

The History And Development Of Six Sigma Quality Management

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Abstract— As of late, the Six Sigma Quality Management Methodology has evolved to become an increasingly vital aspect of business organizations, enabling them to both optimize processes and improve the quality of products and services. A comprehensive analysis on the gradual evolution and inception of Six Sigma quality management was conducted. In addition to this, a quantitative analysis of survey results obtained from both the Australian manufacturing and service sectors were carried out. This was done so that correlations between Critical Success Factors and benefits could be examined. Furthermore this allowed us to gauge the current landscape and development of Six Sigma understanding, so as to identify any potential lapses in Six Sigma knowledge.

Keywords—*quality; management; six sigma, organisation*

I. INTRODUCTION

A. The Need for Quality

Quality management has become increasingly important in recent decades as a direct result of increased globalisation and trade. Furthermore, the continual advancement of the World Wide Web has also facilitated trade and bridged consumers with a myriad of manufacturers and retailers from across the world. Due to the increasingly integrated nature of the global economy along with the benefits of being exposed to international markets, it is understood that there are no shortages of products and services for consumers. As such, businesses in the customer driven service industry and the manufacturing industry must explore for other dimensions in which they are able to ensure unrivalled efficiency in operations to allow for adequate profit margins and business viability.

As a result, organizations are finding it increasingly difficult to compete solely on the premise of price and as such, the emphasis on quality and efficiency in processes became the thrust of competitive advantage. Competitive advantage is a major driver in the use of quality management methodologies; with those who are able to produce a quality product through the most efficient processes with the highest amount of customer satisfaction, gaining a competitive edge over other organizations. This is also the definition of competitive advantage.

B. Brief Introduction to Six Sigma Quality Management

Six Sigma Quality Management is the prodigy of all the traditional quality management methodologies that precede it, borrowing heavily from the concepts of TQM, TQC and SQC. It further extends on the lapses of the aforementioned traditional quality management techniques and has gained worldwide recognition in saving organizations billions of dollars. At the same time, Six Sigma is renowned in optimizing the efficiency of processes throughout the organization. Six Sigma transcends traditional quality management methodologies in the sense that its application is not limited solely to manufacturing neither as an industry nor as a process. Increasing amounts of literature suggest that its application has extended to provide for industries such as service, health or government and its process improvements increasing the efficiency extending beyond invoicing and billing.

C. Nature of Research and Purpose

This paper aims to heavily explore the history and the development of Six Sigma Quality management. In terms of the history, an extensive literature review will be conducted to examine the roots of Six Sigma, the economic conditions present during its inception and its links to the traditional quality management methodologies. Furthermore, an analysis on its workings and successes in the organizations that have successfully implemented Six Sigma will be discussed in detail. The information obtained through the qualitative literature review will be used as the foundations through which the quantitative aspects of this research can take place. Furthermore, by gaining an understanding of the history of Six Sigma as well as the fundamental concepts embraced by it, the author is able to benchmark the level of Six Sigma understanding in Australia.

In terms of examining the developments of Six Sigma, a quantitative research survey will be constructed as a mean of gathering data from organizations across Australia, both whom actively manufacturing and services industries. This is because firstly, Six Sigma was initially implemented in the manufacturing sector; and secondly, to the services industry as extant research suggests an increasing trend for Six Sigma implementation in this industry. The data that the author wishes to obtain is regarding the Australian employ Six Sigma and those whom don't. The recipients of the survey will be addressed primarily to industry's perception of the concepts regarding Six Sigma quality management, their quality initiative history prior to Six Sigma, what the Australian industry deems to be critical, the benefits they have attained and finally, the extensions of Six Sigma in the sense of its fusing with other management techniques. A statistical analysis via use of SPSS will be conducted and correlations will then be computed to identify trends in Australian Six Sigma Quality Management. Furthermore, the results will also allow for the comparison between Six Sigma organizations in other countries so shed further light into the current landscape of Six Sigma quality management in Australia.

Ultimately, this research thesis is divided into two components; the first is the historical significance of Six Sigma quality management and the concepts and philosophies that it entails; secondly, the developments in knowledge, recognition and extensions of Six Sigma in the current Australian manufacturing and services industry. Ultimately, this thesis aims to provide value to the quality management circle by identifying potential lapses and inefficiencies in the knowledge of the Six Sigma methodology in Australia. Furthermore, the statistical analysis conducted will also identify areas which drive the greatest amounts of benefits in Six Sigma implementation so as to assist in organizations developing specific areas of Six Sigma implementation. Lastly, this will also enable the author to gauge the status of development in the evolution of Six Sigma quality management through its extensions with other quality management techniques.

II. LITERATURE REVIEW

A. Introduction

Six Sigma quality management has gained worldwide recognition since its creation by Bill Smith of Motorola in 1986 [1]. Prior to the inception of Six Sigma, various forms of quality management doctrines such as TQM were employed as a means of attaining quality in products manufactured. However, it is without a doubt that the status of worldwide quality in the current years far surpasses that of the time when Six Sigma was initially founded. This could be attributed to improved technology leading to better and more precise machinery used within the manufacturing processes. However, more importantly, this has been a direct result of better quality management doctrines and techniques which have facilitated the development of innovative machinery and processes.

History shows that Six Sigma quality management has allowed organizations to operate at levels where the number of defects has been significantly low, allowing them to realize substantial financial savings.

The understanding of Six Sigma continues to develop as companies increasingly embraces this methodology as the means of generating quality in production and processes. Extensions have also recently been developed as a means of further facilitating improved quality processes as can be seen by the fruition of the method known as 'lean six sigma'.

Ultimately, this literature review will investigate the history of Six Sigma in terms of its creation, its use and its similarities between traditional quality management techniques such as Quality Control (QC), Total Quality Control (TQC) and Total Quality Management (TQM). Its development, in terms of its understanding and extensions will also be analyzed to ultimately gauge both Six Sigma's history and development.

B. Fundamentals of Six Sigma Quality Management

Six Sigma quality management, similar to TQM, employs a philosophical approach in attaining quality in manufactured products and services. The significance of Six Sigma Quality Management is that it incorporates the key elements of all the workings of the quality gurus such as Deming, Juran, Crosby and Ishikawa as well as the management practices of SQC, TQC and TQM. This is further supported by the statement that Six Sigma methodology features a "customer focused, data driven and robust methodology to improve processes and reduce costs" [2]. Ultimately, the five quintessential features of Six Sigma quality management revolves around its use of statistical tools, its customer driven focus & management style, its systematic problem solving method, its specific role structure and lastly, its substantially heavy focus on metrics.

Six Sigma relies heavily on statistics to assist in the quality improvement process and this can be seen through the heavy use of statistics in effectively monitoring the progress of projects at various stages. Similar to Shewhart's work on SPC, Six

Sigma employs use of statistics in order to identify potential hindrances or 'bottle necks' in processes in order to improve them. This is further supported by the definition of Six Sigma which suggests that "Six Sigma is a systematic quantitative approach for improving manufacturing or service processes" [3]. Therefore, through various literature publications, it is understood that Six Sigma utilizes statistical processes in order to track, monitor and improve processes.

According to the American Standard of Quality (ASQ), Six Sigma was first instigated by Motorola in 1986 by an engineer name Bill Smith. Further developments of pre-existing quality management approaches such as TQM led to the inception of a revolutionary quality management tool known as Six Sigma Quality Management which was able to address TQM's shortcomings [4].

Pivotal to the inception of Six Sigma, the Chief Executive Officer (CEO) at the time, Bob Galvin was under immense pressure from competition of Japanese technology manufacturers. Furthermore, Galvin was concerned with the amount of warranty lodgments of Motorola products and this can be supported by the statement where "traditional quality levels that measured defects in thousands of opportunities did not provide enough quality results" [5]. As a result of this, a new standard in quality was insisted, and a revolutionary idea was proposed to measure defects (a term used to describe a product that did not satisfy the customer) to be measured in millions as opposed to thousands. This lay the fundamentals for Bill Smith to implement an innovative, cutting edge methodology known as Six Sigma Quality Management to rid the cost of poor quality.

The fact that Six Sigma methodology has become widely adopted can be seen through its use as a core quality improvement initiative in industries such as service, health, government, defense and even education. Six Sigma implementation within the service industry is suggested to be "growing slowly but steadily" [3]. The ultimate focus of Six Sigma implementation in service industries revolves around improving the overall customer experience. Similar to Deming's teachings, the philosophy behind improving customer satisfaction is customer retention and word of mouth. It is suggested that by applying Six Sigma to improve service times, waiting times as well as delivery times, these will lead to an increase in the quality of service provided. Subsequently, these will decrease the amount of customer complaints whilst at the same time increase the efficiency of processes.

Another example which highlights the broad spectrum of Six Sigma applications, can be found through its use in the health industry. In a study completed by Feng and Manuel it was suggested that Six Sigma has been "slowly but successfully implemented by healthcare institutions" [2]. Within the healthcare industry the most apparent improvements in quality would be a decrease in medical errors. However, if the processes involved in the health industry are broken down, it can be understood that factors such as timeliness, patient satisfaction and the efficiency of physicians are avenues that can be improved. In addition to this, various health departments exist within the health industry and it is suggested by Cherry and Seshadri that the emergency department, admissions, invoicing and surgery documentation processes could all benefit through the implementation of Six Sigma [6].

There is no doubt that Six Sigma has evolved over the years and has adapted to become effective in all facets of business processes regardless of the industry. As such, Six Sigma is also seen as an effective tool through which business processes can improve.

III. SURVEY INSTRUMENT DESIGN

The literature review component of this research allowed for the establishment of links between the differing philosophies of traditional quality management practices, such as QC, TQC and TQM. This ultimately provided the essential groundwork through which a data acquisition tool in the form of an online survey could be created. This is a major component of the research, serving to generate data to facilitate the understanding of the history and development of Six Sigma Quality Management.

By analyzing the various quality management practices as well as the philosophies taught by that of the quality gurus, one is able to gauge the trends in development as well as similarities between the aforementioned doctrines. Further to this, the in-depth analysis of Six Sigma quality management allowed for an understanding of the quintessential features of Six Sigma; features that ultimately led to its dominance in the space of quality management.

This survey was adapted through extant empirical research from [3] and [7] whom also employed the use of a survey tool in their research. The adaptation created an initial starting point through which further refinements and additions could be made. This ensured that the survey could effectively produce the required data to encapsulate both aspects of the history, as well as the development of Six Sigma quality management. Furthermore, the adaptation would significantly increase the

comparability of results whilst at the same time allow the survey to branch off to other aspects of the investigation relating to the history and development of Six Sigma.

The primary design philosophy revolving around this survey instrument is that a heavy emphasis is placed on the ability to gauge the entire spectrum of companies within the space of the service and manufacturing industries. More specifically, one of the critical goals of this survey instrument is the ability to gather information from organizations irrespective of its size and quality management implementation history. By designing a survey in this manner, it is believed to allow for a 360 degree view in the landscape of quality management within Australia. Reason being is that firstly, the survey doesn't discriminate against small and medium enterprises in its ability to implement Six Sigma.

Secondly, this research study aims to explore the history of Six Sigma, therefore by incorporating close ended probing questions into the participant's company's quality management implementation history, it allows for an understanding as to the transition to Six Sigma quality management.

Ultimately, the philosophy regarding this data acquisition tool is to allow for an understanding of the current status of quality management in Australia, with a focus on Six Sigma. As such, it is required that information be obtained on features that Australian companies deem to be critical success factors, the benefits that they have obtained from a customer focus, the doctrine of quality management that they are currently employing and lastly, whether there will be any plans for the future adoption of Six Sigma.

These data, when compared to extant research, will allow for the comparison between the successes of Six Sigma in other countries, whilst at the same time, illustrate the development of Six Sigma methodology in Australia. The factors in which other countries deem as critical success factors allowing them to report significant benefits can then be compared to those factors that Australian companies believe to be critical. Subsequently, this allows for the cross referencing of benefits and the extent of differences can also expose any potential lapses in understanding. Ultimately, these can show areas where quality management implementation can be improved and assist in gaining better results.

A. Sample Pool and Selection

As mentioned above, the strength of this research is in its ability to gauge the six sigma quality management initiatives of the whole scale of organizations within Australia. This means that small to medium enterprises will be invited to participate in this research along with the much larger organizations that are within the manufacturing and service industries. In conducting the research in this manner, it is hoped that a clearer and more holistic perception of the current landscape of six sigma quality management within Australia can be achieved.

The initial distribution of the online survey was conducted in August 2014 and completed in October 2014. In order to maximise the number of relevant respondents who are actively involved in quality management, a database was found from a Quality Control Services register and the accredited companies were researched and subsequently used to populate the sample frame. The selected companies from this list were primarily Small to Medium Enterprises whom were ISO9001 accredited. A distinct register for Six Sigma companies within Australia could not be found. Therefore by distributing the proposed survey to companies who have an existing quality commitment, it was hoped that there will be a higher chance that the company responds and are also employing or contemplating Six Sigma methodology.

The professional online social networking platform known as LinkedIn was also used to identify prospective participants to complete the survey. The primary reason behind this is because one of the main concerns in contacting companies directly through email is the fear that the survey will get lost in the process of being forwarded to the relevant quality professional. Hence, by using the search function on LinkedIn to effectively identify a quality professional in a certain company, the 'middle man' is effectively removed, resulting in a much smoother process in contacting a specialised quality professional and soliciting a response. Furthermore, by selecting respondents in this manner, the reliability as well as the quality of the results obtained will both be higher. This is due to the fact that they will likely be more involved in the quality management or quality improvement processes of the company and as such be able to answer the survey questionnaire with more expertise.

B. Survey Instrument Selection

The survey instrument used within this research will be an online survey questionnaire administered through the survey platform known as Key Survey. While mail out postal surveys continues to be the most common form of gaining information

for research, it was felt that the heavily integrated nature of internet in today's businesses translates to the necessity of using an online survey. Furthermore, this appears to be the most efficient and convenient method for the prospective participants. This is due to the fact that the survey can be accessed through simply clicking a link forwarding them to the survey platform. This contrasts the traditional mail out questionnaires where the survey is required to be filled out using a pen and then processed through a mailing room. The use of an online survey, similar to lean methodology, will effectively rid certain processes that are not value adding and as such improve efficiency in the process. The use of an online survey is a great example of this, whereby the start to end process of the participant starting the survey to completing it, can all be completed online and on the same web page.

IV. RESULTS AND DISCUSSION

A. Response Rate

In order to ensure accuracy and validity of the discussion and analysis of the results obtained, it was an aim to ensure that the highest amount of responses be obtained. As discussed previously, the method in which the surveys were dispersed was through use of both an electronic mail (Email) platform and LinkedIn's 'In-mail' service. Though it was determined that there was no maximum limit as to the amount of responses to collect, a minimum amount of response rates were enforced. It was deemed that 10% was the minimum amount of response rates that should be aimed for in order to carry out a reliable analysis of the results. This was the minimum that must be obtained prior to the analysis of results.

Through the email dispersion of the survey, it was a difficult task to obtain high amounts of responses. There were factors based on the various security features inherent in a company's emailing system as well as the period in which the surveys were distributed. Some recipients of the email suggested that they never received the survey email and this was understood to be due to the company's spam filters preventing the email from reaching the person in question. Another main reason, which was predicted above, was due to the email being from an unfamiliar source which would have caused the recipient to question its authenticity.

LinkedIn's In-Mail platform was somewhat more effective in soliciting responses. This was most likely due to the fact that they could easily check the authenticity of the In-Mail through checking the profile of the sender of the In-Mail. An authentic profile on LinkedIn would most likely have a pool of connections along with a thorough description of their professional profile. This method proved to be an efficient method of soliciting responses as the wait time between sending the survey to the completion of the survey was significantly faster than that of the generic email dispersion. Another factor that leads to a higher response rate through use of LinkedIn is due to the fact that it effectively eliminates the 'middle-man' or the 'gatekeeper' of the quality professionals at their respective companies. At times, where the direct email of the quality professional cannot be found, the survey would be sent off to the administration desk or operations email of the company. However, this decreases the overall success of the email reaching the desired individual as the survey email would potentially be filtered into a spam mail box, ignored or even deleted, resulting in the survey email not reaching anyone at all. As such, LinkedIn was able to allow the author to directly contact the quality professional so as to request his professional expertise.

Out of the 265 survey emails that were dispersed during the period from September to October, 43 professionals responded to the survey. However, of the 43 professionals whom responded, 16 responses were incomplete. As such only 27 responses were used within the analysis, representing a response rate of 10.2%. This percentage of response rate, as mentioned above, was deemed adequate to begin the data analysis.

B. Descriptive Analysis of Results

An in-depth analysis and discussion into the data received from the completed survey can be found below. The findings and peculiarities from the analysis will also be emphasized based on the responses received. Furthermore, it will be interesting to establish links between the data gathered from the current industry to the history and development of Six Sigma quality management.

However, it is important to note that when creating the survey, there was a greater emphasis placed on gaining information regarding the development of Six Sigma, in terms of both knowledge and extensions. This will ultimately provide for a more in depth view as to the current landscape of Six Sigma quality management and how it has evolved in the Australian industry.

1) Respondent Demographics:

The first section of the survey was designed to act as a filtering tool as well as a tool to gather data on the background and demographics of the respondents. Due to the confidential nature of the data needed for the survey, it wasn't required for the exact company name to be provided. What was important however, was the establishment of the industry that the respondents are within. Although the scope of the research was limited to manufacturing and service industries, these branch off into their dedicated sub industries such as retail, cleaning and telecommunications as an example. Furthermore, it allowed for an understanding of the current status and years of six sigma quality management implementation within Australia.

2) Status of Six Sigma Quality Management in Australia:

The first question within the survey aimed to establish the level of use in the Six Sigma methodology. One can argue that the higher the level of use in Six Sigma, the greater its development in terms of its understanding. Ultimately, there are other factors that need to be considered; for example the size of the organization and the history of quality management within the organization. However, the answers provided by the first question will provide a very rudimentary understanding as to the level of development of Six Sigma in Australia. The fact that it also acts as a filtering question broadens the idea of 'Six Sigma development' by attempting to identify reasons to its potential abandonment if present within the survey results. However, the survey results suggested that there were no abandonment of the Six Sigma methodology by the surveyed companies. Figure 1 below shows the level of Six Sigma use within the surveyed companies

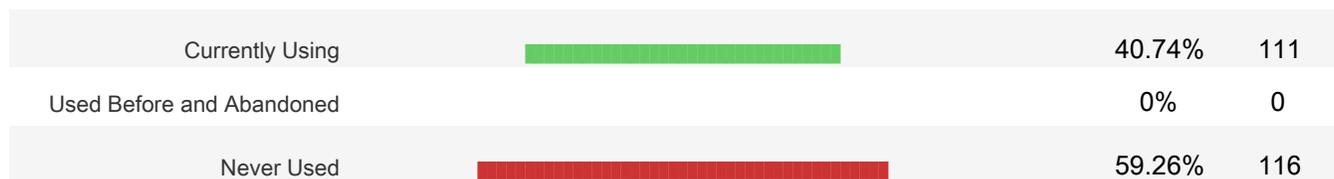


Fig. 1: Level of Six Sigma use in Australia

As can be seen in the figure above, there is a higher percentage of those whom don't actively employ Six Sigma as opposed to those whom do. However, there has been no responses for whether Six Sigma has been "Used before and abandoned". This sheds light on the possibility that Six Sigma is still within its early stages of development and as such its recognition and use isn't as substantial as would have imagined. However, comparing these results with Feng & Manuel (2007) whom conducted a national survey on the implementation of Six Sigma of US healthcare services, found that 27% of the respondents were at the time formally implementing Six Sigma quality management.

Similarly, Chakrabarty et al [3], in a study of Six Sigma implementation by Singaporean Service industries, found that 20% of respondents has an active involvement in the implementation of Six Sigma. Furthermore, in a study by Zu et al (2006), it was found that 21.6% of US manufacturing plants have been actively employing Six Sigma in their manufacturing operations. To better understand the reasons as to whether this percentage is prone to change, if the respondent answered 'never used', they will be asked a qualitative question whether or not there are plans for the future adoption of Six Sigma. Figure 2 below shows the percentage respondents answering whether or not there were any plans for the future adoption of Six Sigma Quality Management.



Fig 2: Whether there were plans for the adoption of Six Sigma

As can be seen from the data acquired, those whom didn't have any plans for the future adoption of Six Sigma are significantly greater than those whom had plans for Six Sigma's future adoption. Some of the reasons as to why there were no plans of Six Sigma Adoption can be found below:

3) History of Quality Initiatives Prior to Six Sigma Methodology:

In lieu with analysing the history of Six Sigma quality management, it would be useful to analyze the trend between the uses of traditional quality management prior to the organizations transition to Six Sigma methodology. Through the various publications and journal articles that were reviewed, it was believed that a significant number of core philosophies that are inherent in Six Sigma were borrowed from TQM. However, the success of Six Sigma was suggested to be due to the fact that it could effectively address the shortcomings of TQM. Therefore, once the results on the history of quality initiatives that were implemented prior to Six Sigma methodology has been acquired, the focus can then be transferred into a survey as to why the organization transitioned to Six Sigma methodology. This will then provide additional background data regarding the history of Six Sigma quality management which is a major focus of this research. The recipient’s quality initiative history prior to Six Sigma implementation can be found in figure 3 below:

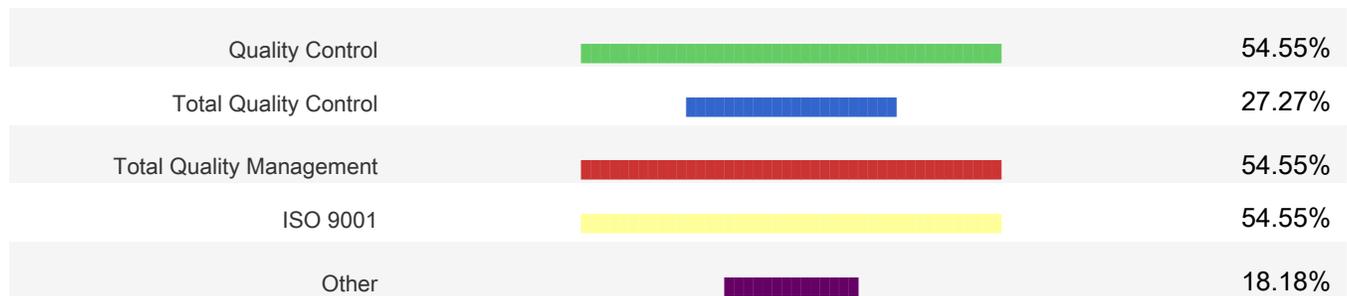


Fig.3 Six Sigma organizations' quality management history

As can be seen, 54.55% of respondents had previously employed TQM, QC or ISO9001 prior to the implementation of Six Sigma. 27.27% of respondents had previously employed TQC whilst 18.18% had selected ‘other’. Based on the results obtained, it would be interesting to understand the reasons as to why organizations made the transition from these aforementioned quality initiatives to Six Sigma quality management. In addition to this, a correlation analysis between Six Sigma implementation and quality management implementation history will shed light into whether or not there is a link between traditional quality management practices and Six Sigma implementation.

4) Reasons for the Transition to Six Sigma Quality Management:

An alternative method to gauge the development of Six Sigma quality management is through analysing the reasons as to why organizations have transitioned from the use of alternative quality management initiatives to Six Sigma. In order to obtain data regarding this question, qualitative open ended questions were used. This is done so as to increase the transparency of the many reasons as to why Six Sigma methodology has been adopted. The data received from those respondents whom completed this survey question can be found in figure 4 below.

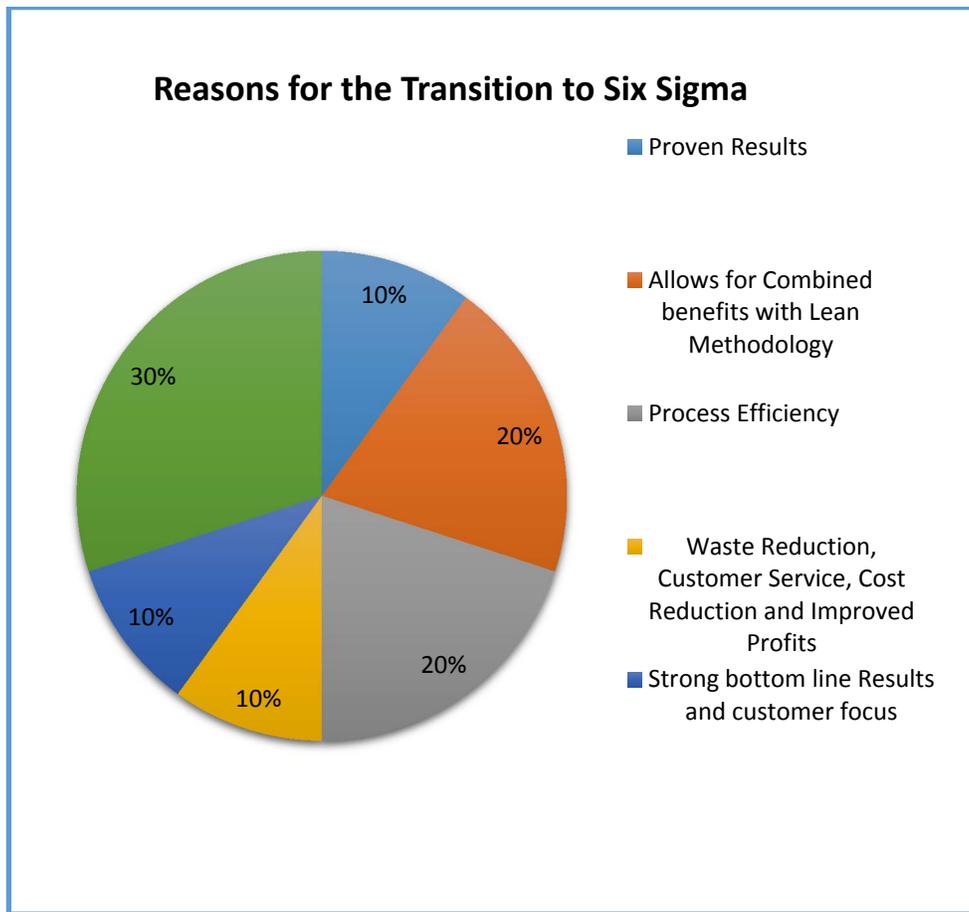


Fig. 4 Reasons for transition to Six Sigma

5) Years of Six Sigma Implementation:

In analyzing the development of the Six Sigma methodology within Australia, another question was asked in order to acquire data on how well established Six Sigma is. Within this research, it is assumed that the greater the number of years of Six Sigma implementation, the greater the ability for organizations to gain experience and develop their understanding of Six Sigma. Ultimately, with greater developments into the understanding and knowledge of Six Sigma, there will be greater success in the implementation of Six Sigma. This will subsequently increase the ability of firms to lead the nation by example through their quality improvements and encourage further adoption of Six Sigma by more organizations. Figure 5 below shows the number of years that Six Sigma has been implemented within the respondent's organization.

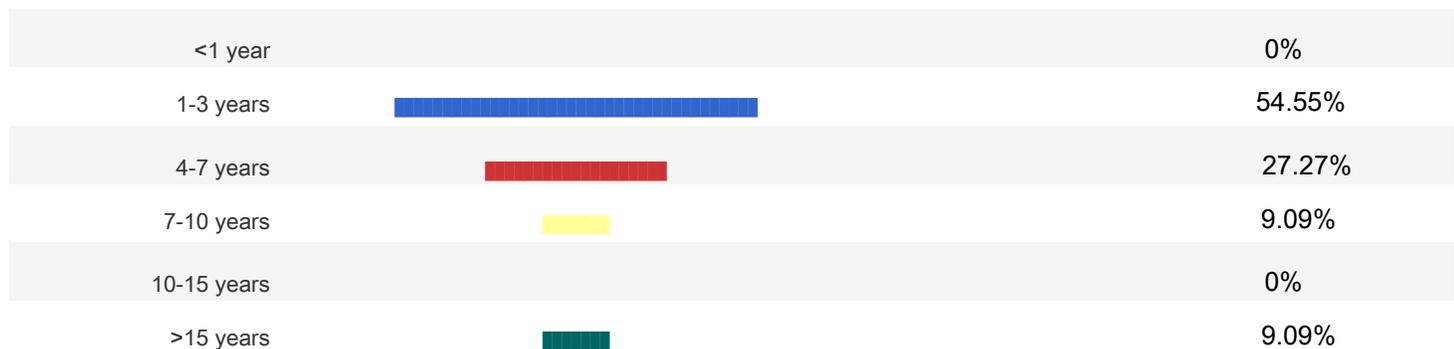


Fig 5 Years of Six Sigma Implementation

As can be seen above, only 9.09% of the respondents have been implementing the Six Sigma methodology for a period of greater than 15 years. The majority of respondents, representing 54.55% of total respondents currently employing Six Sigma have implemented it for only 1-3 years. This is followed by 27.27% of all respondents implementing Six Sigma for 4-7 years and then 9.09% of the respondents implementing it for a period of 7-10 years.

Similar to a study completed by Feng & Manuel [2], their survey on US organizations showed that 60% of total respondents have implemented Six Sigma for a period of 1-4 years, with only 7% of respondents having employed Six Sigma for a period greater than 4 years. The remaining 33% of respondents have implemented Six Sigma for less than a year. Feng and Manuel [2] concluded that based on the data gathered, Six Sigma implementation was still at its 'infancy' stages. Contrasting this to the survey results obtained in this research, it can be suggested that Australia's level of Six Sigma development isn't much more advanced than that of the US when basing the analysis off Feng & Manuel's research. However, in light of the above assumption that the greater the period of Six Sigma implementation, the greater development of its understanding; both the interesting and important fact is, that the years of Six Sigma implementation in Australia has been greater than that of the US when compared to the study conducted by Feng & Manuel [2], thus suggesting a higher level of development.

V. SUMMARY OF FINDINGS

Through the survey conducted, it was found that although the amount of Six Sigma implementation in Australia was higher to that of other countries, in the author's view, the organization's perception of Six Sigma and its potential are still developing. Furthermore, the

- Adoption of Six Sigma methodology is solely triggered by past experiences of senior executives and published results.
- Six Sigma is still within its early stages of development and as such its recognition and use isn't as substantial as would have imagined. Even so, Six Sigma has developed to a stage where it has become synonymously implemented with Lean methodology.
- From the findings, there exists a trend that Six Sigma implementation requires an organization that is well established and in the upper scales in terms of size. This supports the findings of [8] and [9].
- It was interesting to note that those who aren't currently employing Six Sigma sees no need for Six Sigma's future adoption.
- All responses believe that the specified CSF's are important in achieving success in the implementation of Six Sigma. This indicates that there is an understanding in this facet of Six Sigma methodology.
- All Six Sigma users in the survey agreed that DPMO has decreased since the implementation of Six Sigma, however, there are not as many organizations who are operating near their specified Six Sigma level. This also implies that this methodology is still in its' early stages of development.
- Majority of respondents agreed that Six Sigma has allowed them to perform in terms of financial benefits, customer service implications and productivity implications. Though, hypothesis testing suggests that there are no substantial differences present in Australia currently, in terms of performance in these benefits and implications for non Six Sigma users.
- In order to gain a thorough understanding of how Six Sigma CSFs and implications all affect one another, a correlation analysis was performed. This test expressed an importance of upper management commitment, customer satisfaction and customer retention in regards to increasing revenue for Six Sigma users.
- Overall, it can be drawn from the data that the full potential of Six Sigma's benefits has yet to be realized within Six Sigma's development within Australia.

VI. CONCLUSION

This paper aimed to explore the history as well as the development of Six Sigma quality management and this was done so through both a qualitative and quantitative analysis. The qualitative analysis of this research was conducted through a literature review of existing research conducted over the years on the topic of Six Sigma quality management. Since a crucial aspect of this research revolves around the history of Six Sigma, the author believed that it was necessary to analyze the workings of Six Sigma along with its fundamental concepts critical to its success. This was done so that it would enable the author to draw links from Six Sigma quality management to traditional quality management techniques such as Quality Control, Total Quality Control and Total Quality Management.

In addition to this, by exploring the background of Six Sigma and comparing the factors which are deemed critical to the success of Six Sigma, this can allow for benchmarking of the level of knowledge Australian industries comprise on Six Sigma. This also assisted the user with the adaptation of the survey instrument such that the information required from organizations can be acquired. The survey was distributed to 265 respondents from manufacturing and service organizations as found from a list found on a quality services control register. The authors believed that since the organizations already had an active role in quality improvement, there would be higher chances of them also employing Six Sigma. In addition, organizations relevant to the manufacturing and services industry from the ASX200 list of publically listed companies was consulted contacted. Furthermore, LinkedIn was also used as a platform to solicit higher response rates as it allowed the author to directly contact relevant quality professionals.

Unfortunately, despite efforts to solicit higher response rates through employing the methods suggested by Dillman's Total Design Methodology, the response rate of the survey was 10.2% which was only marginally higher than the minimum 10% deemed adequate for a reliable data analysis.

Through the literature review, it is understood that the strength of Six Sigma lay in its ability to generate substantial costs savings and bottom line results. However, the questions that wanted to be answered in this part of the analysis were how Six Sigma was able to do so. In answering this question, the author was able to discover the critical success factors related to Six Sigma which yielded substantial benefits for organizations whom employed it. These were Six Sigma's focus on upper management commitment, customer driven focus, its focus on metrics and statistics as well as its specific role structure on completing projects. By understanding these attributes, a survey could then be adapted to gauge how developed Six Sigma understanding is within Australian Manufacturing and Service Industries.

The results of the online survey were then computed via the statistical program known as SPSS and the current landscape of Six Sigma quality management within Australia was then inferred. Furthermore, a number of hypotheses tests were examined to determine the correlations between critical success factors and the benefits obtained by organizations employing Six Sigma. This will then allow for the identification of aspects of Six Sigma implementation that is potentially underdeveloped and will require further development. (The results are not shown because of page constraints)

In terms of its development, the survey results as well as the tests conducted suggest that whilst the recognition of Six Sigma in Australian organizations are relatively high, its understanding is still somewhat underdeveloped as its use is still within its infancy. Six Sigma's development in terms of its extensions and incorporation with other quality management methodologies were also analyzed. The survey results gave support to a number of existing researches conducted on Six Sigma and the results suggested that the majority Six Sigma users in Australia incorporated Lean methodology. As such, Six Sigma is not commonly implemented as a sole entity, rather it is implemented as what is known as Lean Six Sigma.

Six Sigma has the potency to allow organizations to gain a competitive edge in producing a quality product or service through the most efficient processes, with the highest amount of customer satisfaction possible. This research aimed to determine whether or not there were any lapses in knowledge regarding Six Sigma implementation as well as in determining whether organizations were reaping the full benefits of Six Sigma implementation. Future research into comparing Lean Six Sigma and Six Sigma as a separate entity could be initiated to determine whether the art of implementing Six Sigma is sufficient enough to be incorporated with another quality management methodology. It is believed that incorporating Lean into Six Sigma without adequate knowledge and experience in Six Sigma could effectively limit an organization's ability to reap Six Sigma's full benefits. This could ultimately be a hypothesis that could be tested in the future.

There are inherently a number of limitations within this research, with the main constraint being that of the low response rate. Although the level of response was at an adequate level, a higher number of responses would ultimately provide for a higher level of accuracy in the results obtained. As such, the author feels that in order to reliably capture the current landscape of six sigma quality management in terms of its developments, a higher response rate would be required. In addition to the decrease in reliability and accuracy of data as a direct result of a low response rate, it is also understood that the precision of the research could also be compromised. As such, for future research it would be suggested that the surveys be sent off earlier so as to allow for a longer period of receiving completed surveys. However, due to the constraint of time within this research, the survey was distributed as quickly as possible whilst still satisfying the approval requirements of the University. Ultimately, by obtaining a higher response rate, this would encourage a higher pool of responses and as such increase the reliability of the analysis of results.

Future research should be conducted in order to hone in on the potential shortcomings of Six Sigma to identify its areas of weakness. Quality management has been continually evolving and developing since the onset of Quality Control, with every new quality management methodology being able to effectively address the inadequacies found in the previous system. Six Sigma is no different and as with everything in life, nothing is perfect. Hence, by conducting an in depth analysis on the possible weaknesses of Six Sigma, this may allow for the development of a revolutionary new technique that may be more effective in improving quality.

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