INVESTIGATION INTO IMPACT OF SIX-SIGMA METHODOLOGY FOR CONTINUOUS IMPROVEMENT AND COMPETITIVENESS IN DISCRETE MANUFACTURING INDUSTRY

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ABSTRACT
Manufacturing efficiency is critical in raising the value of exports so as to gainfully trade on the regional and international markets. Increasing popularity of continuous improvement strategies availed mostly to manufacturing enterprises, this research study established that there has not been a similar popularity accorded to the Six Sigma methodology. Thus this work was conducted to investigate the applicability, effectiveness, usefulness, application and suitability of the Six Sigma methodology as a competitiveness option for discrete manufacturing entities. Development of Six-sigma centre in the country with continuous improvement information would go a long way in benefitting the entire industry.

Keywords: Six-sigma, discrete manufacturing, continuous improvement, competitiveness, efficiency

• INTRODUCTION
The critical challenge faced by manufacturing organizations in the country is the development of credible process and Product improvement management systems. While some improvement programs may exist, they are often without a Systematic framework upon which they are based. Often they are derived from purely technical considerations without due regard to the ‘big picture’, the business and operating environments. The industry is therefore characterized by generally low improvement achievements and a good measure of crisis management.

Yet there is need for manufacturing organizations to respond to rapidly changing expectations for them to survive competition in a globalizing marketplace. These include a growing awareness of the connection between quality performance and customer retention, the extent to which quality performance affects safety and the environment, and increasing pressure to achieve high quality in response to market demand, and to contain costs. All this is relevant to local industry today considering the serious nature of current economic challenges, which include principally low productivity due to the ever rising cost of new capital equipment, spare parts and raw materials that largely have to be imported.

Six Sigma methodology is a philosophy whose thrust, provides a strategic framework which enables users to respond to these challenges quickly and simply. Six Sigma manages to achieve this because it never loses sight of the fact that improvement is about processes. If these processes do not exist, the improvement function itself would not exist. Six Sigma therefore starts from first principles with a zero-based review of the improvement requirements of each process in its operating context.
JUSTIFICATION
The application of Six Sigma methodology in local industries is still in its infancy stage and very few organizations apply it to aid their continuous improvement initiatives. Willsgrove Ware Pottery showed a great potential in Six Sigma methodology application, and was subsequently chosen as a case study in this study.
Yet, Six Sigma is one of the most essential pre-requisites for a successful and highly competitive organization. It therefore means that the adoption of Six Sigma by any organization is a move towards renowned competitive advantage and world class competitive performance. In this research work, Six Sigma is examined in the case study, that is WILLSGROVE, to see what system of improvement has evolved at the company as a result its implementation. Two essential concepts were considered when this analysis was taken and these include the DMAIC and DFSS principles. Thus generally, it can be seen that Six Sigma, means a step towards global competitiveness for many Zimbabwean industries and their products are deemed to enter the world market without much constraints. The impacts came out in different categories and these include impact on cost, delivery, manufacturing, customer, market, profit and impact on other stakeholders like employees and shareholders.
The research intends to establish the impact and effectiveness of the Six Sigma methodology in repositioning the organization’s operational performance and products, whose market share had slid to about 28% of the total local market as at the first quarter of year 2012, from a peak performance of about 70% of local market share in the year 2011, and required a viable strategy or methodology to bring it back on growth trend, and to lift up market share to about 45% of the total local market. Gross profit margins have seen a consistent decline from around 65% in the year 2011 down to less than 45% in the year 2012, due to untenable operational costs and quality performance levels of the products and the processes.

3. MANUFACTURING OVERVIEW
Hill (2004) defines manufacturing as a series of interrelated activities and operations involving design, materials selection, planning, production, plant and equipment maintenance, quality assurance and the marketing of consumer and durable goods.

3.1 The Manufacturing Enterprise
The manufacturing enterprise includes everything that is used, owned or done by a manufacturing business (Hill, 2004). Business functions such as human resources, marketing, product design, research and development, sales, purchasing, inventory management, logistics, maintenance, finance and accounting management, etc; are aspects of a manufacturing enterprise. Different manufacturing enterprises often have different departments, but a majority of enterprises have similar business functions (Groover, 2001).

3.2 Manufacturing System
The diagram below shows the classification of manufacturing processes into two major classes, the discrete and the continuous processes. Groover (2001) claims that the bracketed numbers show the sequence in time of development of the processes with the continuous process being the latest process to be developed.

![Figure 1: Classification of Manufacturing Processes- Source: Groover (2001)](image)

Hill (2004) specifies that discrete manufacturing processes involve the processing of countable products. Most manufacturing in Zimbabwe is really discrete manufacturing. Discrete manufacturing can be classified as project, jobbing, batch and line processes.

a. Project Process
The characteristics of a project process is that the product made is a large scale, complex, unique one-off product. The resources used in a project process are normally taken to the point where the product is being made as the product is normally not movable. The building of bridges, stadiums, large aircrafts, and spacecrafts are all considered as project processes.

b. Jobbing Process
The jobbing process is used to make unique one-off products using inexpensive general purpose tools and highly skilled labor. While a common example of jobbing would include the processes performed in any repair shop (electronic repair shop, motor car service garage, shoe repair shop, etc.), other big companies can be identified to be involved in jobbing as well. In the automotive industry for instance, there is an increasing tendency towards customization, e.g. Daimler-Benz.

c. Batch Process

This process is used to manufacture a limited variety and volume of different products. The process involves making the product varieties in sets or quantities called batches, hence batch production. This is the main way in which most discrete products are made and a large number of variations or hybrids to this process have been designed to form processes now normally called the modern manufacturing processes. The modern processes known by such terms as cellular, flexible, holonic, fractal, bionic, adaptive and distributed manufacturing systems derive their basic DNA from the batch processes.

d. Line Process

The line process involves the manufacture of discrete products by passing them through a sequence of operations performed along adjacent locations. The assembly line is a special type of the line process in which the operations are specifically those of joining different parts together to make a finished product or a sub-assembly. Another derivative of the line process is the transfer line process. In the transfer line process, the focus is on automated transfer of workfrom one workstation to the next along the line process. Mass production is not really a type of manufacturing process but rather refers to the idea of manufacturing products in bulk. Usually the term is used to denote a line processes that produce high volumes of products, although the continuous processes normally produce even bigger product volumes than line processes.

e. Hybrid Process

The hybrid processes are not reflected on the diagram because they are as many as there are manufacturing companies in the world. These hybrid systems are derived from the main systems discussed above to specifically suit each particular manufacturing company. The hybrids include mixing the different processes together to different extents. For instance, a beverage making company normally uses continuous processes in the making of the liquid (drink); in the bottling stage the processes become a cross between the transfer line process and the continuous process; while the packaging of the beverages is primarily batch.

Many times even packaging of the products is also automatic. On the contrary, although discrete processes are now computer controlled processes in developed countries, in developing countries like Zimbabwe they remain mainly human processes.

This makes the focus of this research on discrete processes a relevant focus, since these are processes that can be improved the most by the use of improvement strategies. In addition to that, they are the processes that constitute most of the manufacturing activities in the country.

4. SIX SIGMA CONCEPT

Six Sigma is a collection of fact based tools and techniques aimed at helping a business to deliver financial benefits from continuous improvement. It consists of a set of data driven tools and methodologies designed to significantly improve the quality of products and services delivered to customers and it is highly customer driven in that you cannot use the tools without taking the needs and wants of the customer into account. Six Sigma is also facts and data driven, to bring about an analytical and objective, or honest, focus to improving processes (Berger, 2003). Six Sigma can be used to improve any process, and these can include customer satisfaction, product cycle times, manufacturing, defects reduction, distribution and delivery. Innovation and design remain crucial elements in the mixture of success making ingredients of business (Wilson, 2005).

Hahn (1999) reports that management can use Six Sigma in two main and related ways. Firstly, as a quality target for the company’s processes- Six Sigma sets out a target performance level of less than 3.4 defects per million opportunities (DPMO). In fact the right level of sigma will depend on the process and the economics of achieving higher levels of quality. Secondly, as an aspiration towards a culture and management system like General Electric’s where Six Sigma is seen as a mechanism for building a culture of excellence as well as delivery of financial benefits. This second aspiration involves setting up teams to solve specific problems on a project by project basis, and training a very wide group of people so that the whole organization is searching for ways of listening and reacting to the customer, seeking facts to measure current success and focusing on issues that really affect customer satisfaction.

Berger (2003) concludes that Six Sigma is a methodology that maximizes shareholder value by achieving the fastest rate of improvement in customer satisfaction, cost, quality, process speed, and invested capital.

4.1 Benefits of Six Sigma

Goh (1999) reports that even medium sized organizations can have a large portfolio of projects going on at any one time and many of these fail to deliver on time and within budget, and even those that pass these tests rarely produce substantiated financial benefits. George (2002) reiterates that the principle of Six Sigma depicts that the activities that
cause the customer’s critical-to-quality issues and create the longest time delays in any process offer the greatest opportunity for improvement in cost, quality, capital, and lead time. He further states that wait time, material and manufacturing overhead and quality costs are the biggest levers of cost reduction, along with labor. The first thing to do is to gather some information on how well your company is performing. The first diagnostic looks at how good the company is at shaping and delivering improvement projects. It looks at basically two aspects:

• How consistently people will give the same results
• The potential size of the improvement opportunity available to your company

4.2 Six Sigma Culture
Six Sigma culture and infrastructure is the embodiment of principles of transforming goals into action through continuous improvement and innovation, in a form that a company can implement (Hahn, 1999). George (2002), specifies that anyone who has worked within a Six Sigma driven organization knows that Six Sigma isn’t just an “improvement methodology”. It is …

• A system of management to achieve lasting business leadership and top performance applied to benefit the business and its customers, associates, and shareholders.
• A measure to define the capability of any process.
• A goal for improvement that reaches near perfection.

Six Sigma level numbers often associated with Six Sigma presents the capability of a core business process, as measured in defects per million opportunities.

<table>
<thead>
<tr>
<th>Sigma Level</th>
<th>Defects per Million Opportunities</th>
<th>Yield (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>3.4</td>
<td>99.9997</td>
</tr>
<tr>
<td>5</td>
<td>233</td>
<td>99.977</td>
</tr>
<tr>
<td>4</td>
<td>6210</td>
<td>99.379</td>
</tr>
<tr>
<td>3</td>
<td>66807</td>
<td>93.32</td>
</tr>
<tr>
<td>2</td>
<td>308537</td>
<td>69.2</td>
</tr>
<tr>
<td>1</td>
<td>690000</td>
<td>31</td>
</tr>
</tbody>
</table>

The “per million opportunities” aspect of the six sigma metric is critical because it allows to compare the capability of widely different processes. The sigma metric makes sure that simpler processes, which have fewer steps and fewer chances for something to go wrong, aren’t given an advantage over more complex processes.

Wilson (2005) mentions the culture of a Six Sigma company as comprising of the following:

• A climate of open mindedness about the future
• No laissez- faire attitude
• Knowing that doing anything more than once to get it right is bad economics. Production line running at half speed or even at 95% of capacity is not only wasteful, but also has a direct impact on the bottom line
• Employee commitment at work and forget social problems
• Leaders of organizations work hard to create a mindset among their staff that they will do their “best possible work” and it is the responsibility of managers to enable them to do so
• A conviction in the potential of people is critical for success of Six Sigma
• The drivers of change are the customers and the CEO, and customers come first with loyalty, retention and acquisition imperative
• The Six Sigma focus is on consistency, taste and variation; or consistency, accuracy and precision.

4.3 Critical Success Factors for Six Sigma
The system needs to achieve Six Sigma creates a culture characterized by:

**Customer centricity:** the knowledge of what the customer values most is the start of the value stream analysis. The Six Sigma culture is customer centric, its goal is to delight customers. The quality of a product or service is measured from the customer’s perspective, by its contribution to their success. This customer focus comes through the Six Sigma drivers which are:

Voice of the customer: what the customer say they want.
Requirements: voice of the customer input that is translated into specific, measurable elements.
Critical to Quality (CTQ): requirements that are most important to the customers. Defect: failing to deliver to customer’s CTQ. Design for Six Sigma: designing products and processes based on customer requirements.

The gap between what customers desire and what is currently delivered are the areas where significant value can be created for both supplier and customer. Thus Six Sigma is focused on addressing these gaps, increasing operating profit, and becoming part of the DNA of the company and its operations.

Table 2: Service and after sales support process

<table>
<thead>
<tr>
<th>Customer comments</th>
<th>Business implication</th>
<th>CTQ requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Too long to get help</td>
<td>High demand on help desk; cost but no revenue generated. Also lost sales &amp; service revenue</td>
<td>Reduce lead time to match customer expectations</td>
</tr>
<tr>
<td>Service and after sales support spoils the otherwise excellent Customer experience</td>
<td>Loss of future sales</td>
<td>Improve responsiveness on simple queries-bug up with help desk when really needed</td>
</tr>
<tr>
<td>Long support calls are easier to cope with now that the “OS00” number has been put in place</td>
<td>0800 number popular but high cost to Blue</td>
<td>Find a way to make the customer contribute to the support costs</td>
</tr>
<tr>
<td>Would be good to be able to ask for advice on other matters as well as help on specific issues</td>
<td>Lost sales opportunities</td>
<td>More than just a help desk – want to provide an advisor</td>
</tr>
</tbody>
</table>

Figure 2: CTQ Measures Tree analysis; Source Tyzdek (2004)

Six Sigma provides the discipline to help companies go beyond an anecdotal understanding of customer wants and needs to specific requirements-driven process metrics. This changes behaviour from fire-fighting to disciplined improvement based on customer satisfaction.

Every defect in a process not only reduces quality but creates a time delay, generates an additional cost, and produces an associated loss of operating profit. The actual cost of defects depends, of course, on the process, George (2002).

4.4 Six Sigma methodology

Breyfogle (2002) states that Six Sigma methodology improves any existing business process by constantly reviewing and retooling the process. To achieve this, Six Sigma uses a methodology known as DMAIC (Define opportunities, Measure performance, Analyze opportunity, Improve performance, Control performance). Six Sigma methodology can also be used to create a brand new business from ground up using DFSS (Design for Six Sigma) principles. Six Sigma strives for perfection. It allows for only 3.4 defects per million opportunities for each product or service transaction. Six Sigma relies heavily on statistical techniques to reduce defects and measure quality.

According to Keller (2001), the project team will work on a number of different activities to build up the Project Charter and plans. These include:
- Problem/Oppportunity statement.
- Process maps, SIPOC (Supplier Input Process Output Customer) and insights on processes/quick wins.
• Stakeholder and Barrier to Change analysis.
• Project Risk Summary.
• Team Targets and Training
The team will also have the opportunity to use a number of qualitative tools and typically, these include process mapping, SIPOC, analysis of customer surveys and brainstorming.

4.4.1 Project Charter
Berger (2003) reports that the Project Charter provides the focus for the project team as well as the means for senior management to be sure that the project remains relevant to the business and that it is making sensible progress. It is the expected performance contract between the project team and management. In effect, the project Charter says, “If you give us these resources, we will give you these benefits.”
The Charter contains a number of standard areas (Breyfogle, 2000):
• A description of the project.
• A problem/opportunity statement (derived from a customer perspective)
• A goal statement
• Outline financials
• Target dates
• Scope (both in scope and out of scope activities)
• Risk summary
• Linkage between the project and overall business imperatives
• Team names, roles, resourcing and contribution.
SMART is a useful acronym for the Project Charter – targets should be stretching, measurable, achievable, related to the customer and time targeted (www.isixsigma.com).

4.4.2 Project Plan
Project plan is a key document which sets out the target plan and end dates of each phase of the project. The highlights of the project plan are summarized in the project Charter. The main project plan can be attached as a separate detailed plan.
Berger (2003) reports that a typical project plan contains a logical information including answers to the following questions:
• What activity is required in each phase?
• What group/group of activities does it fit within (e.g. a phase or an output or an output)?
• How long will the activity take? (e.g. how many mandays?)
• When will it start and finish?
• Who is responsible? Who will actually do the work?
• What are the critical dependencies? (e.g. what needs to happen before and after this activity?)
A typical Six Sigma project plan is as shown below.

<table>
<thead>
<tr>
<th>Table 3: Project plan- Six Sigma Project, DMAIC; Source – Berger (2003)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Activity</strong></td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>Define need</td>
</tr>
<tr>
<td>Senior management review</td>
</tr>
<tr>
<td>Select champion/sponsor</td>
</tr>
<tr>
<td>Determine methodology/approach</td>
</tr>
<tr>
<td>Initial scoping</td>
</tr>
<tr>
<td>ROI</td>
</tr>
<tr>
<td>Authorization</td>
</tr>
<tr>
<td>Select team lead &amp;members</td>
</tr>
</tbody>
</table>
### Identify team training requirements
- Deliver team training
- Team kick-off

### Define phase - target
- Define phase - actual
- Phase - exit

### Measure & Analyse phase - target
- Measure & analyse phase - actual
- Phase – exit

### Improve phase – target
- Improve phase - actual
- Phase – exit

### Control phase – target
- Control phase – actual
- Phase – exit

### Final sign – off

### On – going monitoring

#### 4.4.3 Project risk summary
The purpose of risk analysis is to be proactive in listing the risks and to have a plan for managing the main ones. He also confirms that Six Sigma projects can fail due to some typical issues like: lack of senior management leadership, lack of acceptance by the business, poorly executed project processes, lack of resources, and lack of focus on project financial benefits.

Berger (2003) frames that risk can be summarized into a simple table where probability of risk occurrence and its impact are stated. The use of probability and impact helps to differentiate major risks (e.g. high probability, high impact) from lower risk issues (e.g. low probability, low impact). Risk analysis can be performed at least once in each phase of a DMAIC project.

<table>
<thead>
<tr>
<th>Project risks</th>
<th>Prob.</th>
<th>Imp.</th>
<th>Preventive/contingent action</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### 4.5 DMAIC – The measure & analyze phases
Data collection and analysis is the art and science of Six Sigma. There are many best practice tools available to help project teams in the Measure and Analyze phases. These tools need good data. The team will analyze the root causes of problems and create a fact based foundation for developing solutions.

The Measure and Analyze phases are often split into two distinct phases in Six Sigma projects. During the Measure and Analyse phases, the project team will produce a number of key outputs:
Baseline performance data and key measures.
Operational data definitions
Sigma level calculations
Comparative best practices and benchmarks
Detailed process maps
Root cause analysis
Analysis insights and conclusions
Validated problem statements and solution options.

The project team will work on structuring and manipulating the key data that will be required for fact based analysis and conclusions. Supporting activities will include:

- Data collection planning and execution
- Sampling and Gage R&R
- Analysis tool selection and use
- Filing key analysis files for ease of future access

The team will use a variety of qualitative and quantitative analytical tools in the Measure and Analyse phases. Below is a table showing key questions and data slicing.

### Table 5: Key questions and data slicing; Source - Keller (2001)

<table>
<thead>
<tr>
<th>Key questions</th>
<th>Data requirement</th>
<th>Analysis methods</th>
<th>Y/n</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 What is the size of the issue?</td>
<td>EMEA delivery metrics for the last 3 months</td>
<td>Metrics reporting package</td>
<td>Y</td>
</tr>
<tr>
<td>2 What are the key causes of the issue?</td>
<td>Stated cause of error as reports</td>
<td>Pareto and Histograms</td>
<td>Y</td>
</tr>
<tr>
<td>3 What parts of the organization own the problems?</td>
<td>Process detail</td>
<td>Process mapping analysis, SPC, analysis</td>
<td>Y</td>
</tr>
<tr>
<td>4 What do the current metrics tell us about the process?</td>
<td>Internal process metrics data</td>
<td>Trend analysis with statistical process control methods</td>
<td>Y</td>
</tr>
<tr>
<td>5 What root causes are evident?</td>
<td>All available data on trends, etc</td>
<td>Cause and effect (fishbone), FMEA, I DMA, Pareto and histograms</td>
<td>Y</td>
</tr>
<tr>
<td>6 Are there any trends by product or customer or country?</td>
<td>Historical data closed by product, customer, country</td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>7 How does the supply chain performance impact the company’s delivery performance?</td>
<td>Supplier performance metrics</td>
<td>Trend analysis by management</td>
<td>N</td>
</tr>
</tbody>
</table>

*Data requirements slicing*:

<table>
<thead>
<tr>
<th>Data requirement/slicing</th>
<th>Who</th>
<th>What</th>
<th>Where</th>
<th>When</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 EMEA delivery metrics for the last 3 months</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Stated cause of error as reports</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Process</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
A sample fishbone diagram is as shown below.

![Fishbone Diagram](image)

**Figure 3**: Cause and effect (fishbone) diagram; Source - Tyzdek (2004)

### 4.6 Calculating Current Sigma levels and Process Capability

During the Measure and Analyze phases, the project team establishes the current sigma levels for the key processes being analyzed. This requires the team to be clear about units of data, number of opportunities and defect definitions. Once the sigma levels have been calculated, the team should discuss or brainstorm the potential improvement opportunity. The team looks at process capability. This being the level of variation in a process relative to the required specification. The specification is usually defined in terms of customer requirements. The project team analyses process capability to identify opportunities to improve average performance and to reduce variation around the average.

### 4.7 Baseline Performance Measures

One of the key activities in the Measure phase is the documentation of baseline measures. There is need to be clear about the measures, the current baseline and the source of the data. Best practices and benchmarks are invaluable in helping project teams to establish the case for business change. Best practices tend to be descriptions of optimum ways to conduct processes. Best practices can be either within a company or from an external company. Most companies benefit significantly just from applying best practices, already in use in other parts of the company, more widely across the whole organization. Best practices are sometimes seen as lessons learnt from one area of a business that could be applied more widely. Benchmarking gives the processes and measures to compare measured performance across companies and industries. Benchmarks are very useful in showing differing levels of performance. They are always quantitative measures which provide comparative statistics.

**Table 6**: Analysis Tool Selection Matrix, source – Berger (2003)
A process map example is as shown below.

<table>
<thead>
<tr>
<th>Decision Analysis</th>
<th>Qual</th>
<th>X</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td>Affinity</td>
<td>Qual</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Brainstorming</td>
<td>Qual</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Customer Survey</td>
<td>Qual</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Value Added Analysis</td>
<td>Qual</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Poke Yoke</td>
<td>Qual</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Process Sigma</td>
<td>Qual</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Process Capability</td>
<td>Qual</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>GAGE R&amp;R</td>
<td>Qual</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Control Chart</td>
<td>Qual</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Run Chart</td>
<td>Qual</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Process Control Chart</td>
<td>Qual</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Histogram</td>
<td>Qual</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Pareto</td>
<td>Qual</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Scatter</td>
<td>Qual</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Regression</td>
<td>Qual</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Probability Distribution</td>
<td>Qual</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Trend</td>
<td>Qual</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Multivariate Analysis</td>
<td>Qual</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Chi Square</td>
<td>Qual</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Hypothesis Testing</td>
<td>Qual</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Yield Analysis</td>
<td>Qual</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Input/Output matrix</td>
<td>Qual</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>ANOVA</td>
<td>Qual</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>DoE</td>
<td>Adv.</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>LMEA</td>
<td>Adv.</td>
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<td>QFD</td>
<td>Adv.</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Data Collection Plan</td>
<td>Projec</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Data Collection Forms</td>
<td>Projec</td>
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</tr>
<tr>
<td>Interview Workbook</td>
<td>Projec</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Stakeholder Analysis</td>
<td>Projec</td>
<td>X</td>
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<td>Risk Summary</td>
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<tr>
<td>Solution Filter</td>
<td>Projec</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Impact/Effort Filter</td>
<td>Projec</td>
<td>X</td>
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<td>X</td>
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<td>Project Scorecard</td>
<td>Projec</td>
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<td>X</td>
</tr>
<tr>
<td>Cost/Benefit Analysis</td>
<td>Fin</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Benefits Segmentation</td>
<td>Fin</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
4.8 Solution Options and Solution Filter

Teams find it hard to find options. Some people follow their gut instincts and more or less pre-empt the decision making process. The danger here is that they define one option a way that is obviously a more likely solution than any other. Six Sigma calls for a rigorous approach to identifying and testing different options. It is important to use option development techniques that prevent any single individual dominating or constraining the range of options considered. Brainstorming techniques such as affinity diagrams and decision analysis can help to keep the “hopper” of options full.

The preferred solution can be determined through application of a two-stage solution filter framework, and a first level evaluation approach based on VSAFE criteria can be applied. The VSAFE criteria possesses the following components:

![Process map example](image-url) - Source: Berger (2003)
• V for value – looks at the expected impact on the bottom line. Will the solution deliver clear financial benefits in excess of implementation costs?
• S for suitable – examines how this idea contributes to the company’s business strategy and business imperatives. Does the proposed solution fit with our business imperatives?
• A for acceptable – the team should take a time to think about how acceptable the stakeholders will find the idea. Will stakeholders agree with this solution option?
• F for feasible – checks that the idea is feasible given time and other constraints. Is it feasible to implement this solution in our organization?
• E for enduring – the team needs to check the likely endurance of the proposed solution. Is the proposed solution option likely to be sustainable?

A second level filter based on weightings can be applied to come up with optimal solutions.

4.9 The DMAIC Process – Control

The objectives of the Control phase are to implement the new processes in all areas of the organization and to put in place robust plans to ensure that the improvement is sustained and financial benefits are delivered. The pilot and Improve phase proved that the new processes will work and can be implemented in all the planned areas. The main task of the Control phase is to “sell” the wider implementation to a wider group of stakeholders and users. It is particularly important to have clear response plans for dealing with the inevitable “teething problems” that can be expected from the wider implementation of new processes.

The outputs of the control phase are:
• Ongoing process management
• Process improvements and control
• Standards and procedures for new processes
• Response plans
• User training in new processes
• Lessons learned
• Team rewards
• The Control phase checklist

At the end of the Control phase, the project team will be disbanded or moved to other tasks. This can leave functional managers and people nervous and apprehensive about the willingness and ability to adopt and sustain the new processes. After all, they have been used to being able to turn to black belts and their team with concerns. Therefore, it is critical that the project team manage the handover process carefully.

The basis of the handover is a clear set of control measures and alarm levels for the new process owner(s). The alarm levels are designed to signal when things are going outside upper or lower tolerance limits. It should also set out what actions the process owner should instigate if these alarms are reached.

4.10 Design for Six Sigma- DFSS

Keller (2001) says that there will be times when continuous improvement through the DMAIC process will not be enough to raise sigma levels to required standards. What will be needed is a radically new process.

Design for Six Sigma (DFSS) is the Six Sigma method for radical process innovation. Berger (2003) agrees with Wilson (2005) that DMAIC is a method for projects that are aimed at an incremental improvement in performance, but DFSS is a method that is used when incremental improvement is not enough or there is no existing process to improve. DFSS is used for radical or new process innovation.

Different Approaches to DFSS

Whilst DMAIC is generally accepted as the best method for continuous improvement, DFSS has spawned a number of different approaches.
• DMADV (Define, Measure, Analyse, Design, Verify).
• DMADIC (Define, Measure, Analyse, Design, Implement, Control).
• DMEDI (Define, Measure, Explore, Design, Implement).
• IDOV (Identify, Design, Optimize and Verify)

4.10.1 Adapting the Measure & Analyse Phases in DFSS

The Measure and Analyse phases of DFSS continue with a greater focus on customer requirements. This is likely to include more work on identifying critical customer requirements by segment. Where data does not exist, it will need to be collected by the DFSS project team. Best practices and benchmarking will for a key part of these phases. The Analyse phase is about understanding detailed customer requirements and options for fulfilling these requirements. By the end of the Measure & Analyse phases, the project team should have a good view of the new concept that will be
required by the customers. They should also have a clear view on the outline target costing that will be required in the Design phase.

4.10.2 Six Sigma as a metric
Six sigma level undoubtedly has value as an indicator of how often your organization’s work fails to meet customer needs. Some advocates of Six Sigma have claimed that the concept also works at the corporate level. By some estimates, a manufacturer operating at 2 to 3 sigma guarantees that 15% of revenue is being wasted as cost of quality; by improving cost of quality to the 5 or 6 sigma level, that wasted 15% of revenue can be transformed into operating profit.

But other companies have been disappointed in trying to use the sigma level of the whole corporation as a valid metric. In service organizations, and even at the enterprise level of manufacturing firms, its not always clear what should be counted as a “defect”:

- From customer’s perspective, long lead time and lead time variation are a defect that causes them to invest more capital in inventory (because they can’t rely on getting the product when they need it from you, the supplier).
- Long lead time also causes excess internal costs, which is certainly a defect from the shareholder’s perspective.

These non-manufacturing defects have enormous impact on operating profit and their removal can lead to huge improvements in operating profit and capital reduction. The best approach is to use sigma level as a process metric. Measure initial sigma capabilities for specific core processes as a baseline, then recalculate them once you have improved those processes. Defects- be they due to process quality or process velocity or any other source- should be weighted not on their frequency, but on their importance to customers and their impact on shareholder value at the enterprise level. This has the further merit that it ties the improvement process into metrics that the operating managers are trying to improve.

4.11 Successfully Managing Six Sigma Change to Deliver
Six Sigma success requires intelligent management of change and an absolute focus on the delivery of financial benefits (Wilson, 2005). Wilson (2005) further reiterates that:

For effective implementation of Six Sigma: The CEO of the company need to embrace the methodology. Impediments to the Implementation of Six Sigma include:

- Maturity- trying to copy too closely the approach of other exemplars, by not discerning enough or being sold a mechanistic process developed by someone who knew only part of the story.
- Six Sigma is a statistical term- it is out of sharing and collaboration that most innovation emerges. If one has to progress, s/he needs to go out there and share. If one wants to die through stagnation, then keep it to yourself.

Six Sigma is the pulling together of the many different types of tools, techniques and thinking of many “small, medium and large giants”. It is an approach that any organization can use.

5. CASE STUDY: WILLSGROVE WARE POTTERY
The case study was done for Willsgrove Ware Pottery for the assessment and application of the impact of Six Sigma methodology which is an organization in ceramic industry.

The main product lines in the ceramic industry are: -

i. tableware
ii. insulators
iii. ornaments

WILLSGROVE Ware Pottery has a manufacturing plant and a network of sales branches across the country.

The dominant ceramic product line in Zimbabwe is tableware. Of the total local tableware consumption, the five major categories of customers for Willsgroove are: retailers; hotels and restaurants; badgedware customers; giftware customers and industrial customers. Tableware products fall under household consumer goods and these are normally distributed through wholesale chains.

However, because of low brand-switching costs, distributors have the ability to source ceramic tableware products from anywhere in the world. Competitors to WILLSGROVE include the likes Ceramatec and to a large extent imports from South Africa and China.

Within the Zimbabwean context, ceramic companies import 80% of their raw materials in value terms and these are the likes of glazes, onglazes and stains, whilst in volume terms, 80% of raw materials are local and this is mainly clays, feldspar, silica and other materials. Imported materials are sourced worldwide from the most competitive sources and the ceramic companies have the lee way to control cost variables in the value chain from purchasing of raw materials, production, warehousing, marketing and distribution.

Willsgrove Ware Pottery, being a player in the ceramic industry in Zimbabwe, had a local market share of 55% in the year 2008, 43% in 2009, 38% in 2010, 30% in 2011 and 38% in 2012 coming down from about 70% market share in
the year 2001. Imported ceramic ware constituted above 50% market share in 2008 whilst the other small players in the ceramic industry such as Ceramatec, Nivek Potteries had a combined total market share of about 15%.

Because of the look East Policy and the globalisation of the economy, the cheap Chinese’ products have taken many markets by storm, gaining significant market shares where Willsgrove products had previously dominated, and these include the South African, Zambian and Botswana markets, without exception of cause, of the Zimbabwean market. Because of these developments, Willsgrove Ware Pottery, has as a result, in line with its corporate guidelines, adopted Six Sigma methodology to grow its local market share to a target of 45% by end of year 2013, from a market share of around 38% as at the beginning of the year.

Six Sigma methodology was chosen as the appropriate tool for the Zimbabwean ceramic industry as it seeks to improve various facets of the industry like cost, customer satisfaction and retention, defects reduction, delivery performance improvement and manufacturing performance improvement initiatives.

5.1 Overview of Willsgrove Ware Pottery
Willsgrove Ware Pottery is by far Zimbabwe’s largest producer of Ceramic products, accounting for more than 50% of the industry’s turnover by volume. It is the largest employer in the local ceramic industry and has the most modern local plant. Size, however, offers no protection in an open competitive market. Willsgrove Ware Pottery, the country’s leading producer of tableware, was the second largest producer in the Southern Africa Development Community region in 2006, with a production capacity of well over 1.5 million pieces per annum. Current capacity is substantially down on this, and the production output, is well below 2012 production levels, because of its fast dwindling market share, which is being taken up by imports and other local competing products.

5.2.1 Willsgrove Core Business Processes
There are four (4) core business processes for Willsgrove, and these are biscuit making, glazing (glost making), decorating (deco making) and hand painting: The defects that occur under each and every one of these processes present opportunities for improvement which were to be addressed by the Six Sigma methodology in form of product and process improvement.

- **Biscuit making** - major defects are: underfire, overfire, edge chip, bottom chip, centre crack, loose handle, and thermal shock. Edge chip, bottom chip, underfire, overfire and thermal shock can all emanate from human error during execution of the firing operations and defective equipment.

- **Glost making** - the major defects were identified as crawling, lumps, knocked glaze and dirt. Crawling and knocked glaze emanate from defects like improper density, incurred during glaze preparation prior to spraying the biscuit product. This afforded opportunities for improvement. Lumps and dirt resulted from errors incurred during the spraying operations and the root cause analysis availed improvement opportunities.

- **Deco making** - the major defects were identified as dunting, underfire, dirt, stuck, water defect, and cutline. Dunting, underfire and stuck defects arise from defective equipment during firing operation or due to operator error during the firing process. Dirt, water defect and cutline arise from errors incurred during the decal applying operational phase. These defects presented the organization with a multitude of opportunities for improvement.

- **Hand painting** - this process presented defects in the form of dirt, crawling and knocked glaze. The occurrence of these defects is as alluded to earlier. It was also established by the researcher, that due to the manual nature and individual skills dependency nature of hand painting, the volume of hand painted products was very low, and this constituted about five percent (5%) of the total production volume, while decorated ware constituted around 20% and plain gloss constituted the remaining 75% of production. Another important aspect established was that rejects at biscuit level, could all be one hundred percent recycled into the production process, whilst rejects at gloss, hand painted and deco levels cannot be recycled and can only be destroyed or relegated to seconds for sale in the Seconds Shop.

5.2.2 Green make tableware process
Mug handles are manufactured through the casting process outlined below:
5.3 Ceramic Products

The traditional ceramic products are essentially made up of clay, flint or quartz and feldspar. But now, it has become possible to make almost any body sufficiently plastic for shaping, either by using bentonite in small quantity instead of using a large amount of ordinary clay, or by using organic binders. It is therefore theoretically possible to use almost any combination of inorganic materials to make ceramic products or properties, very similar, or, if desired, very different from the traditional ones.

The fields of usefulness and uselessness of this was concluded that the simple, chemical, rational analysis of the turn of the century does not give a time idea of the makeup of a clay but can be helpful for checking the variations in a particular clay from a particular pit. Depending on the particular compositions of feldspar, clay and flint in a particular ceramic body, the application or use of a ceramic body can fall into any category that includes: dental porcelain, hard porcelain, Pariton body, floor tiles, translucent porcelain, electrified porcelain, wall tiles and tableware as in Figure 5 below.

![Figure 5: Handle making process](image)

**Figure 5:** Handle making process

**Figure 6:** Ceramic body composition; Source – Singer and Singer (1979)

Basically, the theory on ceramic materials as alluded to by Singer and Singer (1979), fully applies to the Zimbabwean scenario and this forms the basis for clay body preparations within the local ceramic industry.
5.4 Tableware Products

The two major categories of tableware products are domestic ware and hotel ware. In terms of volume in Zimbabwe, i.e. pieces, it is estimated that domestic ware accounts for 87% of the market and hotel-ware about 13.

In terms of value, the hotel ware share would be higher as hotel pieces, especially designed hard wearing pieces, would cost more to manufacture and consequently have a higher sales value. Domestic ware comprises all tableware, serving and kitchen ware used in domestic households. Hotel ware comprises all tableware used in hotels, fast foods outlets, restaurants, canteens, airlines, trains and functions. The domestic tableware market can be split into three distinct usages of everyday, occasional and special. Each usage category may be divided into three price categories: low, medium and upper. Quantifying the three distinct usages into the three price categories is difficult to define internationally and locally due to the vast differences in end user incomes, perceptions and intended usages. Domestic ware and hotel ware can further be categorized into plain ware, decorated ware and hand painted ware, and it is claimed by WILLSGROVE that plain ware contributes more than seventy five percent of their total production. Figure 6 below shows a sample of the WILLSGROVE range of products.

5.5 Ceramic products manufacturing

Below is a schematic diagram of the ceramic tableware manufacturing process for the plant:

5.5.1 Raw materials and other material inputs- Clay bodies (9-15% of production costs)

The main raw materials (kaolin, ball clay and silica) to make the ceramic body are all available locally at what is considered an attractive price. The raw materials of differing qualities are widely dispersed throughout the country. High quality clays that may be required to manufacture superior porcelain or china are not available locally, but there is an abundance of clays suitable for the manufacture of earthenware products. Moulding clays are not available locally and these are imported from the EU.

5.5.2 Glazes, stains and transfers (7-18% of production costs)

Glazes and stains are available from SA. Materials for the manufacture of decal transfers are imported from SA but transfers themselves are produced locally by WILLGROVE Ware Pottery.

5.5.3 Packaging (3- 8% of production costs)
Packaged dinner and tea sets intended for resale in the mass market stores require to be packed in sturdy card board boxes suitable for prominent display on the store shelves. This packaging requirement applies locally only to WILLSGROVE’s products.

5.5.4 Energy (8-12% of production costs)
Energy is required for the kilns, manufacturing, drying, glazing, decorating and handling equipment. Energy for the kilns will be in the form of electricity, Liquid Petroleum Gas (LPG) or coal, or solar energy, or a combination of these resources. Local producers perceive themselves as having problems with high energy costs.

5.5.5 Transportation
Willsgrove’s major source of kaolin is nearby, but it is disadvantaged in having other raw materials having to be transported from far way located areas.

5.6 Observations at Willsgrove
Effort was made to get feedback on the usefulness, effectiveness, suitability and applicability of the Six Sigma methodology. All managers and supervisors were encouraged to note on the issues of Six Sigma usefulness, effectiveness and applicability as a competitive advantage package. Observations on the processes, products and examination of secondary data was carried out by the researcher for a period exceeding two months. The general responses were jotted down and later assessed to derive broad opinion polls of the workers on Six Sigma methodology application.

The manufacturing margins improvement model used for identifying products and processes that needed investigation for WILLSGROVE exhibited the following structure. The identifications were spearheaded by the finance department and the products or processes were ranked according to existing margins and potential for improvement.

The major steps in using the model below in Figure 8 included the following steps:
- Identifying the products and cost centers that needed investigations
- Ranking the products or cost centers according to existing margins and potential for improvement

![Figure 10: Willsgrove model for manufacturing margins improvement](image)

During this part of the project, employees, supervisors and management staff along with some customers were interviewed to establish opinions on usefulness, effectiveness, implementability, suitability and applicability of Six Sigma.

6. RESEARCH FINDINGS
On analyzing the customers and employees’ responses to interview questions to find out if the responses supported the idea that the Six Sigma methodology is a useful, practical, original and applicable methodology for competitive advantage for local manufacturing enterprise.

6.1 Data profiling and analysis for customers
a. Information about the Company
The question sought to establish how customers managed to create the relationship with the company and how they got to know about the organization being capable of meeting their needs. The results show that thirty one percent (31%) of the customers who transacted with the company got to know about the company, through word of mouth of other customers who were satisfied by the product range and service delivery. The contribution shows that satisfied customers can market on behalf of the organization. Forty five percent (45%) and twenty four percent (24%) of the respondents...
disclosed that they got to know about the company through personal visits by employees of the company and through the press and other advertisements respectively.

Table 7: Company Information

<table>
<thead>
<tr>
<th>Adverts</th>
<th>Sales Personnel</th>
<th>Customers</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>24%</td>
<td>45%</td>
<td>31%</td>
<td>0%</td>
</tr>
</tbody>
</table>

b. Delivery lead time
Twenty two percent (22%) of the customers indicated that delivery lead time is excellent and most of these customers fall into the top twenty (20) customers of the organization, which may mean that they are given top delivery priority. Forty seven percent (47%) indicated that delivery lead time is generally good and they are satisfied with the current performance levels which range between 4 and 6 weeks, compared to the over 10 weeks delivery lead times that were being experienced. Thirty one percent (31%) of the customers cited that delivery lead times are reasonable, but sometimes they suffer delays, since there is reoccurrence of some complaints like receiving broken ware from supplier and receiving incomplete orders, which come late on delivery.

Table 8: Delivery Lead Time

<table>
<thead>
<tr>
<th>Excellent</th>
<th>Good</th>
<th>Reasonable</th>
<th>Poor</th>
<th>Awful</th>
</tr>
</thead>
<tbody>
<tr>
<td>22%</td>
<td>47%</td>
<td>31%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

c. Service Quality
Close to ninety one percent (91%) of customers indicated that they are satisfied with the quality of service they receive. In their comments, most of them mentioned that even if they are satisfied with the quality of service they receive, however sometimes product breakages and shortages on delivered products occur, and this causes dissatisfaction within customers.
Nine percent (9%) of the customers indicated that service quality is not good since there is reoccurrence of some complaints like receiving broken ware from supplier and receiving incomplete orders, which come late on delivery.

Table 10: Service Quality

<table>
<thead>
<tr>
<th>Excellent</th>
<th>Good</th>
<th>Reasonable</th>
<th>Poor</th>
<th>Awful</th>
</tr>
</thead>
<tbody>
<tr>
<td>9%</td>
<td>60%</td>
<td>22%</td>
<td>9%</td>
<td>0%</td>
</tr>
</tbody>
</table>

d. Product pricing
Off all respondents, close to 9% indicated that the product prices were high and these were mainly customers from the low income bracket. Fifty six percent (56%) of respondents indicated that product prices were acceptable and eleven percent (11%) indicated that the prices were low.

Table 11: Product Prices

<table>
<thead>
<tr>
<th>Low</th>
<th>Acceptable</th>
<th>High</th>
<th>Unbearably High</th>
</tr>
</thead>
<tbody>
<tr>
<td>24%</td>
<td>56%</td>
<td>11%</td>
<td>9%</td>
</tr>
</tbody>
</table>

e. Employee Performance
Twenty nine percent (29%) of customers disagree that employees are properly trained because they claim they are not given enough attention especially with regards to complaints aimed at elimination/reduction of ware breakages and shortages. Thirty eight percent (38%) of customers tend to agree that employees of Willsgroove Ware Pottery are properly trained and these customers who confirmed this are mostly hoteliers and well established retail customers whose strong links with the organization date back for five years or more. Thirty three percent (33%) of respondents were found to be in agreement that the employees are properly trained.

Table 12: Staff Training

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>33%</td>
<td>38%</td>
<td>29%</td>
</tr>
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</table>

f. Tenure with the organization

The question sought to test customer loyalty for the organization and to evaluate how loyal customers benefit the organization. From the above analysis the number of years that customers have spent with the organization reflect loyalty and a long relationship that has been established. Thirty six percent (36%) of the customers have maintained a relationship with the organization for at least 10 years. Thirty three percent (33%) maintained their business with the organization for a period between three and ten years and below.

Table 13: Tenure

<table>
<thead>
<tr>
<th>Three Years and below</th>
<th>Between three Years and ten years</th>
<th>Ten years and above</th>
</tr>
</thead>
<tbody>
<tr>
<td>25%</td>
<td>42%</td>
<td>33%</td>
</tr>
</tbody>
</table>

g. Frequency of transacting with the organization

The question sought to find out how often customers make transactions with the organization. If they frequently conduct transactions with the organization, then this qualifies that customer satisfaction is a critical factor for the company’s growth and survival. Twenty five percent (25%) of customers indicated that they transact with the company once in a while. Forty two percent (42%) mentioned that they transact with the organization on regular basis and fifteen percent (15%) indicated that they frequently transact with the organization.

Table 14: Transacting Frequency

<table>
<thead>
<tr>
<th>Once in a while</th>
<th>Regularly</th>
<th>Frequently</th>
</tr>
</thead>
<tbody>
<tr>
<td>25%</td>
<td>42%</td>
<td>33%</td>
</tr>
</tbody>
</table>

h. Factors considered by customers in their dealings with the company

Thirty one percent (31%) of the customers feel that product quality is the most important factor in the ceramic tableware sector. However customers also ranked product prices as the other most important factor. Eighteen percent (18%) of customers indicated that delivery/service quality is the third most important factor with a lot of them commenting that delivery efficiency and customer care, including complaints handling are critical factors. Sixteen percent (16%) and four percent (4%) of customers indicated that distribution efficiency and responsiveness rank fourth and fifth respectively in terms of importance and they commented that these are not very critical factors.

Table 15: Important Factors
6.2 Six sigma implementation effect on human resource
The organization came up with team orientation and people management as a strategy of team building and rewarding excellent employees. These teams include Six Sigma project teams, problem solving teams, quality improvement teams and management teams.

The Willsgrove Human Resources manual showed that, in a move to reduce costs and unnecessary expansion, the company implemented a turnaround strategy and streamlined manning levels. The histogram below illustrates how the organization has attempted to reduce their costs through streamlining.

![Histogram of Manning Levels](image)

**Figure 11:** Manning levels over the years (2007 to 2012)
Source: Human Resources Manual – Willsgrove Ware Pottery 20013

6.3 The effect of Six Sigma methodology on organization’s performance
The quality conscious customers have been “hooked on” to the company’s products whose quality attributes surpass or match those of competitors, especially imports, with prices that are highly competitive.

The performance of WILLSGROVE emanating from the application of Six Sigma methodology was verified basing on specific performance metrics as stated below and validated by the researcher through examination of real time operational outputs as workers executed their duties and verification of operational records.
- Market share rose to 38% as at end of 2011 from 30% at the end of 2010 as a result of Six Sigma methodology application. As at March 2012 the market share of WILLSGROVE was determined to be at 42%, which is a positive stride towards their target.
- Gross profit margin was at 70% as at March 2012 as compared to below 45% in 2011.
- Return on profit was averaging 16% as at March 2012 compared to an average of 12% in 2011.
- Record productivity level of 800 pieces per employee per month was being achieved as at March 2012 compared to previous record level achieved in 2011 of 500 pieces per employee per month, and still using the same equipment and technology.
- The researchers determined through verification of sales and production recorded data that customer order delivery cycle times as at March 2012 were that 37% of orders were delivered within 4 weeks, 34% within 5 weeks, 25% within 6 weeks and 4% within 7 weeks, as compared to the delivery cycles that ranged from 6 to 14 weeks as at March 2011, with around 50% of orders being delivered within 10 weeks.

7. RESEARCH DISCUSSION
It was confirmed that for the ceramic tableware industry, the key survival strategy is innovation or continuous improvement, and this is what Six Sigma entails. No tool can succeed in isolation from other tools, and on this note, other supporting frameworks like Reliability Centered Maintenance (RCM) are necessary, as well as the likes of Optimised Production Technology (OPT) and the ISO 9001 Quality Management System which was in existence before the Six Sigma methodology implementation to aid manufacturing efficiency.

To sum it up, it has come as a result of Six Sigma methodology implementation at WILLSGROVE that the factors considered as important by its customers have all improved, and these are product quality, product price and delivery/quality service. This has impacted positively on the customers as their satisfaction levels have been raised.

8. RECOMMENDATIONS

8.1 Six Sigma Experts
Six Sigma methodology implementation in Zimbabwe requires the availability of Six Sigma Master black belt experts, whose availability in Zimbabwe is virtually nil. This creates an information diffusion and implementation barrier to those aspiring Zimbabwean companies wishing to embark on Six Sigma methodology implementation. Six Sigma information centers or Institutes of Continuous Improvement could be established and be responsible for training Six Sigma experts in Zimbabwe. This means that the initial foreign currency expenditure is only expended on the training of the pioneering group of experts, and thereafter it will be funded in local currency.

8.2 Six Sigma Methodology Information Sources
Institutes of higher learning like universities should be trailblazers in terms of information provision especially for continuous improvement tools/techniques. The academic curriculum can also do very well by addressing this critical area through offering courses tailor made for provision of information relating to continuous improvement methodologies or strategies. Other institutes other than universities, like the SIRDC, can establish continuous improvement centers which employ the likes of Six Sigma experts who will be responsible for further research and training of people especially from industries.

8.3 Need for Implementation Process Standardization
The implementation of Six Sigma can benefit a lot of organizations and minimize or eliminate implementation failures if the implementation process is standardized. The fact that there are no standard manuals for the implementation of the Six Sigma methodology means that the success of the implementation program depend in part on the skill and knowledge of the Six Sigma Master black belt; and benchmarking against other companies that would have successfully implemented the methodology.

8.4 Audit Trail Procedures
This will give credence to the capability and guaranteed existence of the methodology as accredited firms will be assured that the methodology is not a fly by night wonder or a fad, and it is there to stay and all what will change are improvements on the methodology itself. Accredited firms can also utilize the Six Sigma accreditation as a marketing tool and assurance aspect to their customers. Internal audit procedures can also be developed by individual organizations to ensure the internal systems’ compliance to the methodology requirements.

8.5 Six Sigma Methodology Customization
Six Sigma methodology are standard and remain the same throughout the geographical divide, best results and benefits of the application of the methodology are derived through customization of the methodology to an organization’s particular situation. There is need to customize the methodology to the organization’s situation and environment as factors like demographics, macro-economic environment, politics, legal, human and social factors can impact greatly on the way the organization conducts its operations. Originality is of strong essence for the effective implementation and application of the Six Sigma methodology. This aspect was strongly recommended to the Case Study company for consideration as dissatisfied customers will spread negative sentiments about an organization to the detriment of the organization.

8.6 Integrated Knowledge Management System
This involves linking the Six Sigma methodology information to all the company’s information system. The Six Sigma methodology must define the culture of the organization, it should be the DNA of the organization, meaning that the Six Sigma methodology information is critical in the decision making process. Decision Support System (DSS) of the organization should be guided the Six Sigma methodology as all activities are geared towards customer satisfaction, continuous improvement and financial gains. Thus both the organizations’ Decision Support Systems and Executive Information Systems (EIS) should exude strong Six Sigma methodology traits if ever the methodology should remain the DNA of the organization.

9. CONCLUSION
The study has revealed that the Six Sigma methodology plays a pivotal role in the organization’s survival, growth, professional image building, customer satisfaction, customer retention and loyalty. It was established that there is a direct relationship between the sales volume and the Six Sigma methodology. This suggests that a strategy-oriented organization is better positioned to deal with environmental changes than a non strategy oriented organization. The findings have also revealed that consumer perceptions on company image vary depending on the implementation of the effective strategies or methodologies. Observations at the Case Study company revealed that Six Sigma methodology application is still at its infancy, as benchmarking is still being done with South African companies.

The other point that was uncovered was that, like any new approach or system being adopted, the success of the Six Sigma methodology as a real time competitive advantage improvement management system, lies on top management commitment. Top management commitment is key to successful implementation of the methodology as a truly competitive advantage package in the industry’s discrete manufacturing sector. Other important requirements for successful Six Sigma application include the availability of resources such as foreign currency, skills such as project management techniques, and time for projects implementation. With these pre-requisites satisfied, Six Sigma can be
effectively used as a competitive advantage option by local discrete manufacturing industries through its provision of a compendium of applicable continuous improvement practices that are readily available from prevailing information sources.

10. FURTHER RESEARCH WORK

Further work is needed in improving the Six Sigma methodology, which include among other aspects; the need for implementation standardization, the need for methodology application accreditation and the need for developing a Zimbabwean improvement strategic model based on the methodology; all of which were not possible during the course of this research study. National institutions of technology need to be equipped to drive effective implementation of Six Sigma methodology as the continuous improvement option of choice and a competitive advantage strategy for penetrating the local, regional and international markets presently dominated by international and multinational conglomerates. Six Sigma is about accuracy, consistency and precision and this is means incorporation of Cleaner Production systems can also be further looked into.

REFERENCES

AUTHORS’ PROFILE

Ignatio Madanhire, graduated with a BSc Mechanical(Hon) Engineering and MSc in Manufacturing Systems and Operations Management in 1993 and 2010 respectively from the University of Zimbabwe. He has been a mechanical engineer with Department of Water – Large Dam Designs, and also worked as a Senior Lubrication Engineer with Mobil Oil Zimbabwe as well as Castrol International dealing with blending plants and lubricants end users. Currently, he is a lecturer with the University of Zimbabwe in the Mechanical Department lecturing in Engineering Drawing and Design. Has published a number of works on cleaner production in a number of journals.

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