish companies revealed that the financial benefit from improvement projects related to TQM were not measured at all (Eriksson and Garvare, 2005). Should not improvement projects be studied financially independently of the name of the project? Next, Six Sigma builds on improvement methods that have been shown to be effective and integrates the human and process elements of improvement.

The third characteristic of Six Sigma is that it sequences and links the improvement tools into an overall approach – that is, DMAIC sequences and links key tools proven to be effective in improving processes. The fourth point is that Six Sigma creates an infrastructure of champions, Master Black Belts, Black Belts and Green Belts that lead, deploy and implement the approach. Here we also want to emphasise the important role of the Champion. The Champions are not 'belts' or analysts in any traditional sense of the word. Champions are responsible for keeping the Six Sigma program focused within their business area, they select Black Belts, approve projects, set improvement targets, and provide the resources needed to conduct the projects (Watson, 2003).

Here we want to add, that from a statistical perspective, most of the 'ingredients' used in TQM as well as in Six Sigma are fairly old. Inspired by Snee (2004) we want to give the following picture.

The *t*-test, among other things used to test statistical significance of effects of process improvements, was published by Gossett in 1908 (Student, 1908). In the 1920s Fisher created Design Of Experiments (DOE) and Analysis of Variance (ANOVA) to analyse experimental data (Fisher, 1925). In the 1950s George Box and his co-workers in England did much to drive industrial adoption of Fisher's ideas, which had been developed for agricultural purposes. A key concept was now response surfaces, which through experimentation enables one to determine the best way to operate a process (Box and Wilson, 1951). Later Taguchi popularised the use of certain experimental designs to achieve product and process robustness (Taguchi and Wu, 1980).

The control chart was developed by Walter Shewhart in the 1920s, when working at Bell Laboratories (Shewhart, 1931). That tool became important during the 1950s within Statistical Quality Control (SQC) to control and improve product quality. In the late 1960s and early 1970s SQC became widely used for process improvements, particularly in the auto industry. SQC was then combined with capability studies, based on capability indices such as C_p and C_{pk}, and use of Pareto charts to identify sources of variation also came into vogue.

Six Sigma has been described as 'old wine in a new bottle', since most of the tools 'packaged' in it have been around for several decades (Thawani, 2004). Juran expressed similar views in an interview published in *Quality Digest* (August 2002):

> "From what I've seen of it, it's a basic version of quality improvement. There is nothing new there. It includes what we used to call facilitators. They have adopted more flamboyant terms, like belts with different colours. The name Six Sigma comes from a measure of what we call process capability, measuring the inherent uniformity of the process. One of the things that is inherent in tools used to achieve improvement under the label of Six Sigma is the concept of process capability. Now, to my knowledge, that concept of process capability goes back to 1926, when I was a young engineer at Western Electric. I got into a problem, and I ended up discovering that every process can be quantified in terms of its inherent uniformity. … In addition, you can also see whether the process is capable but is being misdirected. I am the inventor, if not the reinventor, of that concept."

At the same time as we, of course, recognise and respect Dr. Juran's statement, it may be instructive to note that the *Juran Institute* has solidly embraced Six Sigma and provides a number of instructional and consulting resources devoted to its study and practice.

Many other methodologies and tools, statistical and non-statistical, such as Quality Function Deployment (QFD), Failure Modes and Effects Analysis (FMEA), Lean Management, Process Mapping, and Project Management are also employed in Six Sigma – and in TQM.

To sum up – there are few, if any, new ingredients in the Six Sigma dish, on the contrary. That does not, however, disqualify the concept as there are few new ingredients in any dish – the difference is the proportions and the cooking. The point is whether sufficient ingredients are used to achieve a complete dish and, furthermore, whether the ingredients are used in suitable mixes and proportions.

Despite basic agreement with the views of Snee (2004) and Basu (2004), it is our perspective, referring to the system view and terminology of TQM in Figure 1, that Six Sigma may be appropriately regarded as a methodology within the TQM frame, a view which is further discussed in Klefsjö et al. (2001). We are certainly not alone in this perspective. For example, Micklewright states:

> "I'm a huge proponent of both Six Sigma and Lean Manufacturing. I've been teaching the tools used in Six Sigma for years, and I make a portion of my living from consulting and training in these areas. However, Six Sigma and Lean Manufacturing are business improvement processes that should be viewed as part of a continually improving quality management system." (Micklewright, 2004)

In our view the Six Sigma methodology mainly supports three of the six core values presented in Figure 1, namely 'Base decisions on facts', 'Focus on processes' and 'Continuous improvements'. 'Management commitment' is a prerequisite here, as in other cases, for success.

However, we do not think 'Everybody's commitment' is sufficiently encouraged or supported. We see a risk that the belt-based infrastructure has an unavoidable tendency to glorify some people and, hence, not sufficiently support the TQM value of 'everybody's commitment'. Although GE has saved a lot of money through Six Sigma, Eckes (2003) thinks that this tendency to glorify a few persons may result in lower employee satisfaction. However, on the other hand, we know that some organisations try to keep other improvement methodologies from the TQM sphere when introducing Six Sigma, in order to include all the staff in the improvement work and to just avoid just glorifying a few. One example here is SKF, the global supplier of rolling bearing, seals business and related businesses; see Schön (2006).

Depending on the organisation in which Six Sigma is applied, 'Focus on the Customer' may be inadequately addressed as well. Six Sigma still has a focus on reactive improvements in too many cases. That customer focus is not the primary goal of Six Sigma projects is also illustrated by a study by Greenwich Associates (Swayne and Harder, 2003) including, among others, 11 businesses in the Fortune 500. When asked on an unaided basis to define a successful project, only one of the 13 companies mentioned customers as critical success factors. The three most frequent measures used to quantify the success of Six Sigma projects were cost takeout, productivity and revenue.

We do believe in a process focus, in increased knowledge of variation, and we are in favour of an increased use of statistical tools for quality improvements and we certainly see the benefit of emphasis on education and training. However, we are not convinced that Six Sigma must exist as a distinct concept. On the contrary, we think that many managers may look to Six Sigma as a quick fix or panacea and hence not sufficiently

grasp the 'big picture'. In short, we believe that, appropriately deployed, Six Sigma can produce excellent results, but that it is only a part, albeit a potentially significant part, of a more complete whole.

Lucas (2002) asserts that Six Sigma is essentially a methodology for disciplined quality improvements. Because this is a prime ingredient of TQM, many firms have found that adding a Six Sigma program to their business system, gives them all, or almost all, of the elements of TQM and concludes that "current business system + Six Sigma = Total Quality Management".

5 Some final conclusions

To us, TQM is a constantly evolving management system, and it is thus interesting, not only to reflect upon what Six Sigma has to learn from TQM, but also what the TQM concept could learn from Six Sigma. We have pointed out a few differences that we see as significant, one being the strict financial focus. However, we do believe that some improvement efforts are crucial for organisational development, albeit difficult to price such as the well-being of employees and the trust of customers. It is often profitable in the short term to follow an ethical and ecologically non-sustainable route, for instance by buying from vendors using child labour or choosing coal power over solar.

We believe that if a strict financial return should be used as a criterion for starting projects, we must add generally accepted models that link sustainable decision making with financial results, for instance through increased sales as the result of improved brand status. These models should then be used irrespectively of whether the company says it works according to TQM or Six Sigma or any other management concept.

The cook-book concept of how to implement Six Sigma, starting with a massive educational drive with key personnel organising these has its risks. We have mentioned the peril of creating alienation among the staff not included in the improvement activities. However, when making soup, cook-book recipes have definite advantages, especially for novices. When Taguchi methods were introduced in the Western world, they were criticised for lack of statistical rigor. The point here is that suddenly engineers were using DOE to an unprecedented extent. We believe that this was mainly due to two reasons. The first is of course that the Taguchi methods were visible evidence of what the Japanese did that the Western engineers did not. The second reason, we believe, is that Western statisticians had not been particularly interested in presenting step-by-step approaches to DOE. Many statisticians probably felt that they ought to dissuade engineers from using methodology if proper statistical backup (a statistician) was not around. The Taguchi methods, on the other hand were introduced with hands-on demonstrations, using a language and examples that engineers understood, and without much distracting discussion on statistical implications; see Phadke (1989).

An important part of the Six Sigma cook-book is the extensive education of Black Belts, and often also other belts. The education addresses statistical methodologies, such as DOE, in a hands-on fashion and this is one reason for the fact that the frequency of use of these methodologies is higher in the average Six Sigma organisation than the corresponding TQM organisation.

The TQM community appears to have a reluctance to stress to novices what routes to take when implementing TQM and this is of course a doubtful strategy since the best routes differ from organisation to organisation. Self-assessment using quality award

criteria has been described as a way to first find improvement opportunities for the organisation. However, for many organisations these criteria may be too complex and as they pose questions rather than give answers, they may be too abstract. Questions of what you have done to make your soup smooth or your meal tender are fine if you are a TQM chef, but if you are not, you may end up doing nothing. Six Sigma descriptions, where actions are outlined without much discussion may thus be a fine way of introducing several aspects of TQM to an organisation.

Joseph Juran, who has been critical of ISO 9000 over the years, roughly said in an interview in Sweden once that "Implement ISO 9000 if you want, but do not let it disturb the work with quality improvements". We want to conclude this paper by saying: "Feel free to use Six Sigma, but do try to integrate it with TQM, or else you may end up with too thin a soup that may separate and come apart".

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Notes

[1]Although the contributions by Juran, Deming and Ishikawa are without any doubt, it is important to also mention Homer M. Sarasohn, who was asked by General Douglas McArthur to help reconstruct the Japanese communication industry. Sarasohn together with Charles A. Protzman, and some other colleagues, predated the work by Deming and Juran in Japan by several years. Indeed it was Sarasohn who placed the call to Deming in 1950 when Shewhart was unable to accept an invitation to Japan from JUSE due to illness (Foley, 2004, p.65[0]).

[2]The length of the period is five and three years, respectively, in the two investigations.

[3]Also other names appear.

[4]Basu and Wright (2003).

[5]See, for instance, www.suntroncorp.com (13 February, 2005).

[6]Bhote (2002).

[7]Smith and Blakeslee (2002).

[8]A discussion of the future of TQM can be found in Bergquist *et al*. (2006).