

LEAN SIX SIGMA GREEN & BLACK BELT

140 Exercises and Rationals

CLIMBING THE MOUNTAIN

ir. H.C. Theisens

SECOND REVISED EDITION

Lean Six Sigma Academy[®]

*© Copyright LSSA BV, 2021
Enschede, the Netherlands*

Title: Lean Six Sigma Green & Black Belt
140 Exercises and Rationals

Series: Climbing the Mountain

Author: ir. H.C. Theisens

Publisher: Lean Six Sigma Academy
© Copyright LSSA BV, 2021
Enschede, the Netherlands

Contact: Contact us or visit our website for more information, volume discounts,
online sales and material licensing

www.lssa.eu
info@lssa.eu

Edition: 2nd revised edition, 2021
ISBN 978–94–92240–38-5
NUR 100

All rights reserved. No part of this book may be reproduced in any form or by any means, electronic, photocopying or otherwise, without the prior written permission of the publisher.

Portions of information contained in this book are printed with permission of Minitab Inc. All rights reserved. MINITAB® and all other trademarks and logos for the company's products and services are the exclusive property of Minitab Inc. All other marks referenced remain the property of their respective owners. See minitab.com for more information.

The structure of this book is based on the LSSA® Skill set (rev 3.2, 2021) and the Continuous Improvement Maturity Model – CIMM™. You have the permission to share and distribute this model in its original form by referencing the publisher and author, (LSSA®, Theisens et. al., 2021).

Printed in the Netherlands.

Content

HOW TO USE THIS BOOK	13
1 WORLD CLASS	14
1.1 CONTINUOUS IMPROVEMENT	14
1.1.1 <i>History of Lean and Six Sigma</i>	14
1.1.2 <i>Lean principles</i>	14
1.1.3 <i>House of Quality</i>	15
1.1.4 <i>Eight types of Waste</i>	15
1.1.5 <i>CIMM-framework</i>	15
1.2 CUSTOMER VALUE (VOC & CTQ)	16
1.2.1 <i>CTQ – Nursing home</i>	16
1.2.2 <i>CTQ – Implementation organization</i>	16
1.2.3 <i>CTQ – Ball bearing on shaft</i>	16
1.2.4 <i>CTQ–Flowdown – Baking pancakes</i>	17
1.2.5 <i>CTQ–Flowdown – Hotel room</i>	17
2 POLICY DEVELOPMENT AND DEPLOYMENT	18
2.1 POLICY DEVELOPMENT	18
2.1.1 <i>Mission, vision and core values</i>	18
2.1.2 <i>Competitive strategies</i>	18
2.1.3 <i>Cost of Poor Quality</i>	19
2.1.4 <i>Strategy (BB)</i>	19
2.2 POLICY DEPLOYMENT	20
2.2.1 <i>Change management</i>	20
2.2.2 <i>Stakeholders and project board</i>	20
2.2.3 <i>Stakeholder analysis</i>	21
2.3 COMPETENCE DEVELOPMENT	21
2.3.1 <i>Learning organization (BB)</i>	21
2.3.2 <i>Effective communication (BB)</i>	21
3 PROJECT MANAGEMENT	22
3.1 MANAGING A PROJECT	22
3.1.1 <i>Project prioritization</i>	22
3.1.2 <i>Project charter</i>	22
3.1.3 <i>Motivating and involving project members</i>	23
3.1.4 <i>Project delay</i>	23
3.1.5 <i>Project risks</i>	23
3.2 PROCESS IMPROVEMENT ROADMAPS	24
3.2.1 <i>PDCA-roadmap</i>	24
3.2.2 <i>SCRUM-elements</i>	24
3.2.3 <i>DMAIC-roadmap</i>	24
4 CIMM LEVEL I – CREATING A SOLID FOUNDATION	26
4.1 PROFESSIONAL WORK ENVIRONMENT	26
4.1.1 <i>5S – At the office</i>	26
4.1.2 <i>5S – On a computer</i>	26
4.1.3 <i>5S – Activities</i>	27
4.1.4 <i>5S – Gemba walk</i>	27
4.2 STANDARDIZED WORK	27
4.2.1 <i>Standard Operating Procedure – Paper plane folding</i>	27
4.2.2 <i>One point lesson</i>	28
4.3 QUALITY MANAGEMENT	29
4.3.1 <i>Effective process control methods</i>	29

5	CIMM LEVEL II – CREATING A CONTINUOUS IMPROVEMENT CULTURE.....	30
5.1	VISUAL MANAGEMENT.....	30
5.1.1	<i>Visualization in the workplace.....</i>	30
5.2	PERFORMANCE MANAGEMENT.....	31
5.2.1	<i>Ohno Circle.....</i>	31
5.2.2	<i>Root cause analysis.....</i>	31
5.3	BASIC QUALITY TOOLS.....	32
5.3.1	<i>Affinity diagram – Students.....</i>	32
5.3.2	<i>5–Why technique – Problem solving.....</i>	32
5.3.3	<i>Ishikawa – Pizza complaints.....</i>	33
5.3.4	<i>Cause & Effect matrix – Baking pancakes.....</i>	34
EXCEL.....		34
5.3.5	<i>Scatter plot – Electronic system.....</i>	34
5.3.6	<i>Pareto chart – Customer satisfaction.....</i>	35
5.3.7	<i>Bar chart – Corona.....</i>	35
5.3.8	<i>Bar chart – Top 2000.....</i>	35
5.3.9	<i>Bar chart – CPU2000.....</i>	36
5.3.10	<i>Pie chart – Flashlight production.....</i>	36
5.3.11	<i>Time series plot – COVID–cases.....</i>	37
5.3.12	<i>Time series plot – Meatballs.....</i>	37
5.3.13	<i>Histogram – Meatballs.....</i>	37
5.3.14	<i>Histogram - Welfare.....</i>	38
5.3.15	<i>Boxplot – Coffee pods.....</i>	38
MINITAB.....		39
5.3.16	<i>Stacking columns.....</i>	39
5.3.17	<i>Transposing columns.....</i>	39
5.3.18	<i>Subset data using a formula.....</i>	40
5.3.19	<i>Merge text from columns.....</i>	40
5.3.20	<i>Pareto chart – Call center.....</i>	40
5.3.21	<i>Bar chart – Call center.....</i>	41
5.3.22	<i>Pie chart – Nutritional supplements.....</i>	41
5.3.23	<i>Time series plot – Marketing.....</i>	41
5.3.24	<i>Line plot – Department store.....</i>	42
5.3.25	<i>Histogram – Distribution center.....</i>	42
5.3.26	<i>Histogram (with fit and groups) – Camshaft.....</i>	42
5.3.27	<i>Box plot – Health survey.....</i>	43
5.3.28	<i>Interval plot – Hotel.....</i>	43
5.3.29	<i>Marginal plot – Lifestyle products.....</i>	43
5.3.30	<i>Visualization of data – Demographic data.....</i>	44
6	CIMM LEVEL III – CREATING STABLE & EFFICIENT PROCESSES.....	45
6.1	PROCESS MAPPING.....	45
6.1.1	<i>SIPOC – Baking Pancakes.....</i>	45
6.1.2	<i>Flowchart – Flashlight production.....</i>	45
6.1.3	<i>SIPOC – Pancakes in detail.....</i>	48
6.2	PERFORMANCE METRICS.....	49
6.2.1	<i>Takt time – Flashlight production.....</i>	49
6.2.2	<i>Takt time – Fines.....</i>	49
6.2.3	<i>Lead time – Letters.....</i>	50
6.2.4	<i>Lead time – Applications.....</i>	51
6.2.5	<i>First Time Right (FTR) and Rolled Throughput Yield (RTY).....</i>	51
6.3	BASIC STATISTICS.....	52
6.3.1	<i>Scale types.....</i>	52
6.3.2	<i>Mean and median.....</i>	52
6.3.3	<i>Variance, standard deviation and range.....</i>	52
6.4	VALUE STREAM ANALYSIS.....	53
6.4.1	<i>Three M’s and eight wastes.....</i>	53
6.5	REDUCING MUDA (WASTE).....	54
6.5.1	<i>Waste identification – Logistical process.....</i>	54
6.6	REDUCING MURI (OVERBURDEN).....	55
6.6.1	<i>Work in process – Penny Fab (BB).....</i>	55

6.7	REDUCING MURA (UNEVENNESS)	57
6.7.1	<i>Kanban – Lego injection molding</i>	57
6.7.2	<i>Heijunka – Applications for innovation subsidy (BB)</i>	58
6.7.3	<i>CONWIP – Surface treatment (BB)</i>	58
6.8	VALUE STREAM IMPROVEMENT	60
6.8.1	<i>SMED – Quick changeover</i>	60
6.9	PROCESS AND QUALITY CONTROL.....	61
6.9.1	<i>Process FMEA – Baking pancakes</i>	61
6.9.2	<i>Poka Yoke – Practical examples</i>	61
6.10	TOTAL PRODUCTIVE MAINTENANCE (TPM)	62
6.10.1	<i>OEE – Bread maker</i>	62
6.10.2	<i>OEE medicine packaging (BB)</i>	62
7	CIMM LEVEL IV – CREATING CAPABLE PROCESSES	63
7.1	STATISTICS.....	63
7.1.1	<i>Probability theory – Tossing dice</i>	63
7.1.2	<i>Probability theory – Vase with marbles</i>	63
7.1.3	<i>Population versus sample</i>	63
7.1.4	<i>Sampling methods</i>	63
7.1.5	<i>Sample – Without replacement</i>	64
7.1.6	<i>Multi Vari – Metal sintering (BB)</i>	64
7.1.7	<i>Power – Spindles</i>	65
7.1.8	<i>Power – Logistic center (BB)</i>	65
7.2	DISTRIBUTIONS.....	66
	CONTINUOUS DISTRIBUTIONS	66
7.2.1	<i>Probability plot – Entrance exam</i>	66
7.2.2	<i>Normal distribution – Briquettes</i>	66
7.2.3	<i>Normal distribution – Espresso</i>	66
7.2.4	<i>Normality test – Medicine</i>	67
7.2.5	<i>Weibull – Process time</i>	67
7.2.6	<i>Lognormal – Income distribution (BB)</i>	67
7.2.7	<i>Probability plot – Income tax (BB)</i>	68
	DISCRETE DISTRIBUTIONS	68
7.2.8	<i>Binomial distribution – Boys versus Girls</i>	68
7.2.9	<i>Binomial distribution – Leak tightness</i>	68
7.2.10	<i>Binomial distribution – Quotations</i>	68
7.2.11	<i>Binomial distribution – Screws</i>	69
7.2.12	<i>Poisson distribution – Helpdesk</i>	69
7.2.13	<i>Central Limit Theorem</i>	69
7.3	MEASUREMENT SYSTEMS.....	70
7.3.1	<i>Measurement procedures and systems</i>	70
7.3.2	<i>Measurement Systems Analysis – Laboratory</i>	70
7.3.3	<i>Attribute Agreement Analysis – Blood eggs (BB)</i>	71
7.4	HYPOTHESIS TESTING AND CONFIDENCE INTERVALS	72
7.4.1	<i>Confidence intervals – Shaft diameter</i>	72
7.4.2	<i>Confidence intervals – Ball bearings</i>	72
7.4.3	<i>Confidence intervals – Referendum</i>	72
7.5	TESTS FOR MEANS, VARIANCES AND PROPORTIONS	73
7.5.1	<i>Test for means – Lead time subsidy application</i>	73
7.5.2	<i>Test for means – Fill volume</i>	73
7.5.3	<i>Test for means – Cable tensile strength</i>	74
7.5.4	<i>Test for means – Spindle diameter</i>	74
7.5.5	<i>Test for means – Student height</i>	74
7.5.6	<i>ANOVA – Blood coagulation research</i>	75
7.5.7	<i>ANOVA – Typing speed</i>	75
7.5.8	<i>ANOVA – Beer consumption</i>	76
7.5.9	<i>Test of proportions – Unbiased coin</i>	76
7.5.10	<i>Test of proportions – Call center</i>	77
7.5.11	<i>Paired comparison – Distribution center</i>	77
7.5.12	<i>Chi-square test (Contingency table) – Flower bulbs</i>	78
7.5.13	<i>Chi-square test (Goodness or Fit) – Boys and Girls</i>	78

7.6	CORRELATION AND REGRESSION	79
7.6.1	<i>Regression analysis – Plant growth</i>	79
7.6.2	<i>Regression analysis – Fishermen</i>	79
7.6.3	<i>Logistic regression – Challenger case (BB)</i>	80
7.7	PROCESS CAPABILITY AND PERFORMANCE	81
7.7.1	<i>Process capability – Cable diameter</i>	81
7.7.2	<i>Process capability – Fill weight ointment tubes</i>	81
7.8	DESIGN OF EXPERIMENTS (DOE).....	82
7.8.1	<i>Full Factorial – Cycling experiment</i>	82
7.8.2	<i>Fractional Factorial – Circuit boards (BB)</i>	82
7.9	STATISTICAL PROCESS CONTROL (SPC)	84
7.9.1	<i>Xbar–R control chart – Camshaft</i>	84
7.9.2	<i>I–MR control chart – Supplier</i>	84
7.9.3	<i>P & NP control chart – LCD screens</i>	84
8	CIMM LEVEL V – CREATING WORLD CLASS PRODUCTS.....	85
8.1	PRODUCT LIFECYCLE MANAGEMENT (PLM)	85
8.1.1	<i>Product lifecycle (BB)</i>	85
8.1.2	<i>Durability (BB)</i>	85
8.2	DESIGN FOR SIX SIGMA.....	85
8.2.1	<i>Design for Excellence (BB)</i>	85
8.3	FOURTH INDUSTRIAL REVOLUTION.....	86
8.3.1	<i>Industry 4.0 (BB)</i>	86

RATIONALS

1	WORLD CLASS.....	89
1.1	CONTINUOUS IMPROVEMENT.....	89
1.1.1	<i>History of Lean and Six Sigma</i>	89
1.1.2	<i>Lean principles</i>	89
1.1.3	<i>House of Quality</i>	91
1.1.4	<i>Eight types of Waste</i>	91
1.1.5	<i>CIMM–framework</i>	92
1.2	CUSTOMER VALUE (VOC & CTQ)	93
1.2.1	<i>CTQ – Nursing home</i>	93
1.2.2	<i>CTQ – Implementation organization</i>	93
1.2.3	<i>CTQ – Ball bearing on shaft</i>	93
1.2.4	<i>CTQ–Flowdown – Baking Pancakes</i>	93
1.2.5	<i>CTQ–Flowdown – Hotel room</i>	95
2	POLICY DEVELOPMENT AND DEPLOYMENT	96
2.1	POLICY DEVELOPMENT	96
2.1.1	<i>Mission, vision and core values</i>	96
2.1.2	<i>Value strategies</i>	96
2.1.3	<i>Cost of Poor Quality</i>	96
2.1.4	<i>Strategy (BB)</i>	96
2.2	POLICY DEPLOYMENT.....	97
2.2.1	<i>Change management</i>	97
2.2.2	<i>Stakeholders and project board</i>	97
2.2.3	<i>Stakeholder analysis</i>	98
2.3	COMPETENCE DEVELOPMENT	98
2.3.1	<i>Learning organization (BB)</i>	98
2.3.2	<i>Effective communication (BB)</i>	98

3	PROJECT MANAGEMENT	99
3.1	MANAGING A PROJECT	99
3.1.1	<i>Project prioritization</i>	99
3.1.2	<i>Project charter</i>	99
3.1.3	<i>Motivating and involving project members</i>	99
3.1.4	<i>Project delay</i>	100
3.1.5	<i>Project risks</i>	100
3.2	PROCESS IMPROVEMENT ROADMAPS	102
3.2.1	<i>PDCA–roadmap</i>	102
3.2.2	<i>Scrum-elements</i>	102
3.2.3	<i>DMAIC–roadmap</i>	102
4	CIMM LEVEL I – CREATING A SOLID FOUNDATION	103
4.1	PROFESSIONAL WORK ENVIRONMENT	103
4.1.1	<i>5S – At the office</i>	103
4.1.2	<i>5S – On a computer</i>	104
4.1.3	<i>5S – Activities</i>	105
4.1.4	<i>5S – Gemba walk</i>	105
4.2	STANDARDIZED WORK	106
4.2.1	<i>Standard Operating Procedure – Paper plane folding</i>	106
4.2.2	<i>One point lesson</i>	106
4.3	QUALITY MANAGEMENT	107
4.3.1	<i>Effective process control methods</i>	107
5	CIMM LEVEL II – CREATING A CONTINUOUS IMPROVEMENT CULTURE	108
5.1	VISUAL MANAGEMENT	108
5.1.1	<i>Visualization in the workplace</i>	108
5.2	PERFORMANCE MANAGEMENT	108
5.2.1	<i>Ohno Circle</i>	108
5.2.2	<i>Root cause analysis</i>	108
5.3	BASIC QUALITY TOOLS	108
5.3.1	<i>Affinity diagram – Students</i>	108
5.3.2	<i>5–Why technique – Problem solving</i>	109
5.3.3	<i>Ishikawa – Pizza complaints</i>	109
5.3.4	<i>Cause & Effect – Baking Pancakes</i>	110
EXCEL		111
5.3.5	<i>Scatter plot – Electronic system</i>	111
5.3.6	<i>Pareto chart – Customer satisfaction</i>	112
5.3.7	<i>Bar chart – Corona</i>	113
5.3.8	<i>Bar chart – Top 2000</i>	113
5.3.9	<i>Bar chart – CPU2000</i>	115
5.3.10	<i>Pie chart – Flashlight production</i>	115
5.3.11	<i>Time series plot – COVID–cases</i>	116
5.3.12	<i>Time series plot – Meatballs</i>	116
5.3.13	<i>Histogram – Meatballs</i>	117
5.3.14	<i>Histogram – Welfare</i>	117
5.3.15	<i>Boxplot – Coffee pods</i>	119
MINITAB		120
5.3.16	<i>Stacking columns</i>	120
5.3.17	<i>Transposing columns</i>	121
5.3.18	<i>Subset data using a formula</i>	122
5.3.19	<i>Merge text from 2 columns</i>	123
5.3.20	<i>Pareto chart – Call center</i>	124
5.3.21	<i>Bar chart – Call center</i>	125
5.3.22	<i>Pie chart – Nutritional supplements</i>	127
5.3.23	<i>Time series plot – Marketing</i>	129
5.3.24	<i>Line plot – Department store</i>	130
5.3.25	<i>Histogram – Distribution center</i>	132
5.3.26	<i>Histogram (with fit and groups) – Camshaft</i>	134
5.3.27	<i>Box plot – Health survey</i>	135
5.3.28	<i>Interval plot – Hotel</i>	137

5.3.29	<i>Marginal plot – Lifestyle products</i>	140
5.3.30	<i>Visualization of data – Demographic data</i>	141
6	CIMM LEVEL III – CREATING STABLE & EFFICIENT PROCESSES	142
6.1	PROCESS MAPPING	142
6.1.1	<i>SIPOC – Baking Pancakes</i>	142
6.1.2	<i>Flowchart – Flashlight production</i>	142
6.1.3	<i>SIPOC – Pancakes in detail</i>	143
6.2	PERFORMANCE METRICS	144
6.2.1	<i>Takt time – Flashlight production</i>	144
6.2.2	<i>Takt time – Fines</i>	144
6.2.3	<i>Lead time – Letters</i>	144
6.2.4	<i>Lead time – Applications</i>	145
6.2.5	<i>First Time Right (FTR) and Rolled Throughput Yield (RTY)</i>	146
6.3	BASIC STATISTICS	147
6.3.1	<i>Scale types</i>	147
6.3.2	<i>Mean and median</i>	147
6.3.3	<i>Variance, standard deviation and range</i>	148
6.4	VALUE STREAM ANALYSIS	149
6.4.1	<i>Three M's and eight wastes</i>	149
6.5	REDUCING MUDA (WASTE)	150
6.5.1	<i>Waste identification – Logistical process</i>	150
6.6	REDUCING MURI (OVERBURDEN)	151
6.6.1	<i>Work in process – Penny Fab (BB)</i>	151
6.7	REDUCING MURA (UNEVENNESS)	153
6.7.1	<i>Kanban – Lego injection molding</i>	153
6.7.2	<i>Heijunka – Applications for innovation subsidy (BB)</i>	153
6.7.3	<i>CONWIP – Surface treatment (BB)</i>	154
6.8	VALUE STREAM IMPROVEMENT	156
6.8.1	<i>SMED – Quick Changeover</i>	156
6.9	PROCESS AND QUALITY CONTROL	157
6.9.1	<i>Process FMEA – Baking pancakes</i>	157
6.9.2	<i>Poka Yoke – Practical examples</i>	158
6.10	TOTAL PRODUCTIVE MAINTENANCE (TPM)	160
6.10.1	<i>OEE – Bread maker</i>	160
6.10.2	<i>OEE – Medicine packaging (BB)</i>	161
7	CIMM LEVEL IV – CREATING CAPABLE PROCESSES	162
7.1	STATISTICS	162
7.1.1	<i>Probability theory – Tossing dice</i>	162
7.1.2	<i>Probability theory – Vase with marbles</i>	162
7.1.3	<i>Population versus sample</i>	162
7.1.4	<i>Sampling methods</i>	163
7.1.5	<i>Sample – Without replacement</i>	163
7.1.6	<i>Multi Vari – Metal sintering (BB)</i>	164
7.1.7	<i>Power – Spindles</i>	165
7.1.8	<i>Power – Logistic center (BB)</i>	166
7.2	DISTRIBUTIONS	168
	CONTINUOUS DISTRIBUTIONS	168
7.2.1	<i>Probability distribution – Entrance exam</i>	168
7.2.2	<i>Normal distribution – Briquettes</i>	169
7.2.3	<i>Normal distribution – Espresso</i>	172
7.2.4	<i>Normality test – Medicine</i>	175
7.2.5	<i>Weibull – Process time</i>	176
7.2.6	<i>Lognormal – Income distribution</i>	178
7.2.7	<i>Probability plot – Income tax</i>	180

DISCRETE DISTRIBUTIONS	183
7.2.8 Binomial distribution – Boys versus Girls	183
7.2.9 Binomial distribution – Leak tightness	183
7.2.10 Binomial distribution – Quotations	184
7.2.11 Binomial distribution – Screws	186
7.2.12 Poisson distribution – Helpdesk	187
7.2.13 Central Limit Theorem	191
7.3 MEASUREMENT SYSTEMS	194
7.3.1 Measurement procedures and systems	194
7.3.2 Measurement Systems Analysis – Laboratory	194
7.3.3 Measurement Systems Analysis – Blood eggs (BB)	197
7.4 HYPOTHESIS TESTING AND CONFIDENCE INTERVALS	200
7.4.1 Confidence intervals – Shaft diameter	200
7.4.2 Confidence intervals – Ball bearings	201
7.4.3 Confidence intervals – Referendum	203
7.5 TESTS FOR MEANS, VARIANCES AND PROPORTIONS	204
7.5.1 Test for means – Lead time subsidy application	204
7.5.2 Test for means – Fill weight	206
7.5.3 Test for means – Cable tensile strength	207
7.5.4 Test for means – Spindle diameter	209
7.5.5 Test for means – Student height	210
7.5.6 ANOVA – Blood coagulation research	213
7.5.7 ANOVA – Typing speed	215
7.5.8 ANOVA – Beer consumption	217
7.5.9 Test of proportions – Unbiased coin	221
7.5.10 Test of proportions – Call center	223
7.5.11 Paired comparison – Distribution center	224
7.5.12 Chi-square test (Contingency table) – Flower bulbs	227
7.5.13 Chi-square test (Goodness or Fit) – Boys and Girls	229
7.6 CORRELATION AND REGRESSION	231
7.6.1 Regression analysis – Plant growth	231
7.6.2 Regression analysis – Fishermen	233
7.6.3 Logistic regression - Challenger (BB)	237
7.7 PROCESS CAPABILITY AND PERFORMANCE	240
7.7.1 Process capability – Cable diameter	240
7.7.2 Process capability – Fill weight ointment tubes	241
7.8 DESIGN OF EXPERIMENTS (DOE)	243
7.8.1 Full Factorial – Cycling experiment	243
7.8.2 Fractional Factorial – Circuit boards (BB)	246
7.9 STATISTICAL PROCESS CONTROL (SPC)	250
7.9.1 Xbar–R control chart – Camshaft	250
7.9.2 I–MR control chart – Supplier	251
7.9.3 P & NP control chart – LCD screens	252
8 CIMM LEVEL V – CREATING WORLD CLASS PRODUCTS	253
8.1 PRODUCT LIFECYCLE MANAGEMENT (PLM)	253
8.1.1 Product lifecycle (BB)	253
8.1.2 Durability (BB)	253
8.2 DESIGN FOR SIX SIGMA	254
8.2.1 Design for Excellence (BB)	254
8.3 FOURTH INDUSTRIAL REVOLUTION	254
8.3.1 Industry 4.0 (BB)	254

How to use this book

Many excellent books have been written on Lean and Six Sigma. However, just reading the books will not give you the skills to use the techniques successfully. You can develop these skills by making exercises. This book contains 140 exercises and rationals and is therefore a valuable addition to any theoretical Lean and Six Sigma course. Even experienced Lean Six Sigma specialists can use this exercise book to improve their practical skills. Finally, this book is useful for trainers and teachers who provide training within their own organization or in education.

The structure of this exercise book is based on the 'Continuous Improvement Maturity Model' (CIMM). CIMM is an open standard which is maintained by the Lean Six Sigma Academy (LSSA). This framework describes the process of continuous improvement from the initial phase to the delivery of products and services at the level of 'World Class'. The CIMM framework connects the different methods and encompasses the most commonly applied techniques in the field of problem solving, continuous improvement and new product development.

This exercise book is a supplement to the textbook 'Climbing the Mountain' by H.C. Theisens. Together, these books form the basis for developing yourself in the beautiful field of problem solving and continuous improvement. The book contains examples from multiple sectors. However, all exercises can be made without having prior knowledge of a certain sector.

To make the exercises in this book, both Excel and Minitab are used. The data files required for the exercises can be downloaded from the website of the LSSA: www.lssa.eu.

If you only want to practice with Lean, it is sufficient to make the exercises in chapters 1 to 6 only. Six Sigma topics are covered in Chapter 7. The exercises that only need to be completed by Black Belts are indicated by '(BB)'.

1 World Class

1.1 Continuous improvement

1.1.1 History of Lean and Six Sigma

Various methodologies are applied within the process of operational excellence, continuous improvement and new product development. Each of these methodologies has its own origin, principles and field of application. These different approaches are combined in the CIMM framework.

Briefly describe the origin of the following methodologies and their field of application:

- a) Kaizen.
- b) Lean.
- c) Six Sigma.
- d) Agile.

1.1.2 Lean principles

Liker describes 14 principles that are applied within Toyota. These are divided into four sections:

1. Base your strategy on a long-term philosophy.
2. The right process will produce the right results.
3. Add value to the organization by developing your people and partners.
4. Continuously solving root problems drives organizational learning.

5 of the 14 principles are summarized below:

- Base management decisions on a long-term philosophy, even at the expense of short-term financial goals.
 - Create a continuous process flow to bring problems to the surface.
 - Build a culture of stopping to fix problems, to get quality right the first time..
 - Respect your extended network of partners and suppliers by challenging them and helping them improve.
 - Go and see for yourself to thoroughly understand the situation (Genchi Genbutsu).
- a) Discuss in small groups the meaning of these principles and which of these principles are present within your own organization.

1.1.3 House of Quality

An organization's strategy can be visualized by a 'House of quality'. The roof of the house visualizes the goals of the organization. The foundation of the house describes the values and principles as well as conditions for continuous improvement. The house has two pillars. One pillar is about optimizing the process and the other pillar focuses on preventing quality. The center is about the culture in the organization.

- a) Draw a House of Quality on a sheet of paper or whiteboard and name as many elements from your own organization as possible.

1.1.4 Eight types of Waste

Within Lean, identifying and eliminating waste is one of the most important activities.

- a) Name the eight types of waste.
- b) Name at least one example of your own department or activities per waste.

1.1.5 CIMM-framework

The Lean Six Sigma training aims to teach all employees how to recognize opportunities and how to work on improvement in a structured way. It's about the continuous, never-ending, process of eliminating waste and improving the quality of products and services to be among the best in the world.

Lean originated around 1950 within Toyota. A definition of Lean is difficult to give because, in addition to Toyota's own ideas, it is also an integration of a number of philosophies. Six Sigma was developed by Motorola in 1980 and later became known for the successes of General Electric

- a) Within your group, discuss the differences between Lean, Six Sigma, Kaizen and Agile.
- b) Indicate which techniques are applied in your organization at the different CIMM levels.

1.2 Customer value (VOC & CTQ)

1.2.1 CTQ - Nursing home

The residents of a nursing home complain to the director that the nurses have so little time for a simple chat. The director checks with the employees whether this is correct and gets a lot of irritated faces. They shout: "We have to keep track of all kinds of things and that means we don't have enough time for the real work. We seem to work more like an administration office than in healthcare". The director decides to do something about this and wants to reduce the administrative burden for nurses by 20%.

- a) What is the CTQ of this project?

1.2.2 CTQ - Implementation organization

A government organization receives many complaints from inhabitants calling for information. In particular the complaint: "I am being sent from pillar to post" is an absolute pain point. Further research shows that it is indeed common for customers to have more than one contact with this organization before the correct information is provided. The director of this organization decides to take action and starts an improvement project.

- a) You as a Green Belt are asked to lead this project. The director asks you to define the CTQ for this project. What is your proposal?

1.2.3 CTQ - Ball bearing on shaft

In an assembly process of a lawn mower, a ball bearing must be mounted on a shaft at some point. It turns out that many problems arise here, because sometimes the ball bearing does not fit on the shaft. It is not clear whether the problem is the diameter of the shaft or the diameter of the ball bearing.

- a) You as a Green Belt are asked to lead this project. The director asks you to define the CTQ for this project. What is your proposal?

1.2.4 CTQ-Flowdown – Baking pancakes

This weekend you have a children's party. You have decided to start baking pancakes for all the children. However, children have high demands that a good pancake must meet. They like a warm, tasty, baked and good looking pancake. It is up to you to work this out in a CTQ Flowdown.

The first step is to derive an external CTQ from the cumbersome text above. Subsequently, each external CTQ must be translated into one or more internal CTQs. Answer the following questions:

- a) What requirements must a good internal CTQ meet?
- b) Translate a number of external CTQs into one or more internal CTQs.
- c) Draw up an operational definition for a number of internal CTQs.

1.2.5 CTQ-Flowdown – Hotel room

A hotel has asked its customers what they think is important for a pleasant stay, which can in turn lead to a good rating. This resulted in the table below.

Item	Score	Element
Check In/Out	21	Speed
		Friendliness
Bar	7	Opening hours
		Offer
		Friendliness
Elevator	6	Speed
		Size
		Availability
Room	34	Dimensions
		Cleaning
		View
		Internet
Television	10	Number of channels
		Screen size
		Usability
Bed	15	Size
		Hardness
Internet	7	Speed
		Availability
		Cost
Total	100	

- a) Make a CTQ Flowdown of the two most important topics. Make up your own mind about the measuring frequency and the priority of each element.

2 Policy development and deployment

2.1 Policy development

2.1.1 Mission, vision and core values

The mission describes the reason for an organization's existence. The vision describes the objectives of the organization. Core values reflect the values within the organization.

- a) Can you describe the mission, vision and core values of your own organization, without looking them up? Do you think your colleagues are able to easily identify the mission, vision and core values?
- b) If you have difficulty answering the above question, please indicate why you had difficulty with this.

2.1.2 Competitive strategies

Treacy and Wiersema have described three generic competitive strategies that help organizations to develop an appropriate strategic and operational plan: Operational Excellence, Customer Intimacy and Product Leadership.



Figure 1 – Competitive strategies

- a) Indicate to what extent each of the mentioned strategies are applicable within your organization.
- b) Which competitive strategy is most important to your organization and why? Will this remain the case in the future or would you like to change this?

2.1.3 Cost of Poor Quality

Feigenbaum divided quality costs into visible and invisible costs. He stated that visible quality costs are easy to identify and measure, while invisible quality costs are difficult to identify and not easy to measure. The metaphor for these visible and invisible quality costs is an iceberg. Only a small portion of the cost is visible, represented by the tip of the iceberg, while the majority of the cost is invisible and hidden under the surface of the water.



Figure 2 – Cost Iceberg

- Describe a number of examples of visible costs within your own department.
- Describe a number of examples of invisible costs within your own department.

2.1.4 Strategy (BB)

The diagram below is a spider web created as a result of a self–assessment by an organization's management team.

- Indicate why this score is unlikely.
- Indicate what needs to be improved.

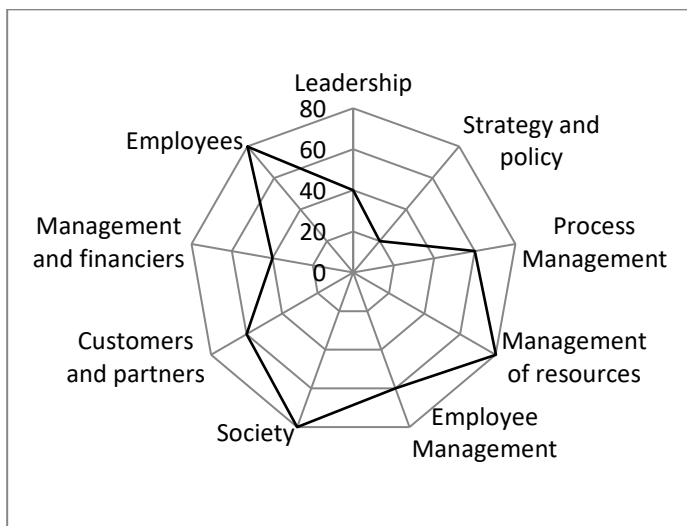


Figure 3 – Assessment spider

2.2 Policy deployment

2.2.1 Change management

An important reason why change is difficult is because it often requires a change in the current organizational structure and culture. Changes can be small, such as an updated work instruction, but it can also be very large, such as with an overall reorganization. Both small and large changes can lead to some form of resistance.

- a) Can you give an example from your private or work environment in which there was a difficult change?
- b) Imagine you are the manager of the organization where you currently work. Imagine that you could make any change you would like. What would you change?
- c) How would the different employees in your organization feel about this change? Would they all be positive, passively hold back or be very negative?

2.2.2 Stakeholders and project board

Projects can have an impact on many people, which are all stakeholders. Stakeholders exist both outside the organization (for example customers) and within the organization.

- a) Please provide a clear and complete description and five examples of these stakeholders. The list should include stakeholders from within and outside the organization.
- b) What is the analysis called that identifies the drivers of these stakeholders. Name the steps and explain them briefly.

The organizational component is of great importance to make Lean or Six Sigma projects a success. The best way for this to succeed is to set up an improvement organization. In any case, the project board always consists of the Champion. The project board may be supplemented with a Supplier, a User and a (Master) Black Belt.

- c) What responsibilities are associated with the aforementioned roles?
- d) Put these roles in an organizational chart.