Implementation: The DMAIC Improvement Process

Alessandro Anzalone, Ph.D.
Hillsborough Community College, Brandon Campus

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Introduction

Recently, a manufacturer was facing the kind of problem that most companies want to face: an increase in orders was overloading the production scheduling process. Customers could not find out promised dates of delivery order status, etc. The whole order entry process encompassed many functions (an engineering review, purchasing status, etc.) that affected production capacity and lead time. This company was concerned about customer retention: customer satisfaction was well below a six sigma level. Immediate action was needed, but their key question was whether process improvements could speed up the flow or if they needed to start hiring more staff.

Introduction

Another company had a much different situation, but faced similarly dire consequences. Their manufacturing process relied on the precise alignment of high-frequency communication diodes, which are about the diameter of a pin. Because these diodes are so tiny, it's easy for them to land on an edge, creating a defective connection and thus becoming scrap. The yield at the key workstation was about 87% (about 2.7 sigma). This company wanted to be at six sigma levels, because that would mean tremendous savings in terms of scrap, rework, cost, and capex investment.

Introduction

At first glimpse, these process improvement challenges sound quite different. One company is dealing with a transactional process where the goal is to quickly and accurately transfer information among groups; the, other is concerned with highly specialized technology at a single workstation. Yet both of these situations can be (and were) improved using the same basic model of Define-Measure- Analyze-Improve-Control, known more familiarly as DMAIC.

Introduction

But it was more than just having a model that made improvement possible. What these companies had in common was the knowledge of when to use the Lean Six Sigma tools and when to call for additional firepower. The results?

- ✓ The order fulfillment challenge was solved by use of some simple process tools, which led to an improvement in cycle efficiency from 7% to 22%. Since the company could handle more work much more quickly, they did not need to hire any additional staff. More details are included at the end of this chapter.
- ✓ The diode challenge was met through the application tool known as mistake proofing. The loss of yield at this step fell to about 3 per million, compared with the initial 130,000 per million failure rate.

Introduction

These disparate applications demonstrate that the Lean Six Sigma DMAIC process provides the framework for solving **any** process problem.

The Context of Improvement

Before getting into the specifics of DMAIC, it will help if you try to imagine the context within which the process and its tools will be used.

At the broadest level, the corporate champion, business unit managers, business unit champions, and others will identify numerous opportunities that are clearly linked to customer needs and core value streams and that have high potential for contributing to shareholder value. Once approved, these opportunities are assigned to specific black belts and their teams by the business unit champion (working closely with the business unit manager). In turn, these teams are expected to apply the Lean Six Sigma improvement process to deliver on the projected benefits.

The Context of Improvement

The highest-priority projects are most often critical-to-quality issues, such as the leaking brake hose fittings example discussed earlier in the course: in that case study, the leaking hoses affected the relationships with and retention of customers and the good reputation of the company. In other cases, the opportunity may be in the form of internal failures or high-cost problems that affect the bottom line rather than the customer. These Hidden Factory costs are completely valid for projects even though they are not related to customer critical-to-quality issues. In fact, this is a very common type of Lean Six Sigma project. Attacking these opportunities usually results in a simultaneous and dramatic reduction in variation, cost of quality, and cycle time.

The Context of Improvement

Transitioning to the Black Belt Team

Part of becoming a Lean Six Sigma organization means incorporating a Lean Six Sigma mentality into every aspect of your work, not just what happens in a designated project. And part of Lean Six Sigma is managing the boundaries between process steps, not just what happens within each step. Therefore, as you look at transferring projects from the initial scoping work done by champions and/or managers to an assigned project being handled by a black or green belt team, there are several process boundary issues you will need to address. For example, you will need to document what information has already been used to bring the project idea this far already and what issues and/or assumptions you expect the black belt or team to investigate further.

The Context of Improvement

Between the selection of projects and team implementation there are several key steps:

- ✓ Each business unit champion must decide which opportunities will create the greatest value in the least time and then assign a black belt or green belt to each selected project.
- ✓ Once those assignments are made, the black belts become involved in confirming the goals and generating data. Although the responsibility for project selection should initially lie with the champion, the black belt can use this information to validate the business opportunities to the champion and provide direction to the green belts and teams.

The Context of Improvement

The confirmation work requires close analysis of the data, discussion with the process owner, and ultimately good judgment when the data is not clear—cut. It can he relatively simple if you have data that confirms the problem is critical-to-quality and existing records that document customers' complaints and/or existing data that can be plotted to expose undesirable trends. In other situations, confirmation might require extensive investigative work, which might be conducted by a black belt team rather than the unit champion or a master black belt.

The DMAIC Process and Its Tools

No matter how you handle the transition from a selected project idea to an active project, at some point the black belt and his or her team will take over. Their job is to deliver on the opportunity. And *the best way to do that is almost always to follow a structured improvement method that leads them logically from a definition of the problem to implementing solutions that address the underlying causes. One of the most widely used improvement models is DMAIC*:

Define: Confirm the opportunity and define the boundaries and goals of the project.
Measure: Gather data to establish the "current state," what is actually going on in the workplace with the process as it works today.
Analyze: Interpret the data to establish cause-and-effect relationships.
Improve: Develop solutions targeted at the confirmed causes.
Control: Implement procedures to make sure the improvements! gains can be sustained.

The DMAIC Process and Its Tools

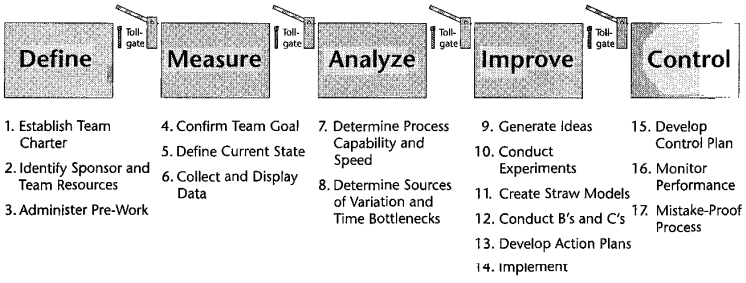


Figure 10-1. The DMAIC process

The DMAIC Process and Its Tools

Tollgate Reviews

One other feature of the DMAIC overview in the preceding figure you may have noticed is the "tollgate" that occurs between each major phase and the next. These tollgates represent critical stages in each process, where the ongoing project is linked back to the corporate goals. During these reviews, the appropriate managers, master black belts, and champions have a chance to

- ✓ Listen to a team present its work.
- ✓ Ask questions to ensure that team is staying focused on the CEO's priorities.

The DMAIC Process and Its Tools

Tollgate Reviews

The purpose of these reviews is manyfold. The managers and Lean Six Sigma resources need to

- ✓ Ensure that the project is on track toward the original goals.
- ✓ Evaluate whether the team seems capable of performing the work necessary to deliver on the potential benefits of this project. (If not, the answer is not to abandon the team, but to determine what additional training and coaching/mentoring will help them fill any gaps.)
- ✓ Help guide the team as appropriate by suggesting particular tools, sources of information, techniques, etc., that they may find helpful.
- ✓ Identify organizational barriers to the team's success and develop strategies for intervening on the team's behalf.
- ✓ Perform critical time checks to keep projects moving along on schedule. (The reviews serve as a tool for champions/sponsors to keep things flowing.)

The DMAIC Process and Its Tools

Process	Activity	Tools	
Define	1. Establish Team Charter 2. Identify Sponsor and Team Resources 3. Administer Pre-Work	Project ID Tools Project Definition Form NPV/IRR/DCF Analysis	PIP Management Process SSPI Toolkit
Measure	4. Confirm Team Goal 5. Define Current State 6. Collect and Display Data	SSPI Toolkit Process Mapping Value Analysis Brainstorming Voting Techniques Pareto Charts Affinity/ID	C&E/Fishbones FMEA Check Sheets Run Charts Control Charts Gage R&R
Analyze	7. Determine Process Capability and Speed 8. Determine Sources of Variation and Time Bottlenecks	C_p and C_{pk} Supply Chain Accelerator Time Trap Analysis Multi-Vari Box Plots Marginal Plots Interaction Plots	Regression ANOVA C&E Matrices FMEA Problem Definition Forms Opportunity Maps
Improve	9.Generate Ideas 10. Conduct Experiments 11. Create Straw Models 12. Conduct B's and C's 13. Develop Action Plans 14. Implement	Brainstorming Pull Systems Setup Reduction TPM Process Flow Benchmarking Affinity/ID DOE	Hypothesis Testing Process Mapping B's and C's/Force Field Tree Diagrams Pert/CPM PDPC/FMEA Gantt Charts
Control	15. Develop Control Plan 16. Monitor Performance 17. Mistake-Proof Process	Check Sheets Run Charts Histograms Scatter Diagrams	Control Charts Pareto Charts Interactive Reviews Poka-Yoke

Table 2-1. Lean Six Sigma tool set

The DMAIC Process and Its Tools

Boundaries and Iterations

Note that the outcome of each tollgate is confirmation that the team has met the requirements of the phase and that it is OK to continue work in the next DMAIC phase. It is not a blanket approval for the team to plow through to Control unchecked.

But while tollgate reviews acknowledge the transition of a team from one phase to another, don't expect the boundaries between phases to be clean-cut. Often the team must delve into subsequent phases to complete the current phases. The reverse is also true. It is not uncommon to revisit and revise work done in an earlier phase because of what is learned in later phases. By dividing the reviews/approvals into stages, Lean Six Sigma recognizes that (a) teams will be gathering information that may influence the feasibility or projected impact of a project and (b) other business circumstances arise that may cause you to shift priorities. Your responsibility as someone guiding the teams is to make a call about whether this use of resources is still appropriate for your organization at this time.

A Walk Through DMAIC

Define

The purpose of Define is for the team to *clarify the goals and refine their understanding of the potential value of a project*. As noted above, you need to determine for your organization who will do what portion of this Define work. In any event, someone needs to confirm the magnitude of the value opportunity in a given value stream, check the assessment of resources required, and develop a plan for how this project will be implemented using DMAIC.

Define Tools. The tools associated with the Define stage primarily serve the function of "information documentation." The team needs a clear written charter that documents the business case for working on this project, the expected returns, team membership, the project sponsor, and so on.

A Walk Through DMAIC

Define

Define Tollgate Review. The final step in the Define phase should be a tollgate meeting between a team (led by a black or green belt) and a guiding team, usually composed of the unit manager, unit champion, master black belt, and process owner (if appropriate). At this stage, the review should focus on the following points:

- ✓ How the project definition has been altered or refined (if at all)
- ✓ What evidence exists to confirm the value opportunity and resource requirements
- ✓ The team's plans for conducting the Measure stage

A Walk Through DMAIC

Measure

The purpose of the Measure phase is gather data that describes the nature and extent of the problem. As such, many of the data-collection tools will be used first in this phase, with subsequent data collection used to confirm improvements in later steps.

Measure Tools. There is a broad range of data and process tools used in Measure, including

- ✓ Brainstorming techniques, to encourage creativity.
- ✓ Process mapping tools, to document how the process works today.
- ✓ Numerous data tools, to collect and display different types of data.

A Walk Through DMAIC

Measure

Measure Tollgate Review. Perhaps no portion of the DMAIC process is as variable as the Measure phase and its tollgate review. The reason is simple: there is no predefined sequence or set of tools that each team must use. Rather, teams must apply their logic and knowledge to create their own path and select tools appropriate to their particular challenges.

In the Measure tollgate, the reviewers have their own challenge: to trace the logic the team pursued in deciding what data to collect and where that data led them. They should be using such investigative statements and questions as the following:

- ✓ “Explain to me where you got that data.”
- ✓ “How is your measurement system?”
- ✓ “What lessons did you take away from that data chart?”
- ✓ “Show me your cause-and-effect diagram. How did you decide which of these causes to pursue with data collection? What data did you collect and what did you find out?”
- ✓ “Why did you decide to collect that particular kind of data?”

A Walk Through DMAIC

Analyze

As you can tell, by the time a team reaches the Analyze phase, it should have a lot of data and information gathered in the Measure phase. *The goal here is to make sense of all that information and to track down the cause-and-effect relationships that produce the targeted defects, process delays, and so on.*

By the end of the Measure phase of DMAIC, the team should have a much clearer picture of exactly what is going on in the process and which steps are contributing the most to delays, quality problems, etc. In Analyze, the goal is to develop knowledge that will help a team use its time in Improve most effectively—where they will want to develop countermeasures that address the underlying causes of problems linked to customer needs and cycle efficiency. Therefore, much of the Analyze phase is devoted to exploring the relationships between input and output variables.

A Walk Through DMAIC

Analyze

Analyze Tools. It should be noted that the Analyze tools are often used to analyze historical data—that is, data that already exists. Using existing data is still appropriate because you are looking for "clues" that will help you determine potential causes of problems. Historical data is an obvious source of potential "clues."

Sometimes these "clues" can give us breakthroughs; but you have to be careful because historical data can be laced with many problems and inherently has some weaknesses. (When I was in Japan, one of my hosts exclaimed: "Don't use dead data!") When we simply can't get the information we need from historical data or there is too much risk of misinterpretation, we use some "power tools" that appear in Chapter 11 (such as Design of Experiments, for statistically determining true cause-and-effect relationships).

A Walk Through DMAIC

Analyze

Analyze Tollgate Review. The Analyze tollgate continues the theme of emphasizing linkages:

- ✓ What causes is the team going to target in the Improve phase?
- ✓ Why did they focus on those causes? What are the links to the data/conclusions reached during the Measure phase?
- ✓ What other potential causes did the team investigate? How do they know those were not actual causes?
- ✓ What data do they have that links the targeted cause to the problem under investigation?
- ✓ What data indicates that improving the identified cause(s) will have the desired impact on the targeted improvement measure (e.g., how do they know that addressing the cause will reduce lead time)?

A Walk Through DMAIC

Improve

Throughout most of Measure and Analyze, a team is challenged to think creatively and inclusively in deciding what potential causes to investigate, what data to collect, how to display that data, and how to interpret its messages. In the Improve phase, the team has to switch from thinking broadly to a focused, practical mindset: now that they know what the causes are, what specific changes can they make in the process to counteract those causes and what methods will achieve the desired effect?

Improve Tools. Of all the tool sets associated with DMAIC, those most commonly used in Improve represent perhaps the broadest mix of both Lean and Six Sigma tools. Pull systems, setup reduction, and Total Productive Maintenance, for example, are traditional Lean tools used in Improve to eliminate work-in-process and time delays; tools such as Design of Experiments and process mapping represent approaches inherited from the Six Sigma/quality improvement tradition.

A Walk Through DMAIC

Improve

Improve Tollgate Review. Predictably, the Improve tollgate picks up where the Measure tollgate left off in pursing the logical links between causes and actions, plus there is a new focus on implementation:

- ✓ What countermeasures did the team develop?
- ✓ How did they decide which ones to implement (e.g., the criteria used to select among options, pilot tests used to see whether the changes had the desired effect)?
- ✓ How do they know that those measures would affect the causes confirmed in Measure?
- ✓ What happened when the countermeasures were first put into practice? What changes did the team make to refine the improvements?

A Walk Through DMAIC

Control

The purpose of Control is to make sure that the gains made will be preserved, until and unless new knowledge and data show that there is an even better way to operate the process. The team must address how to hand off what they learned to the process owner and ensure that everyone working on the process is trained in using any new procedures.

Control Tools. The tools used in Control are focused on implementation: how to document the new procedures, what data to collect regularly on the process to monitor performance, and so on. In many cases, the team will be using tools used earlier in DMAIC (such as control charts), but switching the emphasis to “ongoing monitoring” instead of “cause investigation.”

A Walk Through DMAIC

Control

Control Tollgate Review. The Control tollgate is both a formal closure to the project and a forum where the process owners and other key managers can see what it will take to make sure the process doesn't backslide to its former, unacceptable performance. Four key elements of the review are:

- ✓ Measures: What indicators will be tracked to evaluate process performance?
- ✓ Monitoring: Who will collect data on the indicators? Do they know what to do depending on what the data shows them?
- ✓ Sustainability: What measures have been taken to ensure that all process staff/operators are trained in the new procedures and that any new staff will be similarly trained?
- ✓ Leveraging the Learning: What best practices were established in the project? How are they being documented? What other lessons did the team learn? How is this information going to be shared?

Developing Focus: The DMAIC Filter

In the following diagram, KPIV stands for key process input variables or, in common Six Sigma terminology, the process factors (X's) that affect the process output (Y). When a project begins, the KPIVs are really not "key" variables yet; they are raw ideas for improvement, the potential factors that might have a big influence on quality and/or time. As depicted in the figure, what happens in a DMAIC project is that a team starts with a defined opportunity. At that point, there are lots of ideas for potential improvement—everyone on the team will have their own ideas about what's causing the problem with the output. By using the tools and logically linking causes and effects, the team gradually narrows its focus to those ideas or KPIVs that are most critical or have the largest effect on output. The rest of the KPIVs are essentially "filtered" out as the team collects data showing they are unimportant in terms of CTQ quality or improving cycle efficiency.

Developing Focus: The DMAIC Filter

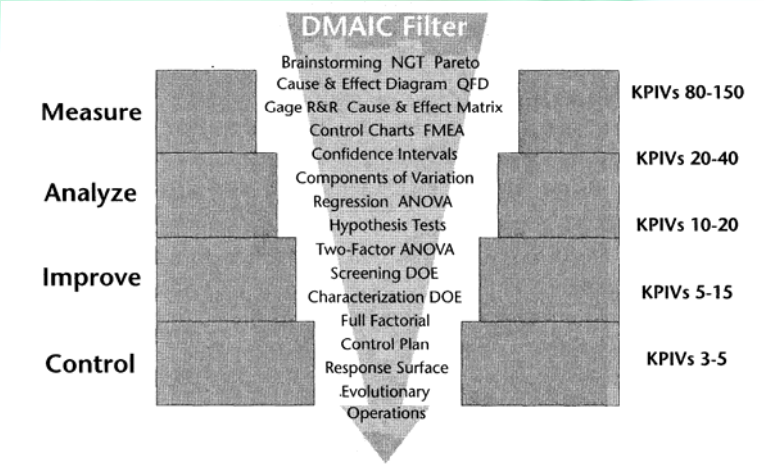


Figure 10-2. The DMAIC filter

Big Gains with Simple Tools: Two Examples

Here is one example of how some of the simple tools described above can nevertheless produce impressive results. At the beginning of this chapter, you read of a company that was facing the imminent need to add personnel to keep up with the purchasing load. One of the first steps they took was to map the flow; as expected, it showed a lot of non-value-added steps. Figure 10-3 shows the original process flow and what steps were taken to improve each type of problems:

- ✓ Light gray symbols are non-value-added steps that were subsequently eliminated.
- ✓ Black symbols are steps that were reduced in terms of time.
- ✓ Dark gray symbols are steps that were moved to a more logical flow elsewhere.

Big Gains with Simple Tools: Two Examples

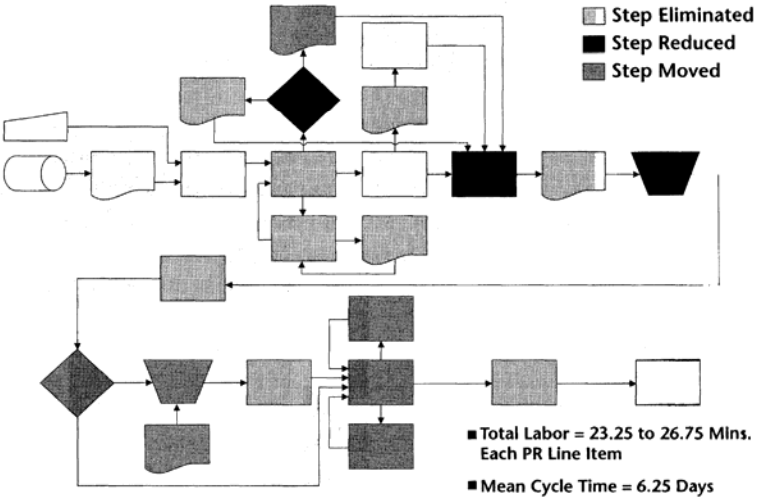
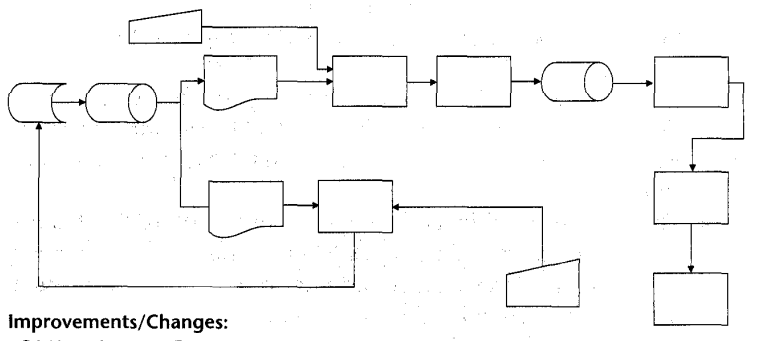


Figure 10-3. Pre-improvement flowchart

Big Gains with Simple Tools: Two Examples



Improvements/Changes:
- QA Notes Input Up-Front
- Electronic Approvals
- Materials Budget Data Provided to Buyer
- Configuration Letter Field Added to OMS
- Drawings Acquired by Procurement

Total Labor = 7.5 Mins. Each PR Line Item

Figure 10-4. New process flowchart

Big Gains with Simple Tools: Two Examples

The results were amazing. The number of steps in the process was reduced from 21 to 7. With a simpler, more streamlined process, the company did not have to hire additional people, achieving savings of $240,000 per year. Process lead time was reduced by 72% and the cycle efficiency increased from 7% to 22%.

How were such gains possible? One of the most important improvement opportunities in most organizations is the fact that few non-manufacturing processes have been mapped! That is, there is no single document that shows all the steps in how the work flows. Simply mapping that flow opens people's eyes to low-hanging fruit that can he picked to improve process speed.

In addition to lacking any form of process map, organizations generally have very little data. When a modicum of data is collected to build a Pareto chart of delay time, for example, immediate solutions become apparent.

Big Gains with Simple Tools: Two Examples

Let's look at another example. One client was doing a poor job of responding to customer inquiries. Should they hire more people to do a better job? This would be equivalent to putting more machines and people in a plant in hopes of speeding up deliveries—it won't work. Remember the Third Law of Supply Chain Acceleration: overall process lead time is directly proportional to the number of "things in process."

Given this knowledge, the client knew exactly what to measure: how much work there was in process! They discovered they received more than 12,000 requests per year, which consumed 6,000 hours of employee time. It was estimated that $350,000 was lost each year due to customer irritation, not even counting the lost follow-on business.

Big Gains with Simple Tools: Two Examples

The company then took the following steps:

- ✓ They divided the process into three major chunks:
  - ✓ Phase 1—Inside Sales receives customer inquiry and requests information from Production Control.
  - ✓ Phase 2—Production Control provides response to Inside Sales request.
  - ✓ Phase 3—Inside Sales provides final response to Customer.
- ✓ They implemented an expedite log sheet to monitor cycle time for each phase with SAP Workflow created (SAP in this case) to control process.
- ✓ They determined Phase 1, which comprised 60.5% of the total cycle time, to be a "Pareto delay" (accounting for the majority of delay time). Along with continuing to monitor the process, they assigned dedicated inside sales reps to handle expedited requests, developed strict guidelines for handoffs, and provided training in the expediting process.

Big Gains with Simple Tools: Two Examples

Results:

- ✓ Total cycle time was reduced from an average of 5.8 days to 1.5 days.
- ✓ They expect $267,500 incremental sales and $83,300 labor cost reduction in the first year.
- ✓ Incremental sales and labor savings will result in $147,000 operating income.

This improvement required only one black belt for four months, with the assistance of 10 people from within the process who devoted about 10% of their time.

Implications for Black Belt Training

As you learn more about DMAIC and its tools, keep in mind the following advice:

- First, it is important to establish a standard improvement process in your black belt training. DMAIC, the process described here, is currently the most common of these processes, but there are other, equally valid models you may already be using. The key point is to make it a standard process that everyone uses or you'll soon be caught in a quagmire of conflicting methods and approaches.

- Second, give priority in black belt training to the simpler tools that teams are most likely to need and use; reserve training in the advanced or more specialized tools (such as those described in the next chapter) to teams that have a demonstrable need for them or for black belts and master black belts who want to cultivate their knowledge in those tools. (One recent Six Sigma book spent 640 pages on tools likely to be used by 10% of black belts at most, leaving just 160 pages for tools useful to the other 90%.)

Implications for Black Belt Training

- Last, it isn't necessary for line managers, executives, or perhaps even champions to understand the ins and outs of all the Lean Six Sigma tools. However, they will be unable to guide a team through offline coaching and the formal tollgate reviews if they are completely ignorant. You will therefore probably want to adapt some elements of the black belt curriculum to provide awareness training for those who need some knowledge of these new methods and tools, but don't have to apply them themselves.

References

1. Michael George, Lean Six Sigma : Combining Six Sigma Quality with Lean Production Speed, McGraw-Hill, first edition , 2002, ISBN-13: 978-0130176158.