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Manufacturing information and database systems adoption and usage trends in Zimbabwe's industries.

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ABSTRACT

In the modern day's global environment, data and information has become a central productive and strategic asset, and the success of the organization depends on its ability to gather, produce, maintain and disseminate this information for its benefit and those in its value chain. The article details the results from a study concerning different types of software packages used by Zimbabwe's manufacturing and engineering firms. The participants were categorized into six industries as, Academic, Power Generation, Manufacturing Chemicals, Manufacturing Engineering, Mining and Transportation. The study revealed that 97% of the companies under investigation had a software package installed for their operations. The "big five" software packages in use in Zimbabwe are SYSPRO, SAGE, SAP, ELLIPSE, Navision and SCADA DELTA V. In the manufacturing sector SYSPRO has the largest market share of 86%. ELLIPSE is largely used in the mining sectors. Companies spend approximately $20 000 as initial investment on the software and nearly $2 000 annually on license fees. More than 50% of the software users are satisfied with the performance of their software packages.

Key Words: Manufacturing Information and Database Systems (MIDS), Enterprise Resource Planning (ERP), Product Data Management (PDM), Product Life Cycle Management (PLM), MOM, MES

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1. INTRODUCTION

Manufacturing Information and Database Systems (MIDS) are generally computerized and are designed to collect and present the data which managers need in order to plan and direct operations within the company. MIDS used in many manufacturing industries vary in type but they help the industries anywhere in their production line. These information systems are computerised, designed to collect, analyse and present data to managers in order to plan and direct operations within the company as stated by the Business Dictionary (2013). A firm needs to determine its competitive strategy before deciding how to use information technology. That is, an organisation should first understand its competitive position, the competitive forces affecting it, and its overall business strategy. The software package selected by an organization should support its competitive strategy and enable it to deal effectively with the competition forces in its industry. Industrial applications of Manufacturing Information and Database Systems are largely in ERP/CRM, PDM/PLM, SCM, and MOM/MES where the bulky of transactional and operational processes are executed.

2. LITERATURE REVIEW

Literature pertaining to MIDS suitable for engineering and academic industries is reviewed in the sections that follow.

2.1 Manufacturing Operations Management and Manufacturing Execution Systems

Manufacturing Operations Management (MOM) Systems are holistic solutions to

improve manufacturing operations performance. The systems are built to consolidate the management of several production processes, such as quality management, sequencing, production capacity analysis, Work-in-Process (WIP), inventory turns, standard lead times, non-conformance management, asset management, and many other processes within one system. MOM systems expand focus from a single facility to the entire supply network, monitoring a variety of aspects of the manufacturing process. Managing different aspects of the whole manufacturing organisation is associated with various challenges in trying to automate the tasks. Different software tools are needed to collect and analyse real-time data and translate it into valuable knowledge that can be used to inform decision making. Traditionally, manufacturers had their own tailor made software applications since standard platforms to integrate systems at the shop floor level were unavailable. In order to resolve the challenge, software providers started to package multiple execution management components into single, integrated solutions called manufacturing execution systems (MES) (Saenz, *et al,* 2009). An MES keeps track of all manufacturing information in real time, receiving up-to-the-minute data from robots, machine monitors and employees. Latest versions of MES solutions include integrated components such as Computer Aided Process Planning (CAPP), CAM, Product Data Acquisition (PDA), Machine Data Acquisition (MDA), and Personnel Time Recording, as well as Time and Attendance (PTR/T&A).

Generally, MES is a process-oriented manufacturing management system which acts as the comprehensive driving force for the organization and execution of the production process. The major tasks of an MES may be summarised as follows:

- Organisation and support of all production related processes
- Implementation of the closed loop of all actions related to the execution of the production processes.
- Exchange of information with all levels of management (Enterprise Resource Planning, ERP) and the manufacturing / process levels, as well as operational support systems, and Supply Chain Management (SCM).

Common standards in modeling manufacturing information systems from the shop floor to the business logistics level are required if integration and interoperability in MES are to be achieved. The Instrumentation, Systems, and Automation Society (ISA) developed a standard to address the integration issues. ISA-95 is a multi-part standard that defines the interfaces between enterprise activities and control activities (Gifford, 2013). The ISA-95 standard aims to enhance the development of MES applications and integration with other information systems of manufacturing companies, particularly ERP systems. The IEC 62264 “Enterprise-Control System Integration” is another set of standards for MES, which defines the functional hierarchy levels of an enterprise, in which decisions of differing timescales and varying levels of detail must be made (IEC®, 2007). The hierarchy of levels are as listed below;

- Level 4: Business planning and logistics
- Level 3: Manufacturing operations management
- Level 2: Monitoring as well as supervisory and automated control of the production process (Batch control, Continuous control and Discrete control)
- Level 1: Control of process or machinery and data acquisition
- Level 0: Production process

2.2 Enterprise Resource Planning (ERP) Systems

In recent years there has been an increase in using Enterprise Resource Planning (ERP) systems in large companies and government corporations mainly in developed countries. While there is wide adoption of ERP systems in Western economies, developing countries lag far

behind. However, due to recent economic growth, developing countries such as Zimbabwe are increasingly becoming major targets of ERP Vendors. There is an urgent need for understanding ERP implementation issues in developing countries, as ERP Systems are still in their early stages in these countries (Otieno, 2008). Developing countries face additional challenges related to economic, cultural and basic infrastructure issues.
According to Nah *et al* (2001), the most important attributes of an ERP system are its abilities to:

- Automate and integrate business processes across organizational functions and locations.
- Enable implementation of all variations of best business practices with a view towards enhancing productivity.
- Share common data and practices across the entire enterprise in order to reduce errors, produce and access information in a real-time environment to facilitate rapid and better decisions and cost reductions.

Edward and Stefan (2001) discussed the ERP selection in small-scale and large-scale companies in Austria. In particular, they addressed the fields of software packages considered and chosen by companies. When purchasing a software package, weights are assigned to different selection criteria, the size and structure of the team responsible for the decision, the methods employed and the effort used. In Zimbabwe there is not much documentation of processes involved prior to purchasing software package. Usually the software is not purchased by the people who use it on a daily basis neither are they involved in selection process for the packages. Gwangwava et al. (2013) developed a technology transfer decision support system (TTDSS). The system can be used to assist companies in decision making when purchasing a software package.

Gargeya & Brady (2005) state that studies, mostly conducted in developed countries, show that organizations often run into costly and sometimes fatal difficulties with implementation and subsequent maintenance of ERP Systems. For example, Akkermans & Van Helden (2002) and Monk & Wagner (2006) observe that a typical ERP implementation initiative takes anywhere between one and three years and typical budgets are in tens to hundreds of millions of dollars. The difficulty in ERP enactment in developing countries may be aggravated by the claim that ERP embodies established ways of doing business thereby requiring organizations adopting ERP systems to change their business processes to conform to business practices inbuilt in ERP packages. Vendors argue that the adoption of these best practices makes the configuring of the software less costly and brings about improvement in the organization's processes. Consequently, organizations and their members often experience pressure to adopt these practices (Gosain, 2004).

2.3 Product Data Management/ Product Lifecycle Management

Product Lifecycle Management (PLM) can be taken as a strategic business approach that applies a consistent set of business solutions that support the collaborative creation, management, dissemination, and use of product definition information. PLM systems support the management of a portfolio of products, processes and services from initial concept, through design, launch, production and use to final disposal. The product life cycle covers the lifespan of a product from the idea through development up to disposal or recycling. The product's life cycle - period usually consists of five major steps or phases: product development, product introduction, product growth, product maturity and finally product decline. These phases exist and are applicable to all products or services (Loannis, 2002). The phases can be split up into smaller ones depending on the product and must be considered when a new product is to be introduced into a market since they dictate the product's sales performance. Product Data Management (PDM) systems provide the tools to control access to and manage all

product definition data. It does this by maintaining information (meta-data) about product information. (Npd-Solutions, 2011). PDM systems are file repositories or “vaults” that hold mechanical CAD files, including parts and assembly models as well as drawing files. In 3D CAD systems, these files rely heavily on each other; they have relationships and contain dependencies that drive details like feature size and placement in other models. If engineers are not careful, small changes in one file can break an entire product assembly. The PDM vault allows mechanical engineers to better manage the complex interrelationships between the part, assembly and drawing files. They can share files with other team members and keep each other up to date on design modifications through a file check-in/check-out process.

3. RESEARCH METHODOLOGY

The research investigates the organisational and national context within which ERP is adopted and used in Zimbabwe, and how the context and ERP influence each other. Methods of investigation used in the research are presented in the sections that follow.

3.1 Research Design

A survey research was used to tap data on the software packages used by firms in Zimbabwe. The study used stratified random sampling to ensure the survey truly represents all the firms in Zimbabwe. The questionnaire was used as the main research instrument for this study and was complimented by interviews to extract key data for the research. Sampling enabled the researchers to draw conclusions about the MIDS packages used in industry and challenges faced in using these systems as organizations endeavour to meet global standards. The sampling process also enabled the researchers to come up with researcher findings within a short space of time.

3.1.1 Data Collection

Data was collected from a sample of organizations. The participants were categorized into six classes of industries, namely, academic, power generation, chemical manufacture, engineering manufacturing, mining, and transportation industries. A random sampling approach was chosen because it is unbiased and covered the whole of Zimbabwe. A simple random sample is meant to be an unbiased representation of a group. The size of the sample was, hence, a trade-off between rising cost of data collection and the diminishing cost of sampling error. The research instruments used are detailed in the next sub-section.

3.1.2 Questionnaires

Thirty four (34) questionnaires were sent to manufacturing organizations. The respondents were guaranteed about the confidentiality of the information to be elicited; thus the confidentiality clause. Open-ended questions were used, allowing the respondents to reply freely without selecting one of the several provided responses. In addition, open ended questions gave room for respondents to freely state their views on the particular aspect of the research. Close-ended questions were also used and these questions provided respondents with guided answers that enabled systematic analysis of data. It was easier to analyse close-ended questions. Close-ended questions permit easy and quick answering of questions by the respondents. Questionnaires were used because of the advantage they offer in saving time and money. The survey covered the whole of Zimbabwe and the use of questionnaires was ideal and cheaper than travelling as they were emailed to the respondents.

3.1.3 Structured Interviews

An interview session was held with engineers and operations managers of different manufacturing industries. Clear and concise interview guides were prepared and given to the interviewees a day before the interview so that they could study and understand the guides before the interview. This enhanced the preparedness of both the researchers and the respondents. Only one question was asked

at a time, making sure that it was concise and clear. No attempt was made by the researchers to put words into the respondents' mouths; it was made clear from the onset that the purpose of the interview was to get the views of the respondents, not those of the researchers. The researchers avoided reacting to the respondents' answers by expressing approval, disapproval, surprise, or shock; the researchers were always appreciative of the answers provided by respondents. The researchers recorded responses verbatim so that the collected data would be accurate and objective and a run-down of the major recorded points was read to the interviewees for them to confirm if the points had been captured correctly. Structured interviews were used because they allowed for the creation of rapport between the researcher and the interviewees. Doan (2009) mentioned that structured interviews had an advantage of providing structural relationships of concepts and one concept could lead to the definition of other unknown related concepts. Structured interviews were also used because they maintained focus and provided information on the raised issues.

3.2 Research Findings

This section outlines the survey results of the software packages used by various organisations in Zimbabwe. The respondents were categorized into specialized industry types that encompass academic, power generation, manufacturing, mining and transport. Major investigations targeted by the research include the types of ERP packages used by each industry category, the age of the installed packages, and implementation challenges, as well as the level of integration of the information systems in companies.

3.2.1 Response Rate

Of the thirty four (34) questionnaires distributed, twenty eight (28) were responded to, which amounts to 82% response rate. Table1 shows that the manufacturing engineering, manufacturing chemicals and power generation industries had the highest response rate of 100%. The transportation industry was the lowest with 0% response.

3.2.2 Market Share of Various Software Applications

The pie chart in Fig 1 shows the market share of various software applications used in Zimbabwe's industries. SYSPRO has the greatest market share overally, followed by SAGE, SAP, Navision, Elipse and other softwares such as Pastel, Oracle, Eagle and Hansa world.

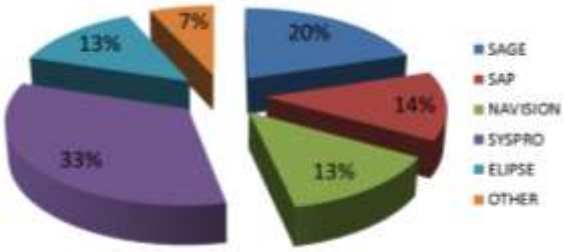

Figure 1. Software Applications Market Share in Zimbabwe

3.2.3 Average Initial Installation Costs of a Multi-user Software Package in Zimbabwe

The average initial cost of installing a multi-user software system in Zimbabwe was found to be between US$ 10 000 and US$ 20 000. It was however noted that 60% of software users were not aware of the investments made by their company towards the purchase of such systems as shown in Fig 2.

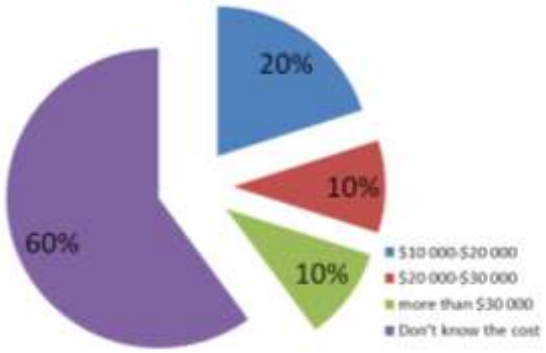

Figure 2. Installation costs of a multi-User software package in Zimbabwe

Table 1. Response rate

Industry	Number of Questioners Sent	Number of Respondents	Percentage Response
Academic	8	5	63%
Power generation	2	2	100%
Manufacturing chemicals	6	6	100%
Manufacturing Engineering	6	6	100%
Mining	10	9	90%
Transportation	2	0	0%
Total	**34**	**28**	**82%**

3.2.4 Software Package Usage Analysis by Industry Category

Fig 3 shows packages used by the mining industry. These packages include ELLIPSE, SAP and PASTEL. SAP is the mostly used application system at 34%.

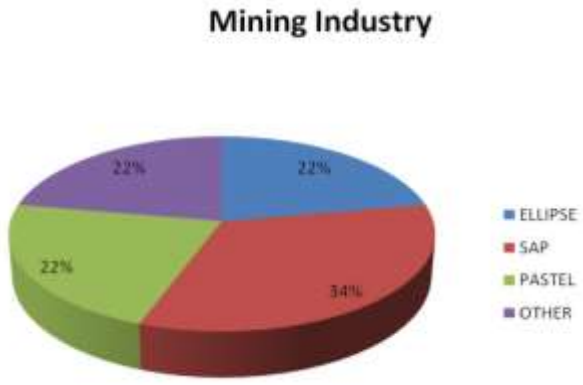

Figure 3. Software Packages used by the Mining Industry

Fig 4 shows software packages used in the manufacturing chemicals industry and SAGE 500 is the mostly used software system.

In the manufacturing engineering industry, SCADA DELTA V as shown in Fig 5 is the mostly used software package at 50% with other softwares being the lowest at 17% and 16% respectively.

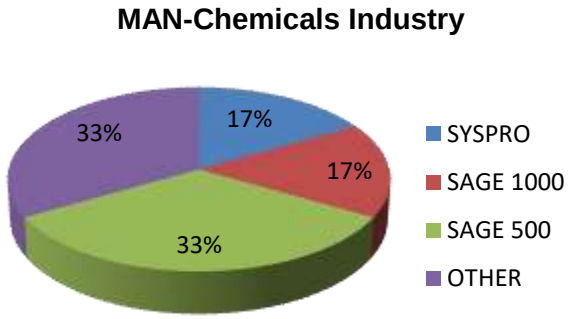

Figure 4: Software Packages used by the Manufacturing Chemicals Industry

Each academic institution seems to be using its own system. This is shown in Fig 6 where all other systems have equal percentages of twenty percent (20%) respectively.

The power generation uses the SAP system. There is 100% usage of SAP because there is one power generation

company in Zimbabwe with distributed branches in different parts of the country. All the branches are linked through one main sever for the organization. This again proves that SAP software is the mostly used as is in the mining industry.

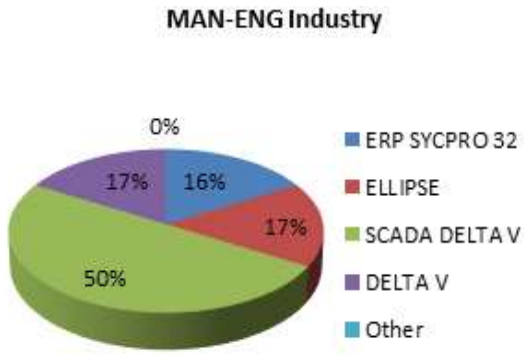

Figure 5. Software Packages used by The Manufacturing Engineering Industry

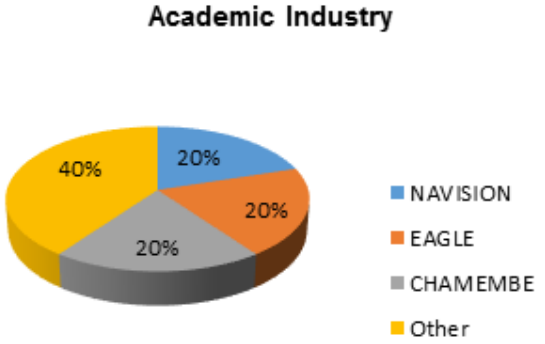

Figure 6. Software Packages used by the Academic Industry

3.2.5 Age Analysis of Installed Software Packages

The age analysis was made to determine the importance attached by companies to investment on new software. Using latest software technology enables companies to be competitive. The research findings show that generally most organizations across different industry categories have installations that are within the range of 0-5 years. This shows the endeavour by the industry to keep pace with fast changing technology. Fig 7 shows the age analysis of the software installations in the mining industry. Seven companies had their installations within the last five years, whilst two companies installed theirs within the last ten years.

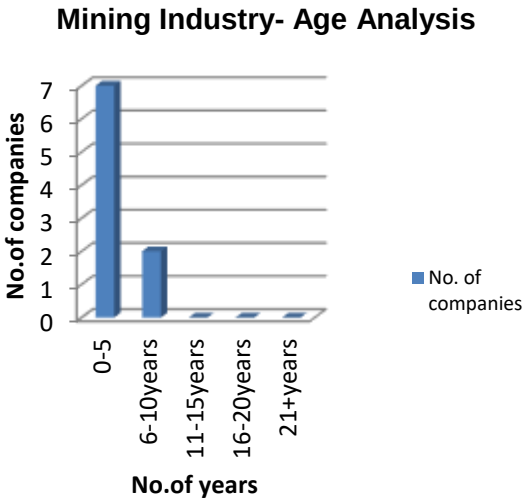

Figure 7. Installation Age of Software used in the Mining Industry

In the manufacturing chemicals industry as shown in Fig 8, three companies installed their software within the last five years, whilst two installed between the last ten years and only one installed in the last twenty years. In the manufacturing engineering industry two companies installed their software between the last ten years, and then four companies had installations more than ten years back as shown in Fig 9.

Figure 8. Installation Age of Software used in the Manufacturing Chemicals Industry

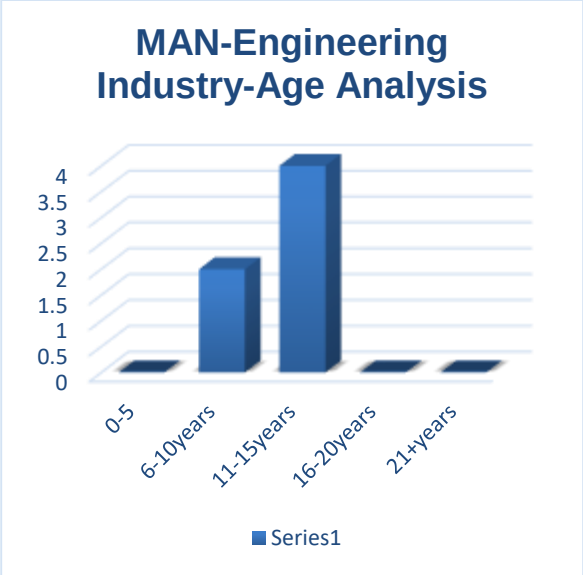

Figure 9. Installation Age of Software used in the Manufacturing Engineering Industry

In the academic industry as shown in Fig 10, three institutions installed between the last five years, the other two between the last ten years.

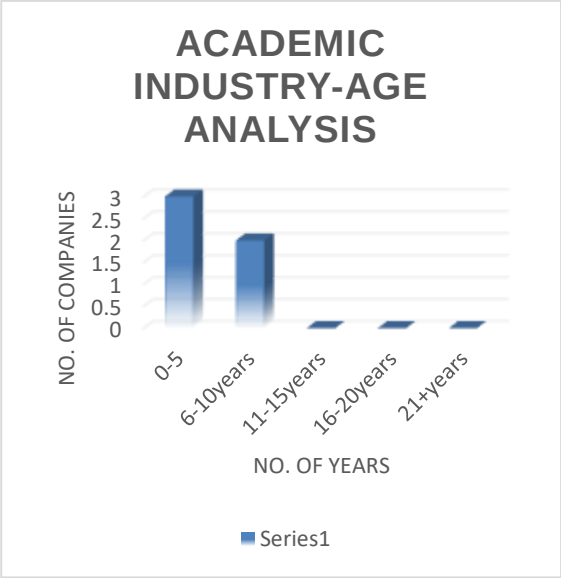

Figure 10. Installation Age of Software used in the Academic Industry

3.2.6 Network Platform used to Support Software Installations.

Most Zimbabwean companies are installing multi-user applications on different sites to cater for various branches for their companies. Only small-scale companies are installing single user software because of the installation costs. Fig 11 shows the types of installations in various industries.

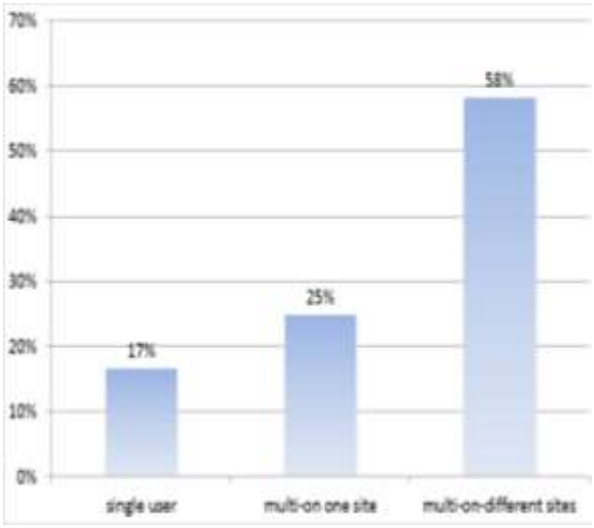

Figure 11. Software users in Zimbabwean Companies

Many companies in Zimbabwe have not yet embraced the technique of cloud computing as shown in Fig 12. 73% of the companies own their server and 27% of the companies are hosted on the cloud.

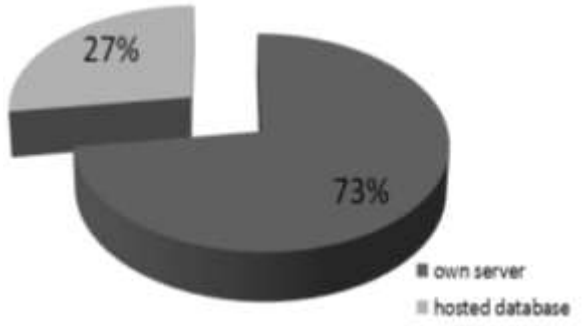

Figure 12. Database Hosting in Zimbabwe

Despite most of the companies having their own servers, internet connectivity has enabled employees to log on to their LAN using the internet. Only 20% of the companies surveyed are unable to access

their network through the internet as shown in Fig 13.

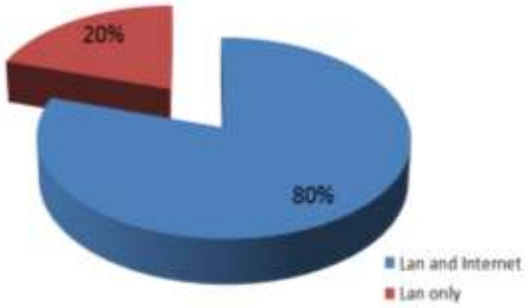

Figure 13. Database Accessing in Zimbabwean Companies

3.2.7 Benefits and Challenges

The respondents stated that having the ERP software improved customer satisfaction, improved process control, reduction of wastes, improved inventory control and labour reduction. Surveyed companies cited the following as benefits of installing these software packages; reduced level of inventory, reduced manpower requirements, better handling of customer orders and reduced cycle time according to the software users in Zimbabwean companies. The statistics of the responses are shown in Fig 14.

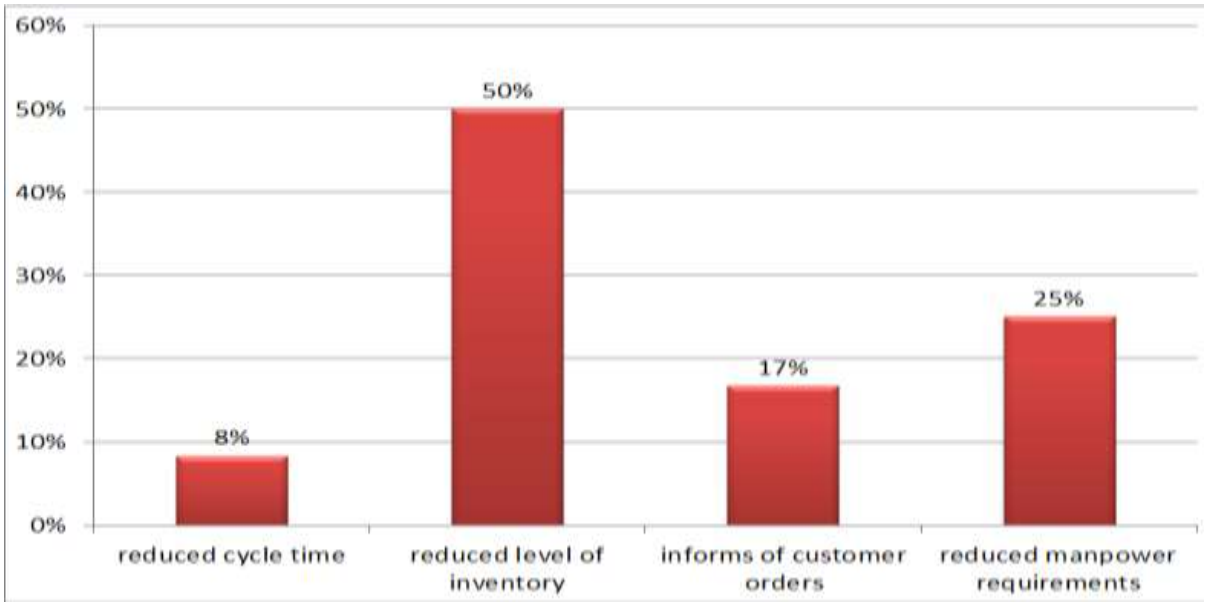

Figure 14. Benefits of Installing Software Packages in Zimbabwe

Whilst licensing, upgrade cost and loss of employment were among the challenges faced by the respondents in the different sectors of the different industry. The respondents also noted that to log on to the system was very slow especially when using a wireless internet connection. Additionally, respondents showed that the systems needed to be financially maintained during their useful life cycle. Table 2 summarises the findings.

The following are the challenges consultants face in implementing ERPs in companies:

i. Lack of commitment and resistance to change from users,
ii. Lack of adequate funding,
iii. Unfair competition,
iv. High turnover of top management,
v. Lack of adequate support resources.

Table 2. Challenges Faced in using ERP Software

IT Department Challenges	End User Challenges
Low computer literacy of users	Network fluctuations
Users' resistance to change	Low system response speed
Hardware upgrade	Reports do not give the correct on the ground situation
Infrastructure robustness	Strong knowledge base required
Maintaining link-up connection	User congestion
Delays in performing tasks	Non user-friendly system
Business Process Re-engineering	Too much centralisation
Infrastructure compatibility	Budget constraints
Inventory grouping	Limited user licences
Budget constraints	Limited storage capability
Identification of assets into the system	Little communication between management and end-users
Poor network systems	Poor integration with other existing systems e.g ON-KEY
Power outages	Hierarchical decision making deems process slow
Lack of backup information	Low computer literacy
Customisation of the Dispatch function	Bar coding
	Slow support response to problems

In Table 3, fifteen (15) respondents mentioned that they purchased the software package as it suited well with their processes, ten (10) said they purchased the software because of its cost and three (3) showed that they purchased the software as it was familiar with to company personnel. All the respondents stated that training was offered when the MIDs was installed in their company.

Table 3. Selection Criteria to Purchase the Software Package

Selection criteria	Respondents rate	Percentage response
Cost	10	36
Suitability to processes	15	53
Familiarity with personnel	3	11
Total	**28**	**100**

4. CONCLUSION

The research indicated that there are top five software packages in Zimbabwe. Syspro, Sage, Elipse, SAP and Navision command the greatest market share in Zimbabwe. It was also concluded that less than half of the population of investigated companies were satisfied with their software. The age analysis of installed software packages revealed a great need to upgrade the technology in various companies. This will improve the competitiveness of Zimbabwe's companies, both in service and product delivery.

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