CLIMBING
THE MOUNTAIN

GREEN BELT
COURSEWARE

LSSA
LEAN
(SIX SIGMA)

MINDSET, SKILL SET & TOOL SET

H.C. THEISENS

Van Haren
PUBLISHING

LSSA Lean (Six Sigma) – Green Belt Courseware

Colophon

Publisher about the Courseware

The Courseware was created by experts from the industry who served as the author(s) for this publication. The input for the material is based on existing publications and the experience and expertise of the author(s). The material has been revised by trainers who also have experience working with the material. Close attention was also paid to the key learning points to ensure what needs to be mastered.

The objective of the courseware is to provide maximum support to the trainer and to the student, during his or her training. The material has a modular structure and according to the author(s) has the highest success rate should the student opt for examination. The Courseware is also accredited for this reason, wherever applicable.

In order to satisfy the requirements for accreditation the material must meet certain quality standards. The structure, the use of certain terms, diagrams and references are all part of this accreditation. Additionally, the material must be made available to each student in order to obtain full accreditation. To optimally support the trainer and the participant of the training assignments, practice exams and results are provided with the material.

Direct reference to advised literature is also regularly covered in the sheets so that students can find additional information concerning a particular topic. The decision to leave out notes pages from the Courseware was to encourage students to take notes throughout the material.

Although the courseware is complete, the possibility that the trainer deviates from the structure of the sheets or chooses to not refer to all the sheets or commands does exist. The student always has the possibility to cover these topics and go through them on their own time. It is recommended to follow the structure of the courseware and publications for maximum exam preparation.

The courseware and the recommended literature are the perfect combination to learn and understand the theory.

-- Van Haren Publishing

Other publications by Van Haren Publishing

Van Haren Publishing (VHP) specializes in titles on Best Practices, methods and standards within four domains:

- IT and IT Management
- Architecture (Enterprise and IT)
- Business Management and
- Project Management

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Topics are (per domain):

IT and IT Management	Enterprise Architecture	Project Management
ABC of ICT	ArchiMate®	A4-Projectmanagement
ASL®	GEA®	DSDM/Atern
CATS CM®	Novius Architectuur	ICB / NCB
CMMI®	Methode	ISO 21500
COBIT®	TOGAF®	MINCE®
e-CF		M_o_R®
ISO/IEC 20000	**Business Management**	MSP®
ISO/IEC 27001/27002	*BABOK® Guide*	P3O®
ISPL	BiSL® and BiSL® Next	*PMBOK® Guide*
IT4IT®	BRMBOK™	Praxis®
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ITIL®	eSCM	
MOF	IACCM	
MSF	ISA-95	
SABSA	ISO 9000/9001	
SAF	OPBOK	
SIAM™	SixSigma	
TRIM	SOX	
VeriSM™	SqEME®	

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CONTENT

Timetabel

Skillset	Module	Content / Topics
DAY 1		
-	Introduction	Introduction and learning objectives
U1.E1.PC1	World Class Performance	Continuous Improvement history
-		Continuous Improvement values and principles
U1.E1.PC2		Discussion: 8x Waste in organization
-		Discussion: principles in organization
U1.E1.PC3		Continuous Improvement Maturity Model
U1.E1.PC4		Continuous Improvement roles and responsibilities
U1.E2.PC1	Customer value (VOC & CTQ)	Voice of the Customer (VOC)
U1.E2.PC2		Critical to Quality (CTQ) & Exercise
U2.E1.PC1,2	Policy Development	Competitive strategies (Operational Excellence)
		True North, Transformation roadmap
-	Lean simulation	Lean Simulation Game (round 1)
DAY 2		
-		Recap
U2.E1.PC3	Policy Development	COPQ, Hard & Soft Benefits
U2.E2.PC1	Policy Deployment	Management of Change; Stakeholder analysis
-		Exercise: stakeholder analysis
U2.E3	Coaching and Intervision	Learning organization, coaching and intervision
U3.E1.PC1	Managing a project	Project selection
U3.E1.PC2		Project charter, SMART
-		Exercise: problem description projects participants
U3.E1.PC3,4,5		Project team, planning and execution
U3.E2	Process Improvement roadmaps	PDCA
-		8D, Scrum, DMAIC roadmaps
-		Evaluation and Home work
DAY 3		
-		Recap
U4.E1.PC1	Professional work environment	Organized Work environment (5S)
-		Exercise: 5S
U4.E2.PC1,2	Standardized Work	Standard Operation Procedures
U4.E3.PC1	Quality Management	Quality Management System
U5.E1.PC1	Visual management	Visual Workplace
U5.E2.PC1,2	Performance management & Kaizen	Standup meetings, Kaizen, RCA
-		Exercise: KPI's & RCA
U5.E3.PC1	Basic Quality tools	Brainstorming, Root cause analyse, 5x-Why
-		Exercise: RCA & 5 Why
-	Lean simulation	Lean Simulation Game (round 2)
DAY 4		
-		Recap
U5.E3.PC2	Basic Quality tools	Visualization of data (7x)
U6.E1.PC1,2	Process mapping	SIPOC, Process Flow diagram, Swimlane
-		Exercise: mapping of a process
U6.E2	Performance metrics	Lean metrics (Takt time, Cycle time etc)
-		ppm, DPU, DPMO, Yield
U6.E3	Basic statistics	Data types and Measurement scales
		Data collection tools
		Descriptive statistics
U6.E4	Value Stream analysis (VSM)	Value Stream Mapping (Current State), VA, NVA
U6.E5	Reducing Muda (Waste)	Waste identification and elimination
U6.E6	Reducing Muri (Overburden)	Flow, Work balancing, resource management

DAY 5

-		Recap
U6.E7	Reducing Mura (Unevenness)	Pull, Kanban, FIFO, Pacemaker, TOC, CONWIP, One Piece Flow
		Quick Change Over (SMED)
-		Evaluation and Home work
U6.E8	Value Stream Improvement	Value Stream Mapping (Future State)
-		Lowering water level
U6.E9.PC1	Process and Quality control	FTR, Poka Yoke
U6.E9.PC2,3		pFMEA, Control Plan
-		Exercise: FMEA making pancakes
U6.E10	Total Productive Maintenance (TPM)	TPM principles and OEE
-		Sample exam
-		Evaluation

PART I

LEAN & SIX SIGMA GREEN BELT

SKILL SET

INTRODUCTION

Within the domain of Lean and Six Sigma individuals can be trained and certified at different levels. The levels are listed in the Table below.

Belt level	Level
Lean Yellow Belt	Awareness
Lean Six Sigma Yellow Belt	Awareness
Lean Six Sigma Orange Belt	Foundation
Lean Green Belt	Practitioner
Lean Six Sigma Green Belt	Practitioner
Lean Black Belt	Expert
Lean Six Sigma Black Belt	Expert
Master Black Belt	Master

Table 1 - Overview of Lean Six Sigma Belt levels

The LSSA - Lean Six Sigma Academy® was established in September 2009 with the objective to develop an international recognized certification scheme for all Lean and Six Sigma Belt levels. For each level the LSSA Exam Board has developed Skill sets with clear criteria for skills and competences. These Skill sets specify which of the overall Lean and Six Sigma techniques are expected to be included within certain Belt level competencies.

The LSSA Green Belt Skill sets describe the assessment criteria for the theoretical and practical exam. Candidates are required to pass both elements to be recognized as a certified Lean or Lean Six Sigma Green Belt. Passing the theoretical exam is a pre-requisite to subscribe for the practical exam. The Green Belt certification can be achieved independently. There are no pre-requisites for certification and therefore does not require any prior completion of any other Belt(s). After completion of the Lean Six Sigma Green Belt you can subscribe for the Lean Six Sigma Black Belt scheme.

Lean Six Sigma training is provided by a global network of 'Accredited Training Organizations' (ATOs). These ATOs provide training programs that are aligned to the LSSA Skill sets. Examination is provided through the LSSA directly or through APM Group Limited. The exams are open to all. Individuals can apply directly or sign up via one of the ATOs. It is recommended that candidates receive training through an ATO to prepare for certification. On the website you will also find information about how you can claim your Digital badge.

Figure 1 – LSSA digital badge

THEORETICAL ASSESSMENT CRITERIA

The assessment criteria for the theoretical exam are as follows:

- For Lean Green Belt:
    - The theoretical exam consists of 40 multiple choice questions.
    - The duration of the exam is 120 minutes.
    - The pass mark is set at 63% (25 marks or more required to pass).
- For Lean Six Sigma Green Belt:
    - The theoretical exam consists of 60 multiple choice questions.
    - The duration of the exam is 180 minutes.
    - The pass mark is set at 63% (38 marks or more required to pass).
- The exam is Open book, where a maximum of 2 books are allowed.
- A calculator or statistical software (e.g. Minitab) is allowed.
- You must be able to identify yourself with photographic ID.

If you pass you will receive a 'Partial certificate' from the LSSA that states you passed the theoretical exam. You will receive the 'Full certificate' if you pass the practical assessment within a maximum period of three years after passing the theoretical exam.

PRACTICAL ASSESSMENT CRITERIA

The assessment criteria for the practical part include the submission of two practical projects that meet the following criteria:

- For Lean Green Belt: one successful project at CIMM level-III (or higher).
- For Lean Six Sigma Green Belt: one successful project at CIMM level-IV or higher.
- The project should have a significant impact to the organization (e.g. a financial impact of €20,000,- or a relevant CTQ has substantially been improved).
- The project must follow the DMAIC or DMADV roadmap.
- The templates for submitting the project can be downloaded from the LSSA website (max. of 25 pages).
- The project should be signed off by the Champion to declare that the project has been carried out professionally and that objectives have been achieved and sustainable.
- A single Green Belt can submit the project for certification in its role of project manager.
- The project must be submitted within three years after passing the theoretical examination.

The project will be assessed by a Master Black Belt, assigned by the LSSA. The criterion listed in Appendix B will be applied. It is advisable to use these criteria during your project. It is additionally strongly advised that the submission is also checked by an internal (Master) Black Belt or coach.

- A 'Pass' result will be awarded when all criteria are addressed within the submission and are deemed to be 'Correct' or 'Not Applicable'.
- The submission must contain a justification of any criteria that is claimed to be 'Not Applicable'.

The result of the practical assessment will be either Pass or Fail. No score will be given. In the event of a 'Fail' result, brief guidance will be given on those criteria that are deemed 'Missing' or 'Incorrect'. Subsequently, a single retake resubmission is allowable.

CONTINUOUS IMPROVEMENT MATURITY MODEL (CIMM)

CIMM summarizes best practices and techniques of different methodologies in one framework, for different stages of maturity. The CIMM framework describes five consecutive stages: Creating a solid foundation, Creating a continuous improvement culture, Creating stable and predictable processes, Creating capable processes and Creating future-proof processes. Within Lean only the first three levels apply. For Six Sigma all five levels apply.

For each instrumental technique in the CIMM framework, it is possible to indicate the associated desired behavior. The CIMM framework identifies a number of behaviors for each improvement technique, which helps determine whether or not the implementation of the technology in question will be a success and results in a lasting impact.
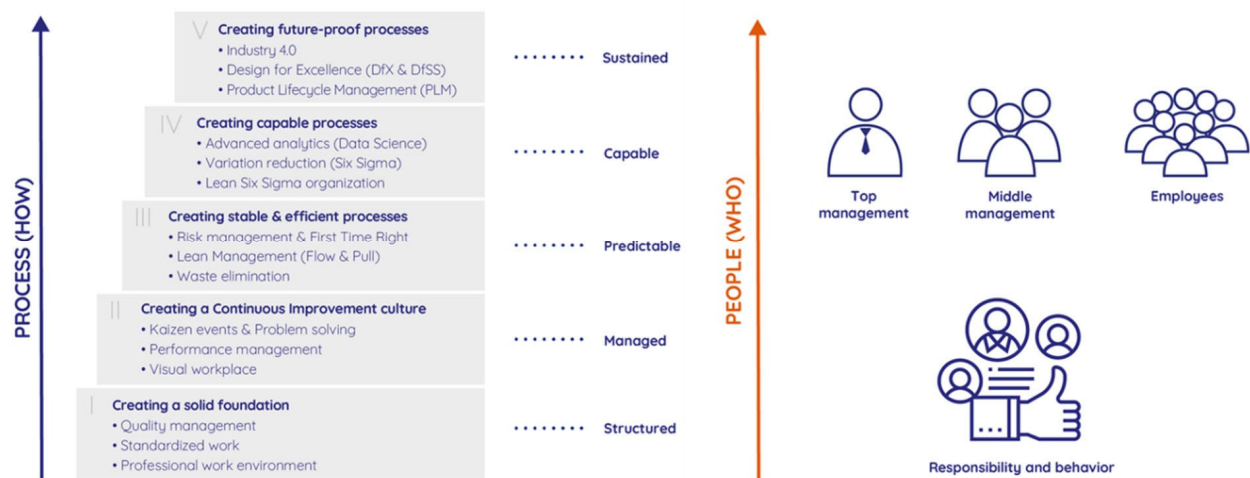

Figure 2 – CIMM Process (HOW) and People (WHO)

The following chapters describe the theoretical skill set elements. The structure consists of a number of 'Units', 'Elements' and 'Performance Criteria'.

- **Unit:** The skill set areas are called 'Unit'. The chapters in the book 'Climbing the Mountain' reflect the 'Units' described in this skill set.
- **Element:** Each 'Unit' consists of a number of 'Elements'. The sections]in each chapter of the book 'Climbing the Mountain' reflect the 'Elements' in this skill set.
- **Performance Criteria:** Each 'Element' consists of a number of 'Performance Criteria' and each 'Performance Criteria' has an explanation. These describe the tools, techniques and competencies that are required to be achieved by the Belt. A 'Cognitive Level' has been assigned to each 'Performance Criteria' according to Bloom's Taxonomy [Appendix A].

Attendees that are preparing for Lean Green Belt certification should a able to measure up to the first six units (U1. till U6.). Attendees that are preparing for Lean Six Sigma Green Belt certification should a able to measure up to the seventh unit (U1. till U7.).

U1.   WORLD CLASS PERFORMANCE

The Unit 'World Class Performance' reviews the general philosophy of continuous improvement. It discusses the overview of different process improvement methods and the history of the most important methodologies. It also explains why continuous improvement is important.

E1. CONTINUOUS IMPROVEMENT

The Learning Element 'Continuous Improvement' reviews the history, values and principles of the most common process improvement methodologies. Also, the culture within a continuous improvement organization as well as roles and responsibilities are reviewed.

U1.E1.PC1   **Continuous Improvement history**   **Understand**
Understand the origins of quality management, TPM, Kaizen, Lean, Six Sigma and Agile.

U1.E1.PC2   **Continuous Improvement values and principles**   **Apply**
Propagate the Lean Six Sigma philosophy and principles. Understand the impact of the Toyota Production System (TPS) on strategy, quality and production. Facilitate the creation of a continuous improvement culture within the organization.

U1.E1.PC3   **Continuous Improvement Maturity Model**   **Apply**
Facilitate the development of the organization's maturity level, which is a combination of developing people and process.

U1.E1.PC4   **Continuous Improvement roles and responsibilities**   **Understand**
Describe the various continuous improvement roles and responsibilities.

E2. CUSTOMER VALUE (VOC & CTQ)

The Learning Element 'Customer first' reviews customer identification (internal/external), customer requirements and the CTQ-measure.

U1.E2.PC1   **Voice of the Customer (VOC)**   **Apply**
Differentiate customer experience into dissatisfied, expected, satisfied and desired quality levels (e.g. KANO model).

U1.E2.PC2   **Critical to Quality (CTQ)**   **Apply**
Convert the Voice of Customer into external CTQs and internal CTQs. Construct a CTQ flowdown that represents the key measurable characteristics of a product or process whose performance standards or specification limits must be met.

U2.   POLICY DEVELOPMENT AND DEPLOYMENT

The Unit 'Policy development and deployment' reviews how policy development and deployment help organizations in defining a continuous improvement strategy and to run efficiently in achieving their objectives.

E1. POLICY DEVELOPMENT

The Learning Element 'Policy development' explains the importance of a so-called True North and how to develop an operational excellence strategy.

U2.E1.PC1   **Vision & True North**   **Understand**
Recall and understand the organization's vision and mission statement. Understand the meaning and importance of the organization's True North. Describe how Operational Excellence can be applied to processes in different types of enterprises.

U2.E1.PC2   **Transformation roadmap**   **Understand**
Understand the meaning of a transition roadmap for implementing continuous improvement.

U2.E1.PC3   **Performance and financial metrics**   **Apply**
Understand that various business processes have various key performance indicators (KPIs). Understand the basics of measurement systems in the organization. Define and use cost of poor quality (COPQ), as a financial metric.

E2. POLICY DEPLOYMENT

The Learning Element 'Policy deployment' is focusing on the execution process of the improvement strategy. Within this element financial and performance metrics will be reviewed.

U2.E2.PC1   **Management of change**   **Understand**
Understand breakthrough projects can have an impact on process owners, internal and external customers and other stakeholders. Participate in developing a stakeholder analysis.

E3. COMPETENCE DEVELOPMENT

The Learning Element 'Competence development' reviews how to develop those who need to ensure that the strategy is implemented successfully.

U2.E3.PC1   **Learning organization**   **Understand**
Identify and document lessons learned from all phases of a project. Identify possible improvements and ownership.

U2.E3.PC2   **Coaching and intervision**   **Understand**
Understand the importance of coaching.

U2.E3.PC3   **Effective communication**   **Apply**
Use effective and appropriate communication for different situations to overcome barriers to project success.

U3.   PROJECT MANAGEMENT

The Unit 'Project Management' outlines the way improvement projects should be executed. A number of process improvement roadmaps is reviewed. The Unit also reviews project selection, team formation, planning and execution.

E1. MANAGING A PROJECT

The Learning Element 'Managing a project' reviews how to set up, plan and execute a project.

U3.E1.PC1	Project selection	Understand

Understand that project selection needs to be aligned with the strategy of the organization. Participate in the project selection process.

U3.E1.PC2	Project charter	Apply

Prepare the project charter in relation to customer requirements and business goals. Define the problem statement, project boundaries (scope), objectives, benefits and measurable targets for the project.

U3.E1.PC3	Project team	Understand

Understand the basic principles of team formation and team member selection.

U3.E1.PC4	Project planning	Apply

Select and construct time management techniques. Set up team meetings, tollgates and publish agendas and ensure that the proper people and resources are available.

U3.E1.PC5	Project execution	Apply

Demonstrate project management skills and apply the proper tools and techniques. Ensure that the project will meet its requirements for time, quality and costs.

E2. PROCESS IMPROVEMENT ROADMAPS

The Learning Element 'Process Improvement Roadmaps' reviews a number of roadmaps, including PDCA and DMAIC.

U3.E2.PC1	Kaizen roadmap (PDCA)	Apply

Apply project management methods that can be used in the workplace for Kaizen initiatives (e.g. PDCA, A3-report).

U3.E2.PC2	Lean Six Sigma Roadmap (DMAIC)	Apply

Apply the DMAIC roadmap for Lean (Six Sigma) projects. Select the proper tools to use during the project.

U3.E2.PC3	Problem Solving Process (8D)	Apply

Facilitate the problem-solving process (e.g. 8D approach).

U3.E2.PC4	Scrum	Understand

Understand Scrum roles, elements and artifacts.

U4.   CREATING A SOLID FOUNDATION

The Unit 'Creating a solid foundation' reviews how to achieve a solid foundation for further process improvement programs. This foundation consists of a proper and organized work environment, reliable equipment and standardized work.

E1. PROFESSIONAL WORK ENVIRONMENT

The Learning Element 'Professional work environment' is about good housekeeping and how to set up a proper and safe work environment in a structured manner.

U4.E1.PC1	Organized work environment (5S)	Apply

Organize the work environment by applying 5S (Sort, Straighten, Shine, standardize, Sustain). Understand that an organized environment will improve safety and moral.

E2. STANDARDIZED WORK

The Learning Element 'Standardized work' is about implementing and improving standards and protocols.

U4.E2.PC1 **Standard Work** **Apply**
Standardize tasks and processes to establish the foundation for continuous improvement. Prepare documents, standard operating procedures (SOPs) and onepoint-lessons to ensure that the improvements are sustained over time.

U4.E2.PC2 **Training within Industry** **Understand**
Understand the basic principles of Training Within Industry.

E3. QUALITY MANAGEMENT

The Learning Element 'Quality Management' is about developing procedures to identify and detect defects. Also preventing mistakes and avoiding problems is part of this element.

U4.E3.PC1 **Quality Management System** **Apply**
Propagate the quality management system and procedures. Identify opportunities for improvement.

U5. LEVEL II – CREATING A CONTINUOUS IMPROVEMENT CULTURE

The Unit 'Creating a continuous improvement culture' reviews how to create a continuous improvement culture at the shop floor. This Unit reviews setting up and facilitate Kaizen teams. It also reviews a number of problem-solving techniques and tools.

E1. VISUAL MANAGEMENT

The Learning Element 'Visual management' reviews how to set up a workplace that is organized and self-explaining.

U5.E1.PC1 **Visual workplace** **Apply**
Apply the elements of Visual Workplace and describe how they can help to control the improved process.

E2. PERFORMANCE MANAGEMENT

The Learning Element 'Performance management' reviews how to set targets, and how to organize the work to be done. The Learning Element also reviews how to facilitate improvement teams at the shopfloor that work on Kaizen improvement initiatives and Problem Solving.

U5.E3.PC1 **Daily stand-up meetings** **Apply**
Implement and facilitate stand-up meetings to drive continuous improvement initiatives. Understand basic principles of Scrum.

U5.E3.PC2 **Kaizen events and problem solving** **Apply**

Describe and propagate the Kaizen principles. Facilitate improvement teams and Kaizen events. Define and apply root cause analysis, recognize the issues involved in identifying a root cause. Apply problem solving process and tools.

E3. BASIC QUALITY TOOLS

The Learning Element 'Basic quality tools' reviews techniques to visualize data and guidelines how to facilitate and participate in brainstorm sessions.

U5.E3.PC1 **Brainstorm techniques** **Apply**

Apply brainstorm techniques: Affinity diagram, 5-Why's and Ishikawa.

U5.E3.PC2 **Visualization of data** **Apply**

Apply basic quality tools to visualize data: Scatter plot, Pareto chart, Bar chart, Pie chart, Time Series Plot, Histogram and Box plot.

U6. LEVEL III – CREATING STABLE AND EFFICIENT PROCESSES

The Unit 'Creating stable and efficient processes' reviews how the logistical flow of processes can be improved and made more stable, predictable and efficient. This Unit reviews tools which can be used to visualize and analyze the process flow as well as a number of tools and techniques that can be used to improve efficiency, effectiveness, productivity and agility of processes. All Level III Learning Elements and Performance Criteria follow the DMAIC structure.

DEFINE

E1. PROCESS MAPPING

The Learning Element 'Process Mapping' reviews a number of tools to map and analyze the flow of a process.

U6.E1.PC1 **High-level process description** **Apply**

Describe key process input variables and key process output variables based on a highlevel process map e.g. SIPOC.

U6.E1.PC2 **Process Flow diagram** **Apply**

Apply process mapping to visualize the flow of activities and decisions within a process.

MEASURE

E2. PERFORMANCE METRICS

The Learning Element 'Performance management' reviews performance metrics for both logistics as for quality.

U6.E2.PC1 **Performance metrics (Time)** **Apply**

Calculate performance metrics related to time (e.g. takt time, cycle time, lead time, queue time, WIP and OEE). Apply Little's Law.

U6.E2.PC2 **Performance metrics (Quality)** **Apply**

Calculate performance metrics related to quality (e.g. ppm, DPMO, DPU and RTY). Understand the difference between a defect and a defective.

E3. BASIC STATISTICS

The Learning Element 'Basic statistics' reviews different types of data, measurement scales and data collection tools. Also a set of measures (statistics) that characterizes a given set of data are reviewed.

U6.E3.PC1 **Data types and Measurement scales** **Apply**

Understand the importance of reliable and accurate data. Describe and review qualitative and quantitative data, continuous (variables) and discrete (attributes) data. Define and interpret nominal, ordinal, interval and ratio measurement scales. Apply Likert scale to convert an ordinal scale into a discrete interval scale.

U6.E3.PC2 **Data collection tools** **Apply**

Define and apply tools for collecting data e.g. data sheets, check sheets, concentration diagrams and questionnaires.

U6.E3.PC3 **Descriptive statistics** **Apply**

Calculate population parameters and sample statistics: measures of central tendency, measures of dispersion, ratios and proportions.

ANALYZE

E4. VALUE STREAM ANALYSIS

The Learning Element 'Value Stream Analysis' reviews how to create a Value Stream Map of the current situation.

U6.E4.PC1 **Value adding versus Non-value adding** **Apply**

Differentiate value adding from non-value adding and necessary activities.

U6.E4.PC2 **Value Stream Mapping (Current State)** **Apply**

Apply Value Stream Mapping to construct a Current State Map of the process to identify waste and non-value adding activities.

IMPROVE

E5. REDUCING MUDA (WASTE)

The Learning Element 'Reducing Muda' reviews how to identify and eliminate Waste in the organization and its processes.

U6.E5.PC1 **Waste identification** **Apply**

Identify and eliminate process Waste (Muda): Overproduction, Waiting, Transport, Overprocessing, Inventory, Movement, Defects and Unused expertise.

E6. REDUCING MURI (OVERBURDEN)

The Learning Element 'Reducing Muri' reviews how to identify overburden in the organization. This element also reviews how to implement flow and work balancing to reduce overburden.

| **U6.E6.PC1** | **Flow** | **Apply** |

Describe the importance of Flow for reducing Muri. Implement flow in the organization.

| **U6.E6.PC2** | **Work balancing** | **Apply** |

Describe the importance of Work balancing for reducing Muri. Implement Work balancing.

| **U6.E6.PC3** | **Resource management** | **Apply** |

Describe how competence management supports the reduction of Muri.

E7. REDUCING MURA (UNEVENNESS)

The Learning Element 'Reducing Mura' reviews how to identify unevenness in the organization and its processes. This element also reviews a number of techniques to reduce unevenness.

| **U6.E7.PC1** | **Pull** | **Apply** |

Describe the importance of pull for reducing Mura. Implement pull in the organization by applying Kanban systems.

| **U6.E7.PC2** | **Volume and Type leveling** | **Apply** |

Implement a balanced process flow by both volume leveling, type leveling and one piece flow.

| **U6.E7.PC3** | **Quick Change Over (SMED)** | **Apply** |

Reduce change over times by implementing Single Minute Exchange of Die (SMED).

E8. VALUE STREAM IMPROVEMENT

The Learning Element 'Value Stream Improvement' reviews how the techniques and tools that reduce Muda, Muri and Mura can be applied in constructing a Future State Value Stream Map.

| **U6.E8.PC1** | **Value Stream Mapping (Future State)** | **Apply** |

Define the gap between the current state and the target condition. Define a Future state map using Value Stream Mapping. Apply techniques to reduce Muda, Mura and Muri.

CONTROL

E9. PROCESS AND QUALITY CONTROL

The Learning Element 'Process and Quality control' looks at how results that have been achieved in process improvement projects can be sustained. This element reviews the following techniques and principles: Process FMEA, Control plan, Jidoka and Poka Yoke.

| **U6.E9.PC1** | **First Time Right (FTR)** | **Apply** |

Propagate the importance of the First Time Right principle. Initiate actions to implement First Time Right. Propagate the line has to be stopped when there is a quality problem (Jidoka). Apply Poka Yoke to avoid quality problems.

U6.E9.PC2 **Process FMEA (pFMEA)**   **Apply**

Describe the purpose and elements of Process FMEA, including the risk priority number (RPN) and evaluate FMEA results for processes, products and services.

U6.E9.PC3 **Control plan**   **Apply**

Prepare a control plan to document and hold gains. Define controls and monitoring systems. Transfer of responsibility from the project team to the process owner.

E10. TOTAL PRODUCTIVE MAINTENANCE (TPM)

The Learning Element 'Total Productive Maintenance' reviews the coherence between reliable systems and equipment and continuous improvement.

U6.E10.PC1 **TPM principles**   **Understand**

Understand the eight pillars of TPM and understand how it can be used within process improvement.

U6.E10.PC2 **Overall Equipment Effectiveness (OEE)**   **Understand**

Interpret the Overall Equipment Effectiveness (OEE) performance metric. Review utilization.

SIX SIGMA
GREEN BELT
SKILL SET

A GUIDELINE FOR
TRAINING AND CERTIFICATION

U7. LEVEL IV – CREATING CAPABLE PROCESSES

The Unit 'Creating Capable Processes' focuses on reducing variation in a stable process with the objective to create a process capable of meeting customer requirements. This Unit reviews the application of Six Sigma and statistical tools used to assure a valid and reliable performance measurement system, to collect data and to analyze the performance of processes. Six Sigma focuses on quality breakthrough improvement projects. All Level IV Learning Elements and Performance Criteria follow the DMAIC structure.

MEASURE

E1. STATISTICAL TECHNIQUES

The Learning Element 'Statistical techniques' reviews a number of metrics that are often used in Six Sigma projects. The element also reviews a number of sampling methods for assuring data accuracy and   integrity.

U7.E1.PC1   **Variation**   **Apply**
Divide special cause and common cause variation.

U7.E1.PC2   **Sampling**   **Apply**
Apply appropriate sampling methods that ensure representative data e.g. random sampling, stratified sampling and systematic sampling. Calculate power and sample size for common hypothesis tests.

E2. DISTRIBUTIONS

The Learning Element 'Distributions' reviews a number of continuous and discrete distributions. The element also reviews the central limit theorem and a number of probability concepts.

U7.E2.PC1   **Continuous distributions**   **Understand**
Interpret Probability Density Functions and Cumulative Distribution Functions. Interpret continuous distributions: Normal, Weibull, Student's t, Chi square and F distributions. Interpret normality test (Anderson-Darling; Skewness and Kurtosis).

U7.E2.PC2   **Discrete distributions**   **Understand**
Interpret discrete distributions: Poisson, Binomial. Understand the central limit theorem.

E3. MEASUREMENT SYSTEMS

The Learning Element 'Measurement Systems' reviews how to evaluate measurement systems.

U7.E3.PC1   **Measurement systems analysis**   **Apply**
Define and describe measurement methods for both continuous and discrete data. Apply measurement systems for continuous data. Interpret repeatability and reproducibility (R&R), stability, bias, linearity, precision to tolerance and number of distinct categories.

ANALYZE

E4. HYPOTHESIS TESTING & CONFIDENCE INTERVALS

The Learning Element 'Hypothesis Testing & Confidence Intervals' reviews test methods that are used to test a hypothesis. This Learning Element also discusses Confidence Intervals that indicate the reliability of test conclusions.

U7.E4.PC1   **Hypothesis testing**   **Apply**
Define and interpret the significance level, power, type I and type II errors in statistical tests.

U7.E4.PC2   **Confidence Intervals**   **Apply**
Define and distinguish between confidence, prediction and tolerance intervals. Distinguish between statistical and practical significance.

E5. TESTS FOR MEANS, VARIANCES AND PROPORTIONS

The Learning Element 'Tests for means, variances and proportions' reviews the most common hypothesis tests to investigate the difference between population means (μ); difference in variances (σ); difference in proportion (p) and difference in counts (λ). Also the ANOVA analysis is reviewed.

U7.E5.PC1	**Tests for means**	**Apply**
	Apply hypothesis tests for means.	

U7.E5.PC2	**Tests for variances**	**Apply**
	Apply hypothesis tests for variances.	

U7.E5.PC3	**Analysis of variance (ANOVA)**	**Apply**
	Apply ANOVA. Interpret the results and the main effect and interaction plots.	

U7.E5.PC4	**Tests for proportions**	**Apply**
	Apply hypothesis tests for proportions.	

U7.E5.PC5	**Chi-square tests**	**Apply**
	Apply Chi-square goodness-of-fit test and Contingency tables.	

E6. CORRELATION AND REGRESSION

The Learning Element 'Correlation and Regression' describes the predictive models using regression techniques to determine the relation between factors on a response.

U7.E6.PC1	**Correlation coefficient**	**Apply**
	Calculate and interpret the correlation coefficient. Determine its statistical significance (p-value) and recognize the difference between correlation and causation.	

U7.E6.PC2	**Regression analysis**	**Apply**
	Apply linear regression analysis. Use the regression model for estimation and prediction. Interpret the residual analysis to validate the model.	

E7. PROCESS CAPABILITY AND PERFORMANCE

The Learning Element 'Process Capability and Performance' explains process capability and performance in relation to specification limits.

U7.E7.PC1	**Process Capability (Cpk)**	**Apply**
	Apply process capability studies. Prepare sampling plans to verify stability. Calculate and interpret process capability indices,: Cp and Cpk to assess process capability.	

U7.E7.PC2	**Short-term and long-term capability**	**Understand**
	Interpret the relationship between long-term and short-term capability.	

U7.E7.PC3	**Process Performance (Ppk)**	**Apply**
	Calculate and interpret process performance indices Pp and Ppk to assess process performance. Interpret the relationship between capability and performance indices.	

E8. DESIGN OF EXPERIMENTS (DOE)

The Learning Element 'Design of Experiments' reviews efficient ways of experimenting. Design of Experiments examines the influence of factors and interactions on a process.

| U7.E8.PC1 | **Principles and terminology** | **Apply** |

Apply DOE elements: responses, factors, levels, transfer function, run order, randomization, balanced designs, residual error, main effects, interaction effects, replicates and repetitions.

| U7.E8.PC2 | **Two-level full factorial experiments** | **Apply** |

Design and apply full factorial experiments. Understand the meaning of contrast.

E9. STATISTICAL PROCESS CONTROL (SPC)

The Learning Element 'Statistical Process Control' explains the controls methods used to identify outof-control situations and deviations over time. Different types of SPC charts are reviewed.

| U7.E9.PC1 | **Control charts** | **Apply** |

Describe the objectives of SPC. Select and apply control charts: Xbar-R, Xbar-S, individuals and moving range (I-MR), p, np, c and u.

| U7.E9.PC2 | **Tests for special causes** | **Apply** |

Interpret control charts and differentiate between common and special cause variation using rules for determining statistical control.

APPENDIX A – BLOOM'S TAXONOMY FOR PERFORMANCE CRITERIA

In addition to specifying content, each performance criteria in this skill set also indicates the intended complexity level of the test questions for each topic. These levels are based on 'Levels of Cognition' (from Bloom's Taxonomy – Revised, 2001), and can be used to create learning outcomes for students.

The Taxonomy of Educational Objectives, often called Bloom's Taxonomy, is a classification of the different objectives that educators set for students (learning objectives). The taxonomy was proposed in 1956 by Benjamin Bloom, an educational psychologist at the University of Chicago. During the nineties, Lorin Anderson a former student of Bloom revisited the cognitive domain in the learning taxonomy. Bloom's Taxonomy divides educational objectives into three 'domains': Affective, Psychomotor and Cognitive. This Skill set only notices the Cognitive domain. The 'Levels of Cognition' are in rank order - from least complex to most complex. The Green Belt skill set only uses the levels 'Understand' and 'Apply.'

Remember
Recall or recognize terms, definitions, facts, ideas, materials, patterns, sequences, methods, principles, etc. The LSSA uses the following verb at this level: Recall.

Understand

Read and understand descriptions, communications, reports, tables, diagrams, directions, regulations, etc. The LSSA uses the following verbs at this level: Describe, Follow, Identify, Interpret, Participate, Understand.

Apply

Know when and how to use ideas, procedures, methods, formulas, principles, theories, etc. The LSSA uses the following verbs at this level: Apply, Assess, Assure, Calculate, Convert, Define, Demonstrate, Divide, Eliminate, Empower, Facilitate, Implement, Motivate, Organize, Plan, Prepare, Present, Promote, Propagate, Review, Select, Standardize, Support, Use.

Analyze

Break down information into its constituent parts and recognize their relationship to one another and how they are organized; identify sublevel factors or salient data from a complex scenario. The LSSA uses the following verbs at this level: Analyze, Construct, Deploy, Design, Develop, Distinguish, Evaluate, Lead, Manage, Translate.

Evaluate

Make judgments about the value of proposed ideas, solutions, etc., by comparing the proposal to specific criteria or standards. The LSSA does not uses this level in their skill sets.

Create

Put parts or elements together in such a way as to reveal a pattern or structure not clearly there before; identify which data or information from a complex set is appropriate to examine further or from which supported conclusions can be drawn. The LSSA does not uses this level in their skill sets.

APPENDIX B – PRACTICAL PROJECT ASSESSMENT CRITERIA

Kaizen & Lean project criteria PDCA

Plan		
	1	The project addresses a customer complaint, problem or business case.
	2	There is a clear problem definition.
	3	Objectives are clearly defined and are measurable.
	4	VOC and VOB are defined and specifications are clear.
	5	The scope of the project is clearly defined.
	6	The most important stakeholders have been identified.
	7	Relevant CTQ (s) have been selected and a CTQ flowdown has been made.
	8	A high level process description has been made (e.g. SIPOC).
	9	The reliability of the data has been investigated.
	10	Process performance has been constructed and assessed against specifications.
	11	A detailed process description has been made (e.g. VSM Current State).
	12	Potential causes have been identified.
	13	Analyzes have been used to identify factors of influence (e.g. Fishbone or FMEA).

Phase	Nr	Criteria
	14	The main root causes have been identified and explained.
	15	Conclusions are clear and supported.
Do	1	Risks have been defined and addressed (e.g. pFMEA).
	2	The improved process meets the specifications of the VOC and VOB.
	3	There is a clear communication and action plan towards the stakeholders.
	4	The client has approved the improvement proposals.
Check	1	There is a proven improvement of the CTQ compared to the baseline measurement.
	2	Standards have been adjusted and documentation has been updated.
	3	Roles and responsibilities have been described.
	4	Employees are instructed and/or trained.
	5	It has been shown that the improvements are sustainable.
Act	1	It has been indicated how performance will be monitored in the future.
	2	Final report is ready and lessons learned have been communicated.
	3	Champion has indicated that objectives and/or savings have been achieved.
Phase	Nr	Criteria

Table 2 - Project Practical Assessment PDCA

Lean en Six Sigma project criteria DMAIC

Phase	Nr	Criteria
Define	1	Project addresses a clear problem description or business opportunity.
	2	Problem description has been clearly defined.
	3	Goals have been clearly defined and are measurable.
	4	VOC and VOB have been clearly defined and requirements are understood.
	5	Scope of the project has been clearly delineated.
	6	Key stakeholders have been identified.
	7	Relevant CTQ(s) have been selected and a CTQ-flowdown has been constructed.
	8	High level process description has been made (e.g. SIPOC).
Measure	1	The collected data has been proven to be representative for the project.
	2	Validity of the data has been verified in an appropriate way.
	3	Historical data has been used to visualize process performance over time.
	4	Performance against requirements has been checked.
	5	Variation in the process has been considered (common cause or special cause).
	6	Short term versus long term performance has been considered.
Analyze	1	Process has been mapped in detail (e.g. VSM Current State).

	2	Potential factors of influence have been determined.
	3	Analysis have been used to identify factors with highest influence.
	4	Hypothesis for root cause has been defined properly.
	5	Input data has been collected and analyzed correctly.
	6	Graphical and statistical techniques have been applied to investigate root causes.
	7	Major root causes have been identified.
	8	Conclusions are clear and have demonstrated strong evidence/are statistically valid.
Improve	1	Risks have been identified and addressed (e.g. pFMEA).
	2	Improved process meets the requirements of the VOC and VOB.
	3	There is a clear communication and action plan towards the stakeholders.
	4	The client (Champion) has approved the improvement proposal.
	5	An improvement of the CTQ compared to the baseline is demonstrated.
Control	1	Standards are adjusted and documentation has been updated (pFMEA, CP).
	2	Rolls and responsibilities have been described.
	3	Employees are instructed and/or trained.
	4	Evidence of 'In-Control situation' is available and sufficient.
	5	Improvements have proven to be sustainable.
	6	Measures have been put in place to monitor process performance.
	7	Project report has been completed. Lessons learned have been communicated.
	8	Champion states that project targets and/or savings have been achieved.
	9	Champion or controller has signed off the project.

Table 3 - Project Practical Assessment DMAIC

PART II

LEAN & SIX SIGMA GREEN BELT

SLIDEDECK

LEAN SIX SIGMA GREEN BELT

VHR SLIDEDECK V3.3

INTRODUCTION

Courseware slidedeck (v3.3)

- Based on LSSA Body of Knowledge (version 3.2)
- Lean Six Sigma Academy©
- ©Copyright LSSA B.V., January 2023
- Enschede, the Netherlands
- info@lssa.eu

LSSA EXAMS (THEORETICAL + PRACTICAL)

	LSS YB	LSS OB	Lean GB	LSS GB	LSS BB
Theory exam	LSS YB	LSS OB	Lean GB	LSS GB	LSS BB
Nr of questions	50	50	40	60	60
Language	NED/ENG	NED/ENG	NED/ENG	NED/ENG	NED/ENG
Pass mark	32	32	25	38	38
Pass mark	63%	63%	63%	63%	63%
Duration	60 min	120 min	120 min	180 min	180 min
Books	Open book	Open book	Open book	Open book	Open book
Tools	-	Calculator	Calculator	Minitab	Minitab
Practical assessment	LSS YB	LSS OB	Lean GB	LSS GB	LSS BB
	-	-	1 project level III (or higher)	1 project level III (or higher)	1 x level III + 1 x level IV (or higher)

INTRODUCTION

Reference materials

- Textbooks: 'Climbing the Mountain | Mindset, Skill set and Toolset'
- Exercise books: 'Climbing the Mountain | Exercise book'
- Courseware: 'van Haren | Courseware book'
- Optional: eLearning portal
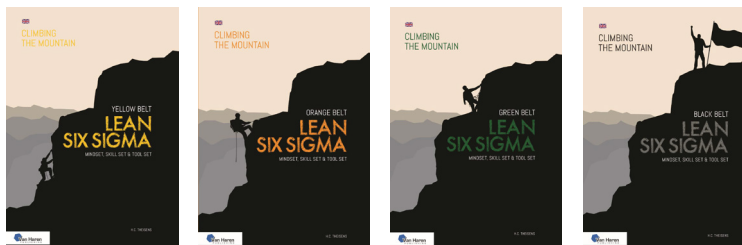
Author: Theisens, H.C.; LSSA 2021

INTRODUCTION

Body of Knowledge

- Publisher: LSSA B.V.
- Version 3.2
- March 2021

Remember	Understand	Apply	Analyze	Evaluate	Create
Recall	Describe	Apply	Analyze	-	-
	Follow	Assure	Construct		
	Identify	Assess	Deploy		
	Interpret	Calculate	Design		
	Participate	Convert	Develop		
	Understand	Define	Distinguish		
		Demonstrate	Evaluate		
		Differentiate	Lead		
		Divide	Manage		
		Eliminate	Translate		
		Empower			
		Encourage			
		Facilitate			
		Implement			
		Motivate			
		Organize			
		Plan			
		Prepare			
		Present			
		Promote			
		Propagate			
		Review			
		Select			
		Standardize			
		Support			
		Use			

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INTRODUCTION

Body of Knowledge structure

- Unit (U)
  The syllabus is presented by syllabus areas; each called a 'Unit'. The chapters in the book 'Climbing the Mountain' reflect the 'Units' described in this syllabus.

- Learning Element (E)
  Each 'Unit' consists of a number of 'Elements'. The paragraphs in each chapter of the book 'Climbing the Mountain' reflect the 'Elements' in this syllabus.

- Performance Criteria (PC)
  Each 'Element' consists of a number of 'Performance Criteria' and each 'Performance Criteria' has an explanation. These describe the tools, techniques and competencies that are required.

- Bloom level
  A 'Cognitive Level' has been assigned to each 'Performance Criteria'- description according to Bloom's Taxonomy. This defines at which level the Belt is expected to apply the respective tool, technique or skill.

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Body of Knowledge Bloom Levels

- Level I – Remember
  Recall or recognize terms, definitions, facts, ideas, materials, patterns, sequences, methods, principles, etc.

- Level II – Understand
  Read and understand descriptions, communications, reports, tables, diagrams, directions, regulations, etc.

- Level III – Apply
  Know when and how to use ideas, procedures, methods, formulas, principles, theories, etc.

- Level IV – Analyze
  Break down information into its constituent parts and recognize their relationship to one another and how they are organized; identify sublevel factors or salient data from a complex scenario.

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INTRODUCTION

Sample Exam

- As part of the training a sample exam paper is provided to candidates with answers and rationales.
- This can be used by the candidates to prepare for the exam.

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U1 – WORLD CLASS

E1 – CONTINUOUS IMPROVEMENT

9

CONTINUOUS IMPROVEMENT HISTORY

Develop and produce products and services
that are the best in the world

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CONTINUOUS IMPROVEMENT HISTORY

1950 →	1950 - 1970	1950 →	1986 →
Deming Q & PDCA	Nakajima TPM	Ohno & Shingo Toyota TPS	Imai Kaizen

1911	1912	1979 – 1986 →	1991 - 1996	1996 →
Taylor Scientific mngt	Ford Belt (Flow)	B. Galvin, Smith & Harry Six Sigma Motorola	Womack & Jones Lean	Jack Welch Six Sigma GE

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CONTINUOUS IMPROVEMENT HISTORY

History of production

Ford: assembly line (1900)

U1.E1   12

CONTINUOUS IMPROVEMENT HISTORY

History of Kaizen

'Take it apart and put it together in a better way'

U1.E1   13

CONTINUOUS IMPROVEMENT HISTORY

History of Lean

Toyota: focus on elimination of Waste

U1.E1   14