IBIMA Publishing
Communications of the IBIMA
http://www.ibimapublishing.com/journals/CIBIMA/cibima.html
Vol. 2011 (2011), Article ID 823656, 15 pages
DOI: 10.5171/2011. 823656

Six Sigma: A Key Driver for Process Improvement

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Abstract

Six Sigma is a one of the most common used programs in production companies for reduce cost, improve productivity and provide a basis for goals improvement which leads to competitive advantage.
Understanding the key Six Sigma factors (Total Quality Management, strong customer focus, data analysis tools, financial results and project management) allows organizations to better support their strategic directions focused on improving customer requirements through the improving of own business systems and operational performances.
In this paper will be described a Six Sigma approach and presented results of the empiric research conducted in Croatian graphic companies. All findings of this empiric research will provide better understanding of Six Sigma benefits and graphic companies, but production companies will be able to guide business and production processes in right directions with minimizing inputs, maximizing outputs and satisfy owners, employees and customers.

Key words: Six Sigma, Process Improvement, Graphic Companies

Introduction

Process improvement is one of the most important tasks of the management in production companies. A contemporary business conditions in extremely turbulent environment with frequent technological changes require constantly adjusting of all activities with emphasis on a business and production process improvement which should be able to enable achieving a strategic goals.

Modern business practice recognizes many Process improvement techniques and Six Sigma program is one of the common used.

Six Sigma, a trademark of Motorola, was introduced 20 years ago has been characterized as the latest management fad to repackage old quality management principles, practices, tools and techniques (Clifford, 2001).
Six Sigma has been identified as a Process improvement approach that dramatically improves performances, enhances process capability and produces bottom line results for organization (Dasgupta, 2003; Linderman et al., 2003; Pantano at al., 2006). Also Six Sigma is defined as a business process improvement approach that seeks to find and eliminate causes of defects and errors, reduce cycle times and cost of operations, improve productivity,

better meet customer expectations and achieve higher asset utilization and returns (Evans and Lindsay, 2005). The focus of Six Sigma is on the customer rather than the product (Douglas and Erwin, 2000).

The success of Six Sigma programs hinges on the sequence of many Six Sigma elements such as management involvement, improvement specialist, performance metrics, systematic procedure and project selection and prioritization.

Six Sigma helps and organization become more ambidextrous by providing a switching structure that allows the organization to act more organically in coming up with new improvement ideas and operate more mechanistically when implementing those (Daft, 2001). Furthermore, the structure of Six Sigma employs numerous mechanisms that simultaneously promote the conflicting demands of exploration and control in the improvement effort. As a result, what is new in Six Sigma when compared to prior quality management approaches is more its organizational implementation rather than the underlying philosophy or the quality tools/techniques employed (Schroeder et al., 2008).

Theoretical framework

Process improvement

Process improvement is a series of actions taken by a process owner to identify, analyze and improve existing processes within an organization to meet new goals and objectives. These actions often follow a specific methodology or strategy to create successful results.

Process improvement results in costs associated with the purchase of new technology, modification of existing equipment, training employees, hiring new employees and investment in information technology infrastructure.

Six Sigma is the process management tool that has yielded the greatest results and Six Sigma is ranked much higher than other Process improvement techniques (see Table 1) (Dushmare, 2006).

Table 1: Rating of process improvement techniques

Process improvement tool	Impact (%)
Six Sigma	53,60
Process mapping	35,30
Root cause analysis	33,50
Cause and effect analysis	31,30
ISO 9001	21,00
Statistical process control	20,10
Total quality management	10,30
Malcolm Baldridge criteria	9,80
Knowledge management	5,80

A standardized process improvement methodology allows look at how to perform work. When all of the major players are involved in Process improvement, they can collectively focus on eliminating waste of money, people, materials, time and opportunities. The ideal outcome is that jobs can be done cheaper, quicker, easier and the most importantly safer.

Using set out tools, techniques and methods taken together with member's knowledge, experiences and efforts is a powerful approach to improving processes.

Six Sigma

Definition of Six Sigma

Six Sigma is an organized, parallel-meso structure to reduce variation in organizational processes by using improvement specialists, a structured method and performance metrics with the aim of achieving strategic objectives (Schroeder et al., 2008). This method is a project-driven management approach to improve the organization's products, services and process by continually reducing defects in the organization. It is a business strategy that focuses on improving customer requirements understanding, business systems, productivity and financial performance (Kwak and Anbari, 2006).

Six Sigma applies a structured approach to managing improvement activities, which is represented by Define – Measure – Analyze – Improve – Control (DMAIC) used in process improvement or Define – Measure – Analyse – Design – Verify (DMADV) used in product design improvement. Both of these procedures are developed in the classic Plan – Do – Check – Act (PDCA) cycle, but Six Sigma specifies the quality management tools and techniques to use within each step (Linderman et al., 2003).

Six Sigma initiatives generally include projects with a broad range of specific objectives, such as yield improvement, cycle-time reduction, inventory reduction, streamlining supplier relationship and improvement customer satisfaction (Shenhar et al., 1997).
Six Sigma programs improve organizational procedures and routines. Six Sigma assumes that the current organizational processes are sound but they need minor improvement to be efficient (Hammer, 2002). Six Sigma does not change the integrity and interconnectedness of organizational process; rather, in improves them (Parast, 2010).

Benefits of Six Sigma are visible in manufacturing (reduction in the number of manufacturing defects), research and development (products for competitive advantage) and financial sector (market share) in companies. So there are two perspectives of Six Sigma process: statistic and business viewpoint:

- Statistic viewpoint: the origin of Six Sigma comes from statistic and statisticians; the term of Six Sigma is defined as having less than 3.4 defects per million opportunities or a success rate of 99,9997% where sigma is a term used to represent the variation about the process average (Antony and Banuelas, 2002).
- Business viewpoint: Six Sigma is defined as a business strategy used to improve business profitability, to improve the effectiveness and efficiency of all operations to meet or exceed customer's needs and expectations (Antony and Banuelas, 2002).

Corporate Process improvement from Six Sigma programs represents a significant opportunity in terms of the reported gains in profitability and customer satisfaction (Dusharme, 2001).
The design of a Six Sigma program requires choices among many types of Champions, Black Belts, Master Black Belts or Green Belts practices (personnel involved in implementing Six Sigma in a company), such as different types of teams, reporting structures, employee selection and training, reward and recognition systems (Lucas, 2002).

Six Sigma strategies, tools, techniques and principles

Six Sigma is a systematic data-driven approach using the DMAIC process through the rigorous application of statistical tools and techniques. Table 2 presents Six Sigma strategies, principles, tools and techniques (Antony et al., 2003).

Table 2: Six Sigma strategies, principles, tools and techniques

Strategies and principles	Tools and techniques
Project management	Statistical process control
Data-based decision making	Process capability analysis
Knowledge discovery	Measurement system analysis
Process control planning	Design of experiments
Data collection	Robust design
Variability reduction	Quality function deployment
Belt system	Failure mode and effects analysis
DMAIC process	Regression analysis
Change management	Analysis of means and variances
	Hypothesis testing
	Root cause analysis
	Business process mapping

Structured methodology helps Six Sigma programs to identify the root causes of the problem, look for solution and improve the process.

Key factors for implementing a successful Six Sigma program in manufacturing and services organizations regarding Antony and Banuels (2002) are:

- Management commitment and involvement
- Understanding of Six Sigma methodology, tools and techniques
- Linking Six Sigma to business strategy
- Linking Six Sigma to customers
- Project selection, reviews and tracking
- Organizational infrastructure
- Cultural change
- Project management skills
- Linking Six Sigma to suppliers
- Training
- Linking Six Sigma to human resources

Regarding Starbird (2002) Six Sigma process is a part of a management system to achieve business excellence in organization following next steps:

- Start process management: identify core processes, customer needs and measures
- Drive performance through reporting: leaders must maintain and report opportunity lists, status and active projects/resources and results from finished projects
- Integrate championing of active projects: select and charter projects and require updates during existing staff meetings

Regarding Johnson and Swisher (2003) useful implementation tips for successful Six Sigma application are:

- Sustained and visible management commitment
- Continuing education and training of managers and participants
- Setting clear expectations and selecting project leaders carefully for leadership skills
- Picking and selecting strategically important projects

The success of Six Sigma programs hinges on the sequence of many Six sigma elements/activities or a model for implementation (Chakravorty, 2009). Six Sigma key success factors has been described by many authors, but in this paper accent will be on following 14 factors collected by Ho et al. (2008):

- Top management's commitment and participation
- Business strategy base on customer demands
- Establishment of the Six Sigma framework
- Project execution and following-up of the results
- Investment of essential resource
- Investment and training framework for trainers and mentors (such as Black Belt)
- Incentive/reward system
- The use of data analysis with data that is easily obtainable
- Attention given to both long-term and short-term targets
- Coordination with knowledge management systems
- Project meshes with company's business strategy
- Cooperation and communication
- Utilization of Six Sigma tools
- The efficacy of teaching material in helping Green Belt students learn

Graphic industry

Graphic industry involving printing, publishing and production of pulp and paper, paper processing and reproduction of recorded media and it's a part of manufacturing industry which accounted for 11.52% of GDP generated by manufacturing industry in Croatia. Also, the manufacture and processing of paper, publishing and printing employ 7.21% of total workforce in the Croatian manufacturing industry. The subsections of graphic industry comprise the manufacture of wood pulp and cellulose, graphic paper and paperboard, other uncoated paper and paperboard, corrugated paper and paperboard, carton, boxes and cases of corrugated paper or paperboard, sacks and bags of paper, folding cartons, boxes and cases of paper or paperboard, household, sanitary or toilet articles of paper, paper envelopes, printed, embossed or perforated paper, labels, waste paper, cigarette filter-tips, newspapers and magazines, business commercial products, forms, notebooks and account books, books and brochures, printed products directly onto materials other than paper and textile.

Modern printing and publishing is based on high technology, specially information and communication, and new way of production satisfies the following needs (Glykas, 2004):

- Printing-On-Demand
- Just-in-time printing
- Distributed printing
- Personalised printing
- Repurposing

The printing and publishing production process is rapidly shifting from analogue to digital technology as the basis for workflows. The efficiency of the production process requires the digitalization of all steps and elimination of analogue methods and materials from the process flow apart from the starting and finishing phase.
Across networks printing and publishing wants to be dial tone service simple, reliable, ubiquitous, fast and cheap (Glykas, 2004).
Whole process is based on seven main phases: ordering, designing, electronic production, film production, printing, finishing and delivering. Therefore, Six Sigma program can be successfully implemented from the first phase of the process.

For manufacturing companies the direct benefit of Six Sigma results from the reduction in the number of defects due to improved manufacturing processes (Kumar et al., 2008)
But the implementation of Six Sigma programs has to take into consideration the level of technological intensity of the company to determine relative impact of program design factors and the application.

Empirical research

Aim and objectives of the research

The aim of this paper is describe and band function of Six Sigma program in production companies, with particular regard to graphic companies. Furthermore, explore Process improvement techniques, Six Sigma strategies, principles, tools and techniques (frequency of use) and Six Sigma key success factors in correlation to Process improvement factors (Yield improvement, Cycle-time reduction, Inventory reduction, Streamlining supplier relationship, Improvement customer satisfaction).

Companies have to identify Six Sigma key success factors for Process improvement which could result with competitive advantage. The results of this research will provide to graphic companies better understanding of Six Sigma benefits and outcomes, insight into the Six Sigma strategies, principles, tools and techniques and Six Sigma key success factors as well. Based on these findings graphic companies, but production companies will be able to guide business and production processes in right directions with minimizing inputs, maximizing outputs and satisfied owners, employees and customers.

Data collection and research methodology

The empiric research has been conducted on defined sample of 120 Croatian graphic companies in a period from November 2009 to January 2010. In sample were involved only companies for which is already known to apply Six Sigma program.
The questionnaires have been collected by e-mails. The companies in sample are graphic production companies involved in printing and publishing. A majority of the respondents belong to middle and upper management and have average 9 years of experience. The average period of application of Six Sigma program in companies in sample is 5.5 years.
The examinee was able to choose one or more answers and answer using a 5-point Likert scale between the endpoints: “never use one” and “very frequently use”, “not influential at all” and “very much influential”, “strongly disagree” and “strongly agree”.

The collection of data was completed in January 2010, followed by data processing. The final sample included 81 questionnaires. The questionnaire return rate was 67.5 %.
The questionnaire was design to measure Process improvement techniques, Six Sigma strategies, principles, tools, techniques and methods and Six Sigma key success factors implementation as well. Those variables will be measured in correlation to five factors which describing Process improvement: Yield improvement, Cycle-time reduction, Inventory reduction, Streamlining supplier relationship and Improvement customer satisfaction.

Data analysis and results of empirical research

First step was to compute Cronbach’s alpha which indicated a strong correlation of variables (see Table 3).
Internal consistency of questions was found computing Cronbach’s alpha which is done for variables in three data categories. This statistic provides an indication of the

average correlation among all of the items that make up the scale. Values range from 0 and 1, with higher values indicating greater reliability. Ideally, the Cronbach's alpha coefficient of scale should be above 0.7.

Table 3: Reliability of survey variables

Process improvement tool	Cronbach's alpha
Six Sigma	0.82
Process mapping	0.78
Root cause analysis	0.72
Cause and effect analysis	0.75
ISO 9001	0.78
Statistical process control	0.72
Total quality management	0.80
Malcolm Baldridge criteria	0.70
Knowledge management	0.75

Next step was to explore rating of Process improvement tools used in Croatian graphic companies in sample. As is visible in Table 4, Six Sigma is the Process improvement tool that has yielded the greatest results (even 48.15 %). Follow Cause and effect analysis (37.04 %) and Process mapping (33.33 %). Malcolm Baldrige criteria is the least represented tool with only 2.47 %.

Table 4: Rating of process improvement tool in Croatian graphic companies

Process improvement tool	No. of companies	Impact (%)
Six Sigma	39	48.15
Process mapping	27	33.33
Root cause analysis	26	32.10
Cause and effect analysis	30	37.04
ISO 9001	22	27.16
Statistical process control	19	23.46
Total quality management	21	25.93
Malcolm Baldridge criteria	2	2.47
Knowledge management	22	27.16

Before exploration of used strategies and principles was computed Cronbach's alpha for variables (see Table 5.

Table 5: Reliability of survey variables

Strategies and principles	Cronbach's alpha
Project management	0.74
Data-based decision making	0.72
Knowledge discovery	0.72
Process control planning	0.78
Data collection	0.75
Variability reduction	0.73
Belt system	0.74
DMAIC process	0.80
Change management	0.77

Furthermore, Table 6 shows the most common used strategies and principles of Six Sigma in Croatian graphic companies. Data collection are presented in 53.09 % companies in sample, follow Project management (51.58 %) and Process control planning (48.15 %) like the most common used strategies and principles. Belt system is represented at least with (only 27.16 %) and this result may indicate that companies in sample don't understand very well the nature and components of Six Sigma programs.

Table 6: The most common used strategies and principles of Six Sigma in Croatian graphic companies

Strategies and principles	No. of companies	Impact (%)
Project management	42	51.85
Data-based decision making	36	44.44
Knowledge discovery	30	37.04
Process control planning	39	48.15
Data collection	43	53.09
Variability reduction	24	29.62
Belt system	22	27.16
DMAIC process	34	41.97
Change management tools	28	34.57

The Cronbach's alpha was computed and for next set of variables before further processing. (see Table 7)

Table 7: Reliability of survey variables

Tools and techniques	Cronbach's alpha
Statistical process control	0.75
Process capability analysis	0.73
Measurement system analysis	0.78
Design of experiments	0.70
Robust design	0.72
Quality function deployment	0.75
Failure mode and effects analysis	0.80
Regression analysis	0.78
Analysis of means and variances	0.74
Hypothesis testing	0.72
Root cause analysis	0.82
Process mapping	0.77

From Table 8 are visible the most common used tools and techniques of Six Sigma in Croatian graphic companies. Process mapping are presented in 56.79 % companies in sample, follow Regression analysis (49.38 %) and Analysis of means and variances (48.15 %) like the most common used strategies and principles. Design of experiments (17.28 %) and Robust design (14.18 %) are represented at least which can indicate non-innovation of a management.

Table 8: The most common used tools and techniques of Six Sigma in Croatian graphic companies

Tools and techniques	No. of companies	Impact (%)
Statistical process control	32	39.51
Process capability analysis	29	35.80
Measurement system analysis	32	39.51
Design of experiments	14	17.28
Robust design	12	14.81
Quality function deployment	20	24.69
Failure mode and effects analysis	29	35.80
Regression analysis	40	49.38
Analysis of means and variances	39	48.15
Hypothesis testing	21	25.93
Root cause analysis	38	46.91
Process mapping	46	56.79

The means and standard deviations of the variables (Six Sigma key factors) are shown in Table 9.

Table 9: Means and standard deviations of Six Sigma key factors

	Mean	S.D.
Top management's commitment and participation	2.55	1.17
Business strategy based and customer demands	1.70	0.98
Establishment of the Six Sigma framework	4.08	1.37
Project execution and follow-up of the results	3.97	1.26
Investment of essential resources	2.83	0.82
Investment and training framework for trainers and mentors	1.62	1.49
Incentive/reward system	2.59	1.05
The use of data analysis with data that is easily obtainable	3.47	1.72
Attention given to both long-term and short-term targets	4.91	1.43
Coordination with knowledge management systems	2.03	0.92
Project meshes with company's business strategy	1.39	1.66
Cooperation and communication	2.61	1.38
Utilization of Six Sigma tools	4.57	1.13
The efficacy of teaching material in helping Green Belts students learn	1.18	1.36

Six Sigma key success factors and factors of Process improvement were analyzed by examining the factors analysis with Varimax rotation (see Table 10). This shows the loadings of each of the variables on the two selected factors. The highest loading variables in each component helps to identify the nature of the underlying latent variable represented by each component. The factor loadings have to be above 0.60.

Table 10: Rotated component matrix

	Process improvement				
	Factor 1	**Factor 2**	**Factor 3**	**Factor 4**	**Factor 5**
Top management's commitment and participation	0.331	0.507	0.397	0.577	**0.722**
Business strategy based and customer demands	0.387	0.394	-0.066	0.226	**0.899**
Establishment of the Six Sigma framework	0.547	**0.881**	0.118	0.549	0.451
Project execution and follow-up of the results	0.481	0.471	-0.110	**0.720**	0.328
Investment of essential resources	0.392	0.582	0.348	**0.683**	0.282
Investment and training framework for trainers and mentors	**0.621**	-0.043	-0.037	0.218	0.144
Incentive/reward system	0.449	0.117	**0.680**	-0.042	-0.116
The use of data analysis with data that is easily obtainable	**0.746**	0.476	0.689	0.258	0.221
Attention given to both long-term and short-term targets	0.122	0.227	**0.734**	0.265	0.301
Coordination with knowledge management systems	**0.689**	0.395	0.551	0.437	0.270
Project meshes with company's business strategy	0.227	0.261	0.192	**0.806**	0.354
Cooperation and communication	0.378	0.488	0.202	0.554	**0.853**
Utilization of Six Sigma tools	0.441	**0.664**	0.480	0.592	0.124
The efficacy of teaching material in helping Green Belts students learn	- 0.028	**0.651**	0.187	0.116	-0.019

Factor 1: yield improvement, Factor 2: cycle-time reduction, Factor 3: inventory reduction, Factor 4: streamlining supplier relationship, Factor 5: improvement customer satisfaction

Further, was used Pearson correlation to explore the strength of the relationship between Six Sigma key success factors and factors of Process improvement (see Table 11). This gives an indication of both of direction (positive or negative) and the strength of the relationship.

The size of the value of Pearson correlation (r) can range from – 1.00 to 1.00. This value will indicate the strength of the relationship between two variables. A correlation of 0 indicates no relationship at all, a correlation of 1.0 indicates a perfect positive correlation and value of – 1.0 indicates a perfect negative correlation (r = 0.10 to r = 0.29 indicate small correlation, r = 0.30 to r = 0.49 indicate medium correlation, r = 0.50 to r = 1 indicate large correlation).

Factor 1: yield improvement, Factor 2: cycle-time reduction, Factor 3: inventory reduction, Factor 4: streamlining supplier relationship, Factor 5: improvement customer satisfaction.

From Table 11 visible is strong correlation between establishment of the Six Sigma framework and all Process improvement factors and coordination with knowledge management systems as well. Strong correlation was found and between Top management's commitment and participation, Cooperation and communication and Utilization of Six Sigma tools with the most Process improvement factors.

Companies in sample didn't recognize importance of Project execution and

follow-up of the results, Incentive/reward system, Project meshes with company's business strategy and the Efficacy of teaching material in helping Green Belts students learn which could indicate immaturity of implemented Six Sigma programs which are implemented average 5.5 years.

Table 11: Pearson correlation coefficients

	Process improvement				
	Factor 1	**Factor 2**	**Factor 3**	**Factor 4**	**Factor 5**
Top management's commitment and participation	**0.549**	**0.562**	0.388	0.487	**0.511**
Business strategy based and customer demands	0.488	0.371	0.116	0.362	**0.798**
Establishment of the Six Sigma framework	**0.631**	**0.823**	**0.509**	**0.577**	**0.682**
Project execution and follow-up of the results	0.293	0.591	0.381	0.396	0.376
Investment of essential resources	**0.744**	**0.697**	0.481	0.261	0.339
Investment and training framework for trainers and mentors	0.297	0.408	0.290	0.117	0.263
Incentive/reward system	0.193	0.288	0.183	0.206	0.301
The use of data analysis with data that is easily obtainable	0.487	**0.622**	0.490	0.391	0.447
Attention given to both long-term and short-term targets	**0.749**	0.431	0.334	0.211	0**.731**
Coordination with knowledge management systems	**0.779**	**0.843**	**0.577**	**0.692**	**0.776**
Project meshes with company's business strategy	0.298	0.337	0.349	0.296	0.324
Cooperation and communication	0.412	**0.811**	**0.513**	**0.727**	**0.788**
Utilization of Six Sigma tools	**0.785**	**0.863**	**0.619**	0.421	**0.791**
The efficacy of teaching material in helping Green Belts students learn	0.106	0.298	0.285	0.229	0.328

Conclusion

A contemporary business conditions in extremely turbulent environment with frequent technological changes require constantly adjusting of all activities with emphasis on a business and production Process improvement which should be able to enable achieving a strategic goals. Modern business practice recognizes many Process improvement techniques and Six Sigma program is one of the common used programs in production companies for reduce cost, improve productivity and provide a basis for establishing improvement goals.

The success of Six Sigma program hinges on the sequence of many Six Sigma elements such as management involvement, improvement specialist, performance metrics, systematic procedure and project selection and prioritization.

In this paper was described and banded function of Six Sigma program in production companies, with particular regard to graphic companies which involving printing, publishing and production of pulp and paper, paper processing and reproduction of recorded media and it's a part of manufacturing industry. Furthermore, was explored Process improvement techniques, Six

Sigma strategies, principles, tools and techniques (frequency of use) and Six Sigma key success factors in correlation to Process improvement factors (Yield improvement, Cycle-time reduction, Inventory reduction, Streamlining supplier relationship, Improvement customer satisfaction).

The results of empiric research shows that Six Sigma program is the most common used process improvement tool in Croatian graphic companies, as it is in the world business practice.
The most common used strategies and principles of Six Sigma in Croatian graphic companies are Data collection (53.09 %), Project management (51.58 %) and Process control planning (48.15 %).
The most common used tools and techniques of Six Sigma in Croatian graphic companies are Process mapping (56.79 %), Regression analysis (49.38 %) and Analysis of means and variances (48.15 %).

Other finding is strong correlation between Establishment of the Six Sigma framework and all Process improvement factors and Coordination with knowledge management systems as well. Strong correlation was found and between Top management's commitment and participation, Cooperation and communication and Utilization of and Six Sigma tools with the most Process improvement factors.
Companies in sample didn't recognize importance of Project execution and follow-up of the results, Incentive/reward system, Project meshes with company's business strategy and the Efficacy of teaching material in helping Green Belts students learn which could indicate immaturity of implemented Six Sigma programs with average age of 5.5 years.

Companies have to identify Six Sigma key success factors for Process improvement which could result with competitive advantage. The results of this research will provide to graphic companies better understanding of Six Sigma benefits and outcomes, insight into the Six Sigma strategies, principles, tools and techniques and Six Sigma key success factors as well. Based on these findings graphic companies, but production companies will be able to guide business and production processes in right directions with minimizing inputs, maximizing outputs and satisfy owners, employees and customers.

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