CHAPTER – 5
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5.1 Introduction

In the previous chapter, the data analysis and interpretation of results were presented. This chapter presents the summary of research findings. The entire chapter is divided into two parts. Part I summarizes the main findings of the present study, and Part II summarizes the hypotheses related findings.

5.2 Part I: Summary of Findings of the Present Study

The main findings of the present study are:

Survey response:

- The survey had been conducted among software professionals with a blend of project management experience, knowledge on different maturity models, agile/scrum, Lean and Six Sigma, and had worked on such strategically important projects from service and product oriented software companies.

- The response rate of 65.3% was found to be encouraging. 98 responses have been obtained from 38 development centers in India and abroad. This included 57 responses from service oriented software companies and 41 responses from product oriented companies.

Profile of the respondents:

- Designation: 23.5% of respondents are senior executives, 31.6% of them are project managers, 27.5% of the professionals are project/team leaders, and 17.3% of them are software engineers.

- Professional Experience: 38.8% of the respondents have more than 15 years of experience, 23.5% of them have 10 to 15 years of experience, 33.7% of the professionals have 5 to 10 years of experience, and only 4.1% of them have 2 to 5 years of experience.
• Current software development model: 43.9% of respondents are following agile methods, 46.9% of them are still following traditional waterfall model, and 9.2% of the professionals are still working on ad hoc model.

• Knowledge on maturity model: 93.9% of the respondents expressed that they have knowledge on different maturity models for improving software development processes.

• Duration of the current project: 38.8% of the projects are running for more than 2 years, 33.7% of the projects are of 1 to 2 years duration, and 27.6% of them are of 6 months to 1 year duration.

Section I: The main findings on the advantages of implementing Lean Sigma to the software development process

• More than two-third of the software developers from service and product segments are of the opinion that more than 50% of the focus is on a smaller set of high priority requirements to deliver value to the customer can be achieved with the Lean Sigma approach.

• Again more than two-third of the software professionals (68.4%) from service and product oriented software companies expressed that customer satisfaction will be increased by more than 50%, if they adopt the Lean Sigma method to improve the software development activities.

• More than two-third of the respondents (72.5%) from service and product segments expressed that the visibility into all work items being developed will be increased by more than 50%.

• As far as quality of the software application/product is concerned, about 75% of the professionals expressed more than 50% improvement in the quality of the application/system can be achieved by adopting Lean Sigma method.

• As far as the productivity of the development process is concerned, more than two-third of the total professionals (71.4%) from service and product groups agreed that the Lean Sigma approach will increase productivity of the software development process by more than 50%.
• About 70% of the respondents from both the segments agreed that the Lean Sigma approach will reduce re-work, which is the main concern in the software industry, by more than 50%.

• Approximately two-third of the respondents expressed that more than 50% improvement in the cycle time can be achieved by adopting Lean Sigma to improve the software development process.

• Approximately 60% of the respondents expressed that lead time can be improved by more than 50% by implementing Lean Sigma approach to software development activities.

Section II: The main findings on the knowledge of Lean and Six Sigma among software professionals

• In defining the problem from the customers’ point of view, 48% of the professionals expressed more than 75% of knowledge, followed by 38.8% of them expressed 50 to 75% of knowledge. In other words, majority of the respondents (86.8%) expressed that they have more than 50% of knowledge identifying the needs of their customers.

• 26.5% of professionals possess more than 75% of knowledge on identifying and elimination of non-value-added activities, followed by 37.7% of them have 50 to 75% of knowledge. Overall, majority of the respondents (64.2%) possess more than 50% of knowledge on identifying and elimination of non-value-added activities.

• In setting up visual workflow to know the status of work items being developed at different stages of software development process, 28.6% of the respondents have more than 75% of knowledge, followed by 31.6% of them showed 50 to 75% knowledge. In other words, majority of the professionals (60.2%) possess more than 50% of knowledge in setting up visual workflow to software development process.

• In “DMAIC” (Define, Measure, Analyze, Improve, and Control) model, 31.6% of the professionals have more than 75% of knowledge, followed by 36.7% of them showed 50 to 75% knowledge. In other words, more than two-third of the professionals (68.3%) possess more than 50% of knowledge on DMAIC model to continuous improvement process.
• 39.8% of the respondents expressed that they have more than 75% of knowledge on process variations and specification limits, followed by 36.7% of them agreed to have 50 to 75% of knowledge. Overall, more than two-third of the respondents (76.5%) possess more than 50% knowledge on process variations and specification limits in software development.

• In root cause analysis, 37.8% of the respondents expressed more than 75% of knowledge on various tools and techniques to identify root causes of quality problem followed by 36.7% of them possess more than 50% of knowledge. In other words, 74.5% of the respondents have more than 50% of knowledge on various tools and techniques to identify root causes of quality problem.

• In developing Value Stream Map (VSM) for software development activities, just 14.3% of professionals have more than 75% of knowledge, followed by 21.4% of them have 50 to 75% of knowledge. In this case, just about one-third of the respondents (35.7%) have more than 50% of knowledge on Value Stream Map.

• In Lean and Six Sigma approaches to software development, about 22% of the respondents have more than 75% knowledge, followed by about 29% of them have 50 to 75% of knowledge. In other words, about 51% of professionals have more than 50% of knowledge on Lean and Sigma to software development process.

Section III: The main findings on the attitude of software professionals towards implementing Lean Sigma to the software development process:

• More than two-third of the respondents (72.5%) from service and product segments expressed that Lean Sigma framework aligns project goals and objectives to company’s strategy to get the project achieve strategic fit in the organization.

• More than two-third of the respondents (72.4%) from service and product groups expressed that with the Lean Sigma model in place, the project team can more collaboratively work together to solve problems in software development activities.
More than two-third of the respondents (70.4%) from service and product oriented companies agreed that with Lean Sigma experience, one can stay ahead in this highly competitive industry with those of other companies.

More than two-third of the total respondents (70.4%) from service and product oriented software companies were in agreement that they feel free to try out new ideas in software development as Lean Sigma framework encourages innovative thinking.

Majority of the respondents (65.3%) from service and product segments were in agreement that Lean Six Sigma framework empower people to make decisions they can feel free to express their thoughts with their managers and executive leadership team.

63.3% of the respondents expressed that the Lean Sigma will establish more trust and confidence among team members that creates an open and comfortable work environment.

Majority of the respondents (62.3%) were in the agreement that recognition and rewards are given on contribution to Lean Six Sigma program for continuous improvement.

Majority of the professionals (64.3%) from service and product oriented companies responded that training on Lean Six Sigma is provided to enable me to execute my work more efficiently.

**Section IV: The main findings on the opportunities in implementing Lean Sigma to the software development process**

- More than two-third of the respondents (71.5%) expressed more than 50% opportunities in understanding the need for prioritizing the requirements to quickly deliver value to customer.
- More than two-third (74.5%) of the respondents from service and product groups found more than 50% opportunities through visualization of workflow control to understand the sources of errors in software development process.
- More than two-third of the professionals (67.4%) responded to have assessed more than 50% opportunities in understanding and eliminating non-value-added activities in software development process.
• Majority of the respondents assessed more than 50% opportunities in enforcing limitations on work-in-progress to the capacity of the team.
• More than two-third of the respondents (73.5%) expressed more than 50% opportunities in reducing defect rates by encouraging to produce right thing the first time.
• More than two-third of the total respondents (70.4%) had assessed more than 50% of opportunities in adopting quantitative software project management approach through Function Point Analysis (FPA).
• More than two-third of the respondents (69.4%) from service and product segments had opinion of getting more than 50% of opportunities of Lean Six Sigma to improve the process collaboratively and continuously based on facts using scientific approach.
• Majority of the respondents (62.3%) found more than 50% opportunities in defining value stream for software development process.

Section V: The main findings on the challenges in implementing Lean Sigma to the software development process

• Majority of the professionals (58.1%) expressed challenges most of the time, followed by challenges some time (32.7%) in setting up visual flow (Kanban screen) to software development process.
• In identifying non-value-added activities, 51% of the respondents expressed challenges most of the time, followed by 35.7% of them expressed challenges some time.
• Identifying bottlenecks and wait time to work items at different stages of software development process, 48% of the respondents expressed difficulty in most of the time, followed by 35.7% of the expressed challenges some time.
• In getting leadership commitment for deploying Lean Sigma programs, 53.1% of the software professionals expressed challenges most of the time, and 28.6% of them expressed challenges some time.
• 49% of the professionals expressed challenges most of the time, followed by 30.6% of them expressed challenges some time in aligning the goals, and
objectives of software development projects with the organization’s strategic goals, and objectives.

- In setting financial benefits to Lean Sigma effort, 49% of the software professionals expressed challenges most of the time, followed by 33.7% of them expressed challenges some time.
- In designing Lean Sigma framework for the software development process, 46% of the respondents expressed challenges most of the time, followed by 29.6% of them expressed challenges some time.
- 42.9% of the professionals expressed challenges most of the time, followed by 35.7% of them expressed challenges some time in identifying and creating metrics to evaluate Lean Six Sigma framework to software development projects.

Section VI: The main findings on the validation of the proposed conceptual model for implementing Lean Sigma to the software development process:

- Most of the respondents (94.9%) expressed that visual workflow will help to know the status of work items being developed at different stages of software development process and will bring more transparency into the team.
- 80.6% of the respondents from both service and product groups were in the agreement that the proposed Lean Sigma model will help to improvise the workflow in our software development process to achieve shorter-lead time.
- 78.6% of professionals expressed that the proposed Lean Sigma model will help analyzing and monitoring our software development process closely to assure that unexpected changes or variations do not occur.
- 80.6% of respondents from both the segments (service and product) expressed that with the proposed Lean Sigma framework, the results of process changes are measured to confirm the desired improvements to software development process.
- More than two-third of the respondents (73.5%) from service and product companies expressed that the proposed Lean Sigma model will increase the chances of our project being assessed and supported by top management are good.
• More than two-third of the total respondents (73.5%) from service and product segments were in the agreement that complete visibility into all work items and their workflow help identify and eliminate non-value-add activities in our software development process.

• 65.3% of the respondents from service and product segments expressed that with the Lean Sigma model that the software development process can be updated or changed incrementally to better process for improved quality and productivity.

• More than two-third of the professionals (68.4%) expressed that Value Stream Map (VSM) encourages team members to involve actively in creating processes and procedures to optimize the process.

5.3 Part II: Summary on the Verification of the Hypotheses

The summary on the verification of the hypotheses in the present study are:

**H$_{0.1a}$**: There are no significant advantages in adopting Lean Sigma approach to improve the capability of the software development process.

The null-hypothesis H$_{0.1a}$ stated as ‘There are no significant advantages in adopting Lean Sigma approach to improve the capability of the software development process’, is not supported as the one-sample t-test revealed that, there existed significantly more advantages of Lean Sigma approach to improve the capability of software development process than the expected advantages. In other words, we reject the null hypothesis and accept the alternate hypothesis. There are significant advantages in adopting Lean Sigma to improve the capability of software development process.

**H$_{0.1b}$**: There is no significant difference in the advantages between service and product oriented software companies in adopting Lean Sigma approach to improve the capability of the software development processes.

The null-hypothesis H$_{0.1b}$ stated as ‘There is no significant difference in the advantages between service and product oriented software companies in adopting Lean Sigma to improve the capability of the software development process’, is accepted as the independent samples t-test on various statements on the advantages of Lean Sigma to improve software development process revealed that there were no statistically significant differences in the opinion between service and product segments. In other
words, the null-hypothesis is supported as the pattern of responses is statistically
similar between service and product oriented software companies.

**H\textsubscript{0.2a}: The knowledge of Lean and Six Sigma among software professionals is not sufficient to improve the capability of the software development process.**

The null-hypothesis H\textsubscript{0.2a} stated as “The knowledge of Lean and Six Sigma among software professionals is not sufficient to improve the capability of the software development process” is not supported as the test statistics revealed the there existed significantly more knowledge on Lean and Six Sigma among software professionals to improve the capability of software development process than the expected knowledge level. Therefore, the null-hypothesis is rejected and alternate hypothesis is accepted. The knowledge level of Lean and Six Sigma approaches is sufficient among software professionals to improve the capability of software development process.

**H\textsubscript{0.2b}: There is no significant difference in the knowledge of Lean and Six Sigma among software professionals between service and product oriented software companies to improve the capability of the software development process.**

The null-hypothesis H\textsubscript{0.2b} stated as ‘There is no significant difference in the knowledge level of Lean and Six Sigma among software professionals between service and product oriented software companies to improve the capability of software development process’, is partially accepted as for few statements on the knowledge level of Lean and Six Sigma, test statistics revealed significant differences and for few statements non-significant differences. It is also observed that for few statements, the knowledge level is non-significant in only one segment. In other words, the knowledge levels on Lean and Six Sigma among software professionals to improve the software development process were not same for few statements in service and product oriented companies. Therefore, we partially support the null-hypothesis.

**H\textsubscript{0.3a}: There is no sufficient favorable attitude among software professionals towards implementing Lean Sigma to improve the capability of the software development process.**

The null-hypothesis H\textsubscript{0.3a} stated as “There is no sufficient favorable attitude among software professionals towards implementing Lean Sigma to improve the capability of software development process” is not supported as the one-sample t-test revealed that, there existed a significantly higher agreement on the favorable attitude among software
professionals towards implementing Lean Sigma to improve the capability of software development processes than the expected level of agreement. In other words, we reject the null-hypothesis.

\( H_{0.3b} \): There is no significant difference in attitude among software professionals between service and product oriented software companies towards implementing Lean Sigma to improve the capability of the software development process.

The null-hypothesis \( H_{0.3b} \) stated as “There is no significant difference in attitude among software professionals between service and product oriented software companies towards implementing Lean Sigma to improve the capability of software development process” is supported as the test statistic revealed that there existed non-significant differences between service and product groups. In other words, the attitude among software professionals towards implementing Lean Sigma to improve software development process was same in service and product segments. Therefore, we accept the null-hypothesis.

\( H_{0.4a} \): There are no significant opportunities for implementing Lean Sigma to improve the capability of the software development process.

The null-hypothesis \( H_{0.4a} \) stated as “There are no significant opportunities for implementing Lean Sigma to improve the capability of the software development process” is not supported as the one-sample t-test revealed that, there existed significantly more opportunities in Lean Sigma approach to improve the capability of software development process than the expected opportunities. In other words, the null hypothesis is rejected, and alternate hypothesis is accepted. There are significant opportunities in implementing Lean Sigma to improve the capability of software development process.

\( H_{0.4b} \): There is no significant difference in opportunities between service and product oriented software companies in implementing Lean Sigma to improve the capability of software development process.

The null-hypothesis \( H_{0.4b} \) stated as “There is no significant difference in opportunities between service and product oriented software companies in implementing Lean Sigma to improve the capability of software development process” is supported as the independent samples t-test revealed that there were no statistically significant
differences between service and product segments. Therefore, the null-hypothesis is accepted.

\( H_{0.5a} \): There are no challenges in implementing Lean Sigma to improve the capability of the software development process.

The null-hypothesis \( H_{0.5a} \) stated as “There are no challenges in implementing Lean Sigma to improve the capability of the software development process” is not supported as the one-sample t-test revealed that, there existed significantly more challenges in implementing Lean Sigma approach to improve the capability of software development process than the expected challenges. In other words, we reject the null hypothesis and accept the alternate hypothesis. There are significant challenges in implementing Lean Sigma framework to improve the capability of software development process.

\( H_{0.5b} \): There is no significant difference in challenges between service and product oriented software companies in implementing Lean Sigma to improve the capability of the software development process.

The null-hypothesis \( H_{0.5b} \) stated as “There is no significant difference in challenges between service and product oriented software companies in implementing Lean Sigma to improve the capability of the software development process” is partially accepted as for few statements on challenges in implementing Lean Sigma, test statistics revealed significant differences and for few statements non-significant differences. It is also observed that for few other statements the challenges are significant for only one segment. In other words, some challenges in implementing Lean Sigma to improve the software development process were not same in service and product oriented companies. Therefore, we partially support the null-hypothesis stated as there is no significant difference in challenges between service and product oriented software companies in implementing Lean Sigma to improve the capability of software development process.

\( H_{0.6a} \): The implementation of the proposed conceptual model for Lean Sigma will not improve the capability of software development process.

The null-hypothesis \( H_{0.6a} \) stated as “The implementation of the proposed conceptual model for Lean Sigma will not improve the capability of software development process” is not supported as the one-sample t-test revealed that, there existed a significantly higher agreement among software professionals that the proposed
conceptual model for Lean Sigma could improve the capability of software development processes than the expected level of agreement. In other words, we reject the null-hypothesis.

H_{0.6b}: There is no significant difference between service and product oriented software companies on the implementation of the proposed conceptual model for Lean Sigma to improve the capability of the software development process.

The null-hypothesis H_{0.6b} stated as “There is no significant difference between service and product oriented software companies on the implementation of the proposed conceptual model for Lean Sigma to improve the capability of software development process’, is partially supported as for few statements on the proposed conceptual model for Lean Sigma, test statistics revealed significant differences and for few statements non-significant differences. In other words, the agreement on the proposed conceptual model for Lean Sigma to improve software development process was not same for few statements in service and product segments. Therefore, we partially accept the hypothesis.