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Critical thinking and business process improvement

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Abstract

Purpose – The purpose of this paper is to explore the dynamics of critical thinking (CT) in contrast with Six Sigma and the "5 Whys" approach that is used by many managers to conduct "Root cause analysis" in business process improvements.

Design/methodology/approach – The research integrates principles of traditional literature review with a reflective inquiry of a practitioner.

Findings – Six Sigma and its "5 Whys" methodology is insufficient in root cause analysis unless coupled with CT. The paper demonstrates that some extraordinary business successes were achieved by CT, while catastrophic failures were often the result of selective biases, rigid thinking, and/or tendencies to deal with steps of processes, isolated processes, and/or independent situations. Consequently, the paper identifies a new domain that can be added to training in Six Sigma and 5 Whys.

Research limitations/implications – The study does not address specific ways to integrate CT into Six Sigma, 5 Whys, and/or root cause analysis in business process improvement initiatives. Future research is needed in this area.

Originality/value – The paper explores a new perspective to convalescing Six Sigma and 5 Whys methods. It provides a specific example and suggestions to help practitioners avoid faulty conclusions, while conducting investigations to improve business processes. It also opens the door for encompassing aspects of CT in Six Sigma training. As such, it benefits both practitioners and academics.

Keywords Critical thinking, Six Sigma, Process management, Problem solving

Paper type Conceptual paper

Introduction

There is a paucity of critical studies on Six Sigma beyond that of "how to" and that of descriptive accounts, with a focus on measures and results (McAdam and Lafferty, 2004). Anbari and Kwak (2004) confirmed that integrating the data-driven, structured Six Sigma processes into organizations has room for improvement. While recognizing the need for improvements in Six Sigma, some researchers suggested improving it using different technical approaches (Siviy *et al.*, 2005; Goh and Xie, 2004).

A deeper scarcity of studies that compare and contrast Six Sigma with Critical Thinking, CT, exists as well. In fact, when Emerald search engine was used to locate papers tackling the term "Six Sigma" and the term "Critical Thinking" concurrently in all fields excluding text, surprisingly, zero papers were produced. This lack of research that combines Six Sigma and CT became more evident when two other search engines, EBSCO and Proquest, rendered zero papers critiquing Six Sigma in contrast with CT. This dearth of such research can be attributed to the fact that Six Sigma was born and raised in the field by practitioners. Indeed, Motorola was the first company to launch Six Sigma initiatives in 1986 (Rancour and McCracken, 2000). Consequently, researchers

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focused on Six Sigma's statistical aspects, implementations, benefits, and methodologies. As a result, an opportunity for a research to fundamentally improve Six Sigma does exist; such research may provide insights to the reasons some organizations experience great deal of success while others experience disappointments with process improvement initiatives.

Six Sigma, 5 Whys, and Critical Thinking

Six Sigma has been defined as "an organized and systematic method for strategic process improvement and new product and service development that relies on statistical methods and the scientific method to make dramatic reductions in the customer defined defect rates" (Linderman *et al.*, 2003). From the statistical perspective, the term Six Sigma is defined by convention as having less than 3.4 defects per million opportunities (DPMO) or a success rate of 99.9997 percent, where the term sigma is used to represent the variation about the process average (Anthony and Banuelas, 2002). Motorola confirms that Six-Sigma was invented by them in 1986 as a metric for measuring defects and improving quality (Motorola Inc., n.d. b). Since then, it has evolved into a robust business improvement methodology that focuses an organization on customer requirements, process alignment, analytical rigor and timely execution (Motorola Inc., n.d. b). DMAIC is a Six Sigma problem-solving methodology. It is an acronym for Define opportunity, Measure performance, Analyze opportunity, Improve performance, and Control performance (Motorola Inc., n.d. b). Motorola documented more than $17 billions in savings as a result of Six-Sigma efforts over a period of 18 years (Motorola Inc., n.d. a).

Asking "why" five consecutive times is an approach that many Six Sigma practitioners use to help identify the "root cause" of a problem or a defect. It was made popular in the 1970s by the Toyota Production System, TPS. In fact, Taiichi Ohno, the father of TPS, was a proponent of the five whys method to root out problems and fix the process for good (Alukal, 2007). The 5 whys strategy involves looking at any problem and asking: "Why?" and "What caused this problem?"

While Six Sigma is just over two decades old, and its roots as an improvement program can be traced back to initiatives undertaken in several companies in the 1800s, (Bhuiyan and Baghel, 2005), CT can be traced to over 2,500 years ago when Greek philosophers initiated a journey to establish a framework for thinking. Socrates may have drafted the first chapter in CT by what is known as "Socrates Questioning". In more recent years, a number of researchers (Watson and Glaser, 1980; McPeck, 1981; Paul, 1982; Facione, 1984; Ennis, 1985; Brookfield, 1987; Kurfiss, 1988; Siegel, 1991; Boostrum, 1994; and Halpern, 1996) have put forth definitions and theories regarding CT.

In 1987, as a result of variations in the theories and definitions of CT, American Philosophical Association assigned Peter Facione to head a systematic inquiry into research on critical thinking. Facione and a panel of experts representing several academic disciplines formed the "Delphi Project". One outcome of this project was a definition of CT. The panel's consensus statement regarding the definition of CT and the Ideal Critical Thinker states:

> We understand critical thinking to be purposeful, self-regulatory judgment which results in interpretation, analysis, evaluation, and inference, as well as explanation of the evidential, conceptual, methodological, criteriological, or contextual considerations upon which that judgment is based. CT is essential as a tool of inquiry. As such, CT is a liberating force in

> education and a powerful resource in one's personal and civic life. While not synonymous with good thinking, CT is a pervasive and self-rectifying human phenomenon. The ideal critical thinker is habitually inquisitive, well-informed, trustful of reason, open-minded, flexible, fair minded in evaluation, honest in facing personal biases, prudent in making judgments, willing to reconsider, clear about issues, orderly in complex matters, diligent in seeking relevant information, reasonable in the selection of criteria, focused in inquiry, and persistent in seeking results which are as precise as the subject and the circumstances of inquiry permit. Thus, educating good critical thinkers means working toward this ideal. It combines developing CT skills with nurturing those dispositions which consistently yield useful insights and which are the basis of a rational and democratic society (Facione, 1990, p. 2).

Table I demonstrates the similarities between the definition of Six Sigma and the definition of Critical Thinking as adopted by the Delphi Project.

As Table I demonstrates, there are identical similarities between Six Sigma and CT, but CT is more comprehensive than Six Sigma. Actually, every step of Six-Sigma requires the broad aspects of critical and independent thinking to render sound judgments i.e. define the problem correctly, measure accurately, analyze deeply, etc. In a way, as a philosophy, Six Sigma frames the situation to improve it and control it, but CT liberates the situation as a way to shape it and/or optimize its shape.

Furthermore, statistics are essential to Six Sigma (Maleyeff and Kaminsky, 2002) but statistics without CT can be fatal. Best (2001) cites the following quotation "Every year since 1950, the number of American children gunned down has doubled" and states:

> Accepting these data without CT leads to mistakes, as the statement is "impossible". What makes this statistic so bad? Just for the sake of argument, let's assume that "the number of American children gunned down" in 1950 was one. If the number doubled each year,

Purpose	DMAIC	A framework for improving business processes and/or corporate strategic initiatives
	CT	A framework for thinking
Approach	DMAIC	Define, measure, analyze, improve, and control performance
	CT	Interpretation, analysis, evaluation, and inference
Outcome	DMAIC	Identify root causes of opportunities/defects, and improve corporate performance
	CT	Explanation of the evidential, conceptual, methodological, criteriological, or contextual considerations
Who/character	DMAIC	The top five essential characteristics for a Six Sigma black belt include: effective communicator, team builder, results-oriented personnel, change agent, and customer advocate (Antony *et al.*, 2007). They are trustworthy, passionate, team players, approachable, and great communicators (Waxer, n.d.)
	CT	Habitually inquisitive, well-informed, trustful of reason, open-minded, flexible, fair minded in evaluation, honest in facing personal biases, prudent in making judgments, willing to reconsider, clear about issues, orderly in complex matters, diligent in seeking relevant information, reasonable in the selection of criteria, focused in inquiry, and persistent in seeking results which are as precise as the subject and the circumstances of inquiry permit (Facione, 1990, p. 2)

Table I.
Six Sigma – DMAIC and critical thinking: compare and contrast

> there must have been two children gunned down in 1951, four in 1952, eight in 1953, and so on. By 1960, the number would have been 1,024. By 1965, it would have been 32,768 (in 1965, the F.B.I. identified only 9,960 criminal homicides in the entire country, including adult as well as child victims). By 1970, the number would have passed one million; by 1980, one billion (more than four times the total US population in that year). Only three years later, in 1983, the number of American children gunned down would have been 8.6 billion (nearly twice the earth's population at the time). Another milestone would have been passed in 1987, when the number of gunned-down American children 137 billion would have surpassed the best estimates for the total human population throughout history 110 billion. By 1995, when the article was published, the annual number of victims would have been over 35 trillion; a really big number of a magnitude you rarely encounter outside economics or astronomy.

The original statistics came from the Children's Defense Fund, a well-known advocacy group for children. The CDF's *The State of America's Children Yearbook 1994* does state: "The number of American children killed each year by guns has doubled since 1950." Note the difference in the wording – the CDF claimed there were twice as many deaths in 1994 as in 1950; the article's author reworded that claim and created a very different meaning. (Best, 2001).

In addition, in business statistics and numeric data can not tell the whole story; not only because process improvements can be achieved at the expense of long-term sustainability, or at the expense of factors that are not a measured part of the process such as morale, culture, and/or corporate politics and power but also because process improvement is a philosophy (Ayad, 2005). In other words, workability without sense making jeopardizes the integrity of the entire initiative to improve processes in Six Sigma methodology. Thus, CT is vital to business processes because it is more holistic than the rigid and measured approach of Six Sigma since CT can deal with the unmeasured aspect of processes including spoken and unspoken corporate politics and other social dimensions.

Critiquing the 5 "Whys" approach

The following example is based on this author's repertoire as a practitioner, and it examines the 5 whys approach by citing a business situation where a manager received a telephone call from an irate customer to complain that the business delivered the wrong product for the second time in less than a month to the customer. The manager decided to deploy the 5 whys methodology to identify the root cause of the problem. So, he asked his Human Resources Manager, his Assistant Manager, and the employee involved. Here is a summary of the inquiry:

The manager asked human resource manager (HRM): "Why do you think we delivered the wrong product?" The answers came as follows:

- We delivered the wrong product because our newly hired associate did not get the attention he needed from his manager.
- Why: Because the assistant manager was busy, so he did not follow up on this.
- Why: Because he was handling many projects.
- Why: Because he was trying to show you how hard he could work.
- Why: Because you work hard and he wanted to make sure that you rate him favorably on his performance review.

The manager followed the same method of asking "why" with his assistant manager, AM, and the answers were as follows:

- We delivered the wrong product because our newly hired associate faxed the wrong order.
- Why: Because training he received was ineffective.
- Why: Because trainer did not mention this specific product and its delivery.
- Why: Because training material is out of date.
- Why: Because HRM and operations did not update training yet but they are scheduled to doing that tomorrow.

The contradictory perception indicates a major problem for this investigation that was further complicated by employee's perception. When the employee was asked: Did you receive adequate training on this product and its delivery, his answer was "no" which supported the AM reasoning; and when he was asked: Did your manager follow up on you; his answer was "no" which supported the HRM position. However, the newly hired employee clarified that originally he faxed the correct order but the shipping company delivered the wrong product; then the customer called another employee and changed his original request, but the other employee had an input error which resulted in the wrong delivery.

One could argue that the technique was misapplied in this case, and if the employee involved instead of his supervisors was asked "why" five times chances are the root cause may have been discovered. Or if the team was assembled, and asked by a facilitator instead of the direct manager, the root cause may have been discovered. But the purpose of this "real life" scenario is to prove that the quality and accuracy of the 5 why questioning approach depends on CT of both the surveyor and the surveyed along with the approach used because in "real life" problems are rarely linear and root cause of problems are rarely the outcome of one single influence. The scenario also illustrates that asking Why five times could lead to fallacies in reasoning. In addition, when managers investigate using the term "Why", employees tend to feel threatened and may tell what the "boss/facilitator" wants to hear. Furthermore, this example illustrates that lack of CT for those who were asked can lead to wrong answers and wrong conclusions as well.

As such, 5 Whys alone is insufficient as a tool to identify root cause of problems or process' defects. Limiting the questioning to "why" under any situation deprives the researcher from a wealth of potentially related information that can be acquired by asking more questions such as those suggested by Browne and Keeley (2004, p. 13):

(1) What are the issues and the conclusions?
(2) What are the reasons?
(3) Which words or phrases are ambiguous?
(4) What are the value conflicts or assumptions?
(5) What are the descriptive assumptions?
(6) Are there any fallacies in the reasoning?
(7) How good is the evidence?
(8) Are there rival causes?

(9) Are the statistics deceptive?

(10) What significant information is omitted?

(11) What reasonable conclusions are possible?

Fundamental management considerations for CT in 5 Whys

There are numerous examples of catastrophic failures that occurred as a result of selective blindness on the part of senior management personnel. The Esso Longford gas explosion, the Chernobyl disaster, and the loss of both the Columbia and Challenger space shuttles are just few examples of such failures. In life, let alone business, people may see what they want to see, and ignore "evidence" that does not correlate with their own view of the world. In an interview with MSNBC, Drew Westen, director of clinical psychology at Emory University, said:

> Everyone from executives and judges to scientists and politicians may reason to emotionally biased judgments when they have a vested interest in how to interpret the facts (MSNBC, 2006).

Sanders (2002), argued that by ignoring the science of complexity and nonlinear thinking small companies are taking big companies by surprise. She wrote in the *Washington Post*:

> Linear thinkers tend to rely on past experience to travel from Point A to Point B. Nonlinear thinkers tend to look for changes since the last time they made the trip. A failure to recognize those changes is why blue-chip giants often get caught off guard by small, innovative companies such as Southwest Airlines, Starbucks, IKEA, Old Navy, DirecTV, Hotmail and NetBank (Sanders, 2002).

Consider the following wave, shown in Figure 1:

The consequences of how the two peaks and bottoms move in relation to each other dictate the holistic outcome of this dynamics. For example, if the wave moved with the same velocity, with other specific conditions, the same shape remains the same. But if the wave moved with conditions that would add the peaks up, the result would look totally different similar to that shown in Figure 2.

The challenge with internal corporate waves and/or in framing a question by a rigid "5 whys" is far more complex because while focusing on one wave, or one question, or one aspect, other waves or influences may inflict serious conditions and consequences. Some

Figure 1.
Wave in motion

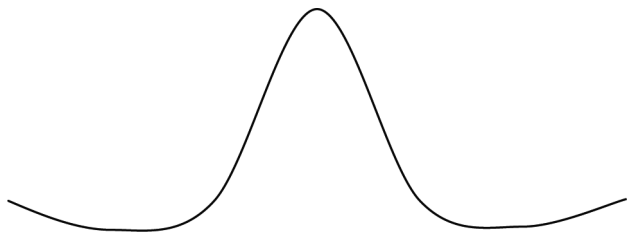

Figure 2.
Unified wave

critical corporate waves move under the influence of uncertainty and unpredictability that cannot be easily measured; let alone linearly understood. Thinking in a traditional linear manner based on the availability heuristic, the observer may conclude that nothing would change, and he/she would not predict that unified wave.

It is critical for the 5 whys methodology to understand and incorporate biases into its method. The intention is neither to ignore life experiences and strategies that worked nor to allow them to dictate the outcome; on the contrary, the intention is to produce a balancing act towards sustained improvements. Schön (1983) articulated such a possibility by saying: "Indeed, his (practitioner's) balancing act and his strategy of mystery and mastery are bound together in a system of knowing in practice" (Schön, 1983, p. 229) and "especially the artful inquiry by which they (practitioners) sometimes deal with situations of uncertainty, instability, and uniqueness." (Schön, 1983, p. 268).

5 whys' practitioners are invited to reflect in action, develop and grow a personal theoretical and practical repertoire of knowledge, and use the principles of complexity while considering the context of situations and related questions with a wide view about them. For practitioners, it is critical to translate sound judgment based on critical thinking within scientific methodologies into timely actions to maximize profitability and sustain success.

Conclusion

The Six Sigma approach, and its methods including 5 whys, has been applied to increase the overall performance of different business sectors. However, integrating the data-driven, structured Six Sigma processes into organizations has room for improvement. While recognizing the need for improvements in Six Sigma, some researchers suggested improving it using different technical philosophies. A main area of improvement, however, is in the integration of the principles of CT into the process of Six Sigma.

CT as a framework for thinking with its artistic and scientific capacities can prove invaluable for Six Sigma projects. This paper demonstrated that business improvement methodologies such as 5 Whys to identifying root causes of defects, business process variations, and other business problems are insufficient without CT because CT could guard the judgment from biases, bad data, wrong interpretation, and fallacies in reasoning. Furthermore, CT has the capacity to explore the context of situations, and provides a broad platform for understanding patterns, consequences, and risks. This may explain the mystery behind the wide variations between successes and failures in the initiation and implementation of Six Sigma initiatives across industries as employees trained on Six Sigma and Six Sigma consultants vary greatly in their CT capacities and life-experiences as witnessed by this author. Jim Phillips, chairman and executive director of FedEx Institute, recalls his conversation with Bill Gates: "In the early days I was having lunch with Bill Gates, and we were talking about how hard it was to find people, and he said he was having great success with philosophy students". They think logically (Sherard, 2002). While CT is critical to 5 whys, more research is needed to specifically incorporate CT in the basic training of Six Sigma and its methods including 5 whys.

According to a recent survey published by CNN, CT and problem solving were two of top five competencies hiring managers look for in employees. Technical proficiency, team building, and customer service were the other three (Castellini, 2006).

References

Alukal, G. (2007), "Lean *Kaizen* in the twenty-first century", *Quality Progress*, Vol. 40 No. 8, pp. 69-70.

Anbari, F.T. and Kwak, Y.H. (2004), *Success Factors in Managing Six Sigma Projects*, The George Washington University, available at: http://home.gwu.edu/~kwak/Six_Sigma_PMI_2004.pdf (accessed 4 December 2007).

Anthony, J. and Banuelas, R. (2002), "Key ingredients for the effective implementation of Six Sigma program", *Measuring Business Excellence*, Vol. 6 No. 4, pp. 20-7.

Antony, J., Douglas, A. and Antony, F.J. (2007), "Determining the essential characteristics of Six Sigma black belts: results from a pilot study in UK manufacturing companies", *The TQM Magazine*, Vol. 19 No. 3, pp. 274-81.

Ayad, A. (2005), "The cause and effect of my quality journey", *Quality Progress*, Vol. 38 No. 10, p. 83.

Best, J. (2001), *The Chronicle Review*, available at: http://chronicle.com/free/v47/i34/34b00701.htm (accessed 26 December 2006).

Bhuiyan, N. and Baghel, A. (2005), "An overview of continuous improvement: from the past to the present", *Management Decision*, Vol. 43 No. 5.

Boostrum, R. (1994), *Developing Creative and Critical Thinking: An Integrated Approach*, National Textbook Company, Lincolnwood, IL.

Brookfield, S.D. (1987), *Developing Critical Thinkers*, Open University Press, Milton Keynes.

Browne, M.N. and Keeley, S.M. (2004), *Asking the Right Questions*, Prentice-Hall, Englewood Cliffs, NJ.

Castellini, R. (2006), "More to see pay increase in 2006", *CNN*, January, available at: www.cnn.com/2006/US/Careers/01/04/cb.aol.survey/index.html (accessed 26 December 2006).

Ennis, R.H. (1985), "A logical basis for measuring critical thinking skills", *Educational Leadership*, Vol. 43 No. 2, pp. 44-8.

Facione, P.A. (1984), "Toward a theory of critical thinking", *Liberal Education*, Vol. 70, pp. 253-61.

Facione, P.A. (1990), *Executive Summary – Critical Thinking. A Statement of Expert Consensus for Purposes of Educational Assessment and Instruction*, California Academic Press, Millbrae, CA.

Goh, T.N. and Xie, M. (2004), "Improving on the Six Sigma paradigm", *The TQM Magazine*, Vol. 16 No. 4, pp. 235-40.

Halpern, D.F. (1996), *Thought and Knowledge: An Introduction to Critical Thinking*, 3rd ed., Lawrence Erlbaum Associates, Mahwah, NJ.

Kurfiss, J.G. (1988), *ASHE-ERIC Higher Education Report No. 2: Critical Thinking Theory, Research, Practice and Possibilities*, Association for Study for Higher Education, Washington, DC.

Linderman, K., Schroeder, R., Zaheer, S. and Choo, A. (2003), "Six Sigma: a goal – theoretic perspective", *Journal of Operations Management*, Vol. 21 No. 2, pp. 193-203.

McAdam, R. and Lafferty, B. (2004), "A multilevel case study critique of Six Sigma: statistical control or strategic change?", *International Journal of Operations & Production Management*, Vol. 24 Nos 5/6, pp. 530-49.

McPeck, J. (1981), *Critical Thinking in Education*, St Martin's Press, New York, NY.

Maleyeff, J. and Kaminsky, F.C. (2002), "Six Sigma and introductory statistics education", *Education + Training*, Vol. 44 Nos 2/3, p. 82.

Motorola Inc. (n.d. a), available at: www.motorola.com/content.jsp?globalObjectId=3071-5801 (accessed 4 December 2007).

Motorola Inc. (n.d. b), available at: www.motorola.com/content.jsp?globalObjectId=3074-5804 (accessed 4 December 2007).

MSNBC (2006), "Political bias affects brain activity", January, available at: www.msnbc.msn.com/id/11009379 (accessed 4 December 2007).

Paul, R. (1982), "Teaching critical thinking in the 'strong' sense. A focus on the self-deception, coordinating views and a dialectical mode of analysis", *Informed Logic Newsletter*, No. 4, pp. 2-7.

Rancour, T. and McCracken, M. (2000), "Applying Six Sigma methods for breakthrough safety performance", *Professional Safety*, Vol. 45 No. 10, pp. 29-32.

Sanders, I. (2002), "To fight terror, we can't think straight", *Washington Post*, available at: www.washingtonpost.com/ac2/wpdyn?pagename=article&node=&contentId=A30968-2002May4&notFound=true (accessed 4 December 2007).

Schön, D. (1983), *The Reflective Practitioner*, Basic Books, New York, NY.

Sherard, S. (2002), "Technology center to serve as hub for U of M academics", *Memphis Business Journal*, available at: www.bizjournals.com/memphis/stories/2002/07/22/story3.html (accessed 4 December 2007).

Siegel, H. (1991), "The generalizability of critical thinking", *Educational Philosophy and Theory*, Vol. 23, pp. 18-30.

Siviy, J., Lynn Penn, M. and Harper, E. (2005), "Relationships between CMMI and Six Sigma", Carnegie Mellon University, available at: www.sei.cmu.edu/pub/documents/05.reports/pdf/05tn005.pdf (accessed 4 December 2007).

Watson, G. and Glaser, E.M. (1980), *Watson-Glaser Critical Thinking Appraisal Manual*, The Psychological Corporation, San Antonio, TX.

Waxer, C. (n.d.), "Top ten Six Sigma black belt candidate qualities", available at: www.isixsigma.com/library/content/c030317a.asp (accessed 4 December 2007).

Further reading

Erwin, J. and Douglas, P. (2000), "Six Sigma's focus on total customer satisfaction", *The Journal for Quality and Participation*, Vol. 23 No. 2, pp. 45-9.

Lee-Mortimer, A. (2006), "Six Sigma: a vital improvement approach when applied to the right problems, in the right environment", *Assembly Automation*, Vol. 26 No. 1, pp. 10-17.

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