Design of Warehouse Management System Using Mobile Application for Shoe Manufacturing Industry

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Abstract

The goal of this study is to design a system/user interface for inbound and outbound materials in the warehouse with the use of a cell phone application that is linked in the ERP system of the company. Shelf management, inbound and outbound operations were the operations that have been improved by implementing the use of QR code scanning in the application. Root Cause Analysis (RCA) was utilized in identifying processes that involve personnel to make decisions and actions that can lead to human error that can contribute to decreasing the warehouse's operational effectiveness. Questionnaire was given to the R/M Warehouse supervisor, leader and staff. The questionnaire was designed to: 1.) find common problem/s met in warehouse processes and task 2.) Collect suggestions for system improvement and design 3.) Identify user requirement/s for the system. A total of 37 warehouse personnel of Company Y took part last January 19, 2021 in answering the questionnaire. Out of the 37 participants 5(14%) are leaders and 32(87%) warehouse staff assigned various tasks. Process was reviewed as well by utilizing the HIPO chart and was able to identify processes that involve personnel to make decisions and actions that can lead to human error that can contribute to decreasing the warehouse's operational effectiveness. The comparison shows unnecessary operations were eliminated after the use of the warehouse application thus it reduces manpower work hours needed to perform the warehouse processes and it eliminates paper records that can lead to encoding inaccurate information in the ERP system.

Keywords
Inventory management, warehousing application, inbound/outbound materials, shelf management, and automation

1. Introduction
Shoe industry is continuously growing. Followed by the latest report published by Credence Research, Inc. "Global Footwear Market - Growth, Future Prospects and Competitive Analysis, 2018-2026," the market was valued at US$ 222.4 Bn in 2017, expected to grow at the CAGR (Compound Annual Growth Rate) of 3.1% from 2018 to 2026. Heightening demand for sports and designer shoes is the reason behind the emergence of the footwear market. Footwear comprises athletic and non-athletic; footwear is made up of various materials such as leather, plastic, and rubber among others. Purchase of footwear has doubled over the past few decades and introduction of different designs and styles has helped to retain customers and nabbed attention of the new customers as well. (Marketers Media, 2018).

Company – X is a duly registered as corporation, established in 2015 to engage in manufacturing and exporting premium footwear for various international brands such as CCC & ZZZ. Its main customers are international brands. At full capacity, it can employ at least 2,500 workers from around the province of Pampanga and its environs. Company – X started to produce the main product "XXX" in November 2015, on 2016 we started to have a business partner with ZZZ Brand and started to produce its main product. Company – Y Establishment was established on

August 11, 2016 and started to operate in May 2017. It is trading under the business name "Company – Y". ZZZ brand is the only product produced in FPMI. Currently have a total of 2628 employees on site. At full capacity, it will employ at least 3,200 workers from around Pampanga province. Figure 1 shows Company X and Company Y target capacity from year 2016 to 2021.

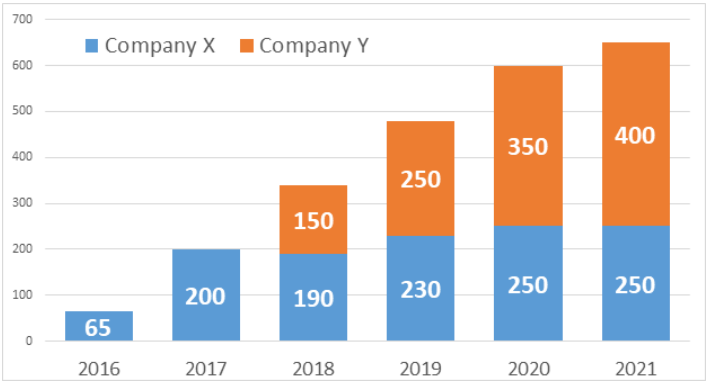

Figure 1: Company – X and Company – Y Yearly Capacity and Target Capacity for 2020 (In Ten Thousand)

Currently the industry uses an ERP system to order materials needed for the production. Materials are all imported from china. Upon receiving the materials all are received manually. Materials arrive in the factory in bulk and are checked manually using a printed list of materials. After receiving materials are stocked in the materials warehouse. Each material is separated according to its classification on different racks. Each rack is labeled with material type and quantity. Every material stored is recorded and uploaded on the system.. Leather materials come from process animal skin and defects are sometimes present on the material, to properly identify the needed quantity of material it is graded based on the area that can be used. Aside from the defects present on the leather, its color and texture should also be almost the same. Ensuring that the correct grade is present on the material should be declared before sending to cutting because it will dictate the usage of each cutter.

It is estimated that there is an average of 300 containers each month arriving that requires around 800 labor work hours to complete all inbound processes until stock-in on the system. There is an average estimate of 1000 material withdrawal transactions each month that requires around 1500 labor work hours to complete a monthly transaction. With this heavy warehouse transaction the company is losing 240,000 in Philippine pesos on a monthly basis for the material losses and production line downtime.

There are numerous studies in the shoe manufacturing industry. However, previous studies did not explore the opportunities of using mobile devices and the new and emerging technologies such as QR code scanning to lessen the manual transactional tasks.

It is in this light the study will aim to the following objectives:
(1) To identify areas for improvement in the current inbound/ outbound material process and shelf management of a shoe manufacturing warehouse
(2) To design a system/user interface for the inbound and outbound materials in the warehouse with the use of a cell phone application that is linked in the ERP system of the company.
(3) Propose a new process that can be followed to further decrease material lead time and improve warehousing processes efficiency.

Following will be the significance of this study: 1) to provide a innovative alternative to conventional warehousing procedures such as receiving, storing and sending materials and 2) to provide the impact the project will provide to a company

2. Review of Related Literature

Cost efficiency is one of the cornerstones of the logistics business. In warehouse logistics, many companies have taken action to replace the manual work with automatic warehouses, conveyors, and other automation applications (Mikko and Marko 2005). The primary aim of automation is to reduce the costs of operations (Baker and Halim 2007).

Warehouses are one of the important components of the supply chain; they represent 20% of the total logistics cost. It takes up to between 2% and 5% of the cost of sales of a corporation and with today's highly competitive global business environment organizations are emphasizing on Return on Assets, and hence minimizing warehousing costs has become an important business issue (Subramanya et al. 2012). Many firms are automating their basic warehousing functions to achieve the increase in throughput rates or inventory turns required for their warehousing operations to be cost effective.

Warehouse automation is the process of automating the movement of inventory into, within, and out of warehouses to customers with minimal human assistance (Jenkinsl 2021). As part of an automation project, a business can eliminate labor-intensive duties that involve repetitive physical work and manual data entry and analysis. Often automation refers to the use of robots; in many cases automation simply refers to the use of software to replace manual tasks (Wu et al. 2013). Organizations operate at various levels of maturity and there is no one size fits all solution to automation. The automation needs of an organization should be driven by the goals they are trying to achieve and the problems they are looking to solve. Before making a large investment, the company must conduct a detailed data driven, fact-based assessment across people, process, and technology to identify the right fit to the purpose that will fulfil the two important objectives when automating warehouses which are improving cost efficiency and controllability of operations (Chouhan et, al. 2020).

Root cause analysis can be used for tool selection (Doggett 2005), it can also be used to improve quality and productivity (Matho and Kumar 2008). RCA's basic purpose is to identify the underlying problem by digging deeper into a problem.

HIPO chart is a tool that can be utilized to come up with a software design (Stevens et. al. 1974). It can easily sort out all the features that a developer wants to incorporate in a software. To achieve the target outcome of a system, the HIPO chart must be studied well. All the input and output must be considered to address all identified problem. This study focused on 3 raw material processes for a shoe manufacturing company in the Philippines. Those three processes are: Inbound Material Process, Shelf Management & Outbound Material Process hence, we focus on the current process analysis and system design. The development of a fully functional warehouse management system can be continued for future research.

3. Methodology

3.1 Description

Root Cause Analysis (RCA) is utilized to identify the processes that involve personnel to make decisions and actions that can lead to human error that can contribute to decreasing the warehouse's operational effectiveness. In addition, data was collected through disseminating a questionnaire. The questionnaire was designed to: 1.) find common problem/s encountered in warehouse processes and task 2.) Collect suggestions for system improvement and design 3.) Identify user requirement/s for the system. From the RCA and questionnaire, the user interface was then drawn on by using HIPO (Hierarchy plus Input-Process-Output) technique.Also, Pareto Analysis is used to create a user interface that will solve the top 80% of the problem. Using the theory of pareto analysis that 80% of the consequences came from the 20% of the root causes.

3.2 Procedure

RCA as defined by American Society of Quality is a collective term that describes a wide range of approaches, tools, and techniques used to uncover causes of problems. Some RCA approaches are geared more toward identifying true root causes than others, some are more general problem-solving techniques, and others simply offer support for the core activity of root cause analysis. Using RCA uncovers the true causes of the problem and separates the symptoms from the true causes that lead to the maximum benefits of solving the problem and preventing recurrence.

Sample collection and establishing the voice of the customers through questionnaires was done . A total of 37 warehouse personnel of Company Y participated in answering the questionnaire. Out of the 37 participants 5(14%) are leaders and 32(87%) warehouse staff are assigned various tasks.

The HIPO technique is a tool for planning and/or documenting a computer program. A HIPO model consists of a hierarchy chart that graphically represents the program's control structure and a set of IPO (Input-Process-Output) charts that describe the inputs to, the outputs from, and the functions (or processes) performed by each module on the

hierarchy chart. SWOT Analysis is a strategic planning technique to identify the internal and external factors affecting the business operations or project planning. Using this technique we were able to find out the organization's Strengths, Weaknesses, Opportunities and external Threats that affect the business. The output of this technique was used as the reference to improve the process. This also uncovered the organizational culture dealing with automation or changes.

Using system evaluation we were able to compare the current system and the automated system and analyze its advantages. This includes the measurement of the final results against its initial performance without the automated system in place.

4. Results

Using RCA uncovers the true causes of the problem and separates the symptoms from the true causes that lead to the maximum benefits of solving the problem and preventing recurrence. In figure 2 below is the RCA for the inventory management system of the subject company/organization. The researchers were able to facilitate 5 Whys RCA to uncover the true cause of the problem in inventory management of the subject company and to identify the best fit solution to the root cause.

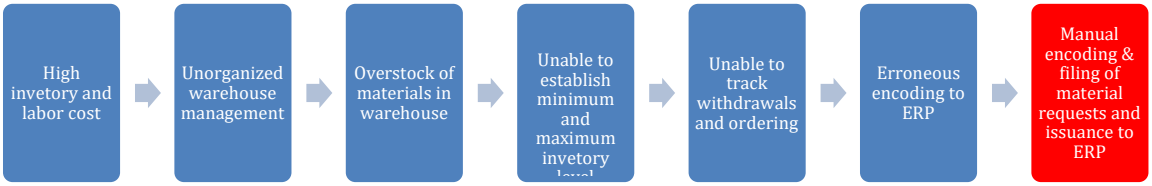

Figure 2: RCA for warehouse managements system

Manual encoding & filing of material requests and issuance to ERP is the possible root cause of the problem. Human intervention provides inaccuracy to the inventory management of the organization. By reducing the manual interface, errors are most likely to reduce and provide more accurate information. To validate the results from RCA, we developed a questionnaire and distributed it to the involved persons in the organization. Based on the result of the questionnaire, 64.9% answered that each simple task like checking records, recording quantity of materials, finding area of materials, checking of schedule, etc. takes more than 10 minutes to complete as shown in Table 1. Though these are simple tasks a significant amount of time is used this shows that there is still a room for improvement when it comes to completion speed of simple tasks.

Table 1: Average Duration of Assign Warehouse Task

	Frequency	Percent	Cumulative Percent
< 5minutes	2	5.4	5.4
5 minutes - 10 minutes	11	29.7	35.1
> 10 minutes	24	64.9	100.0
Total	37	100.0	

Results of the questionnaire also provide common problem encountered on warehouse task as shown in Table 2 wherein 13 (35%) answered that they receive or send wrong record/s which can result in wasting time to double check some items. 9 (24%) of the participants said that they also encountered inconsistent record/s. Followed by missing files (14%) and too much waiting (3%). Most problems encountered are record related problems.

Table 2: Common Problem/s Encountered on Warehouse Task

	Frequency	Percent	Cumulative Percent
Missing Files	5	14%	14%
Wrong Record/s	13	35%	49%
Inconsistent Records	9	24%	73%
Too much waiting	1	3%	76%
Others	9	24%	100%
Total	37	100%	

As part of the survey, respondents were also asked their suggestions on how to improve the current process through automation and results are shown in Table 3 wherein 12 out of 37 participants (32%) think that the "Stock In and Out

Process" should be automated. Previous results already showed that there is already a record related problem on site and simple tasks are consuming more time than the standard. It makes sense that this process is selected by most personnel for this process involves repetition in checking, counting, and sending. Quality checking record follows; it was selected by 8 participants (22%). Next is material search (16%), Material location identification (5%) and Shelf management (5%).

Table 3: Suggested task to be automated

	Frequency	Percent	Cumulative Percent
Stock In/Out Materials	12	32%	32%
Quality Checking Records	8	22%	54%
Others	7	19%	73%
Material Search	6	16%	89%
Shelf Management	2	5%	95%
Material Location Identification	2	5%	100%
Total	37	100%	

Figure 3 below showed the results of Pareto Analysis of tasks prone to mistakes according to the process owners as verified through the results of the questionnaire. The top contributors accounting for the top 80% are: a. inspection b. checking and c. recording.

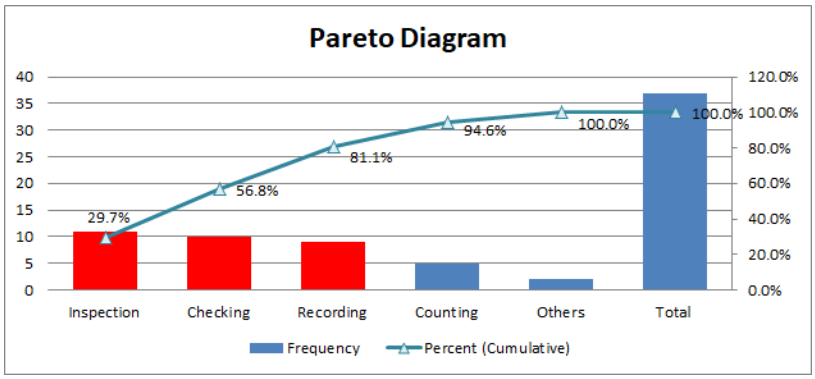

Figure 3: Pareto Analysis

The top 80% of the problem will be the focused area for the development of software applications that can reduce the human interface and likelihood of human error.

4.1 SWOT Analysis

The Company has been in shoe manufacturing for more than 50 years. They provide great support to the local shoe industry by providing capable people that can teach local personnel how to make shoes in a global standard. The labor workforce is very crucial when it comes to shoe manufacturing as this industry is labor-intensive. It needs a skilled workforce. The company has a young and highly trainable workforce. The organization in the Philippines is still young and operating for 2 years. Despite the length of operations and standard operating procedures in place, the organizations haven't reached the global standards. Another challenge is automation and innovation has not been supported due to a lack of data; this opens a huge opportunity that can be exploited to increase the company's profitability. Figure 1 shows, the company's strengths and weaknesses and the opportunities and threats in the external environment.

5. Discussion

5.1 Software Design

Materials delivery arrives in the factory several times every week after unloading the materials it is sorted and recorded manually before it is encoded in the system. The manual encoding can be a cause of the error of materials including the quantity is encoded to identify how much stock is available. Human error is one of the influencing factors that

affect the firm's performance in inventory management (Grosse et. al, 2014). After encoding the received materials, they will manually assign the storage for the materials depending on available racks in the warehouse. The same materials are usually stacked together depending on storage availability. One challenge in shelf management is looking for materials and immediately identifying how much stock you have for a certain material, usually to get that information one personnel must check the system multiple times. When the production request materials the process starts when the request arrives in the warehouse, one personnel must process the request and deduct the requested quantity in the ERP system manually. After the process, other personnel will pack the materials and ready for sending it to the production area. Various processes during the flow required encoding, listing, searching, and arranging that require personnel to decide every process and in every decision, the personnel are prone to making an error. Figure 4 is the HIPO Chart of material flow.

Table 4. SWOT Analysis

Strengths		Weaknesses	
S1	Provide superior quality, reliability, and service	W1	Long lead time
S2	Strong company culture	W2	Less innovation/automation activities
S3	Stable Management team	W3	High administrative cost
S4	A stable relationship with partners and brands	W4	Unstable efficiency
S5	Good shoemaking technique and practices	W5	High production cost
S6	The strong shoe development team	W6	High employee turnover rate
S7	Strong support from the main company	W7	High fixed cost (Factory rent)
		W8	Local Tech/Management/Experience/Quality mind-set needs to be improved
		W8	Poor quality
Opportunities		Threats	
O1	Expansion in the Philippine markets to create larger factory recognition	T1	High external competition from other shoe factories overseas
O2	Production quality and design can still be increased	T2	A continuous increase in labor cost
O3	Expansion opportunity from China order loss	T3	Emerging local shoe manufacturing companies
O4	Long term vision for Philippine factory	T4	All material supplier is overseas
O5	Strong support from customer	T5	New technology is accessible on the market to all competitors
O6	The young workforce is highly trainable		
O7	China-US trade war, Transfer orders from China		

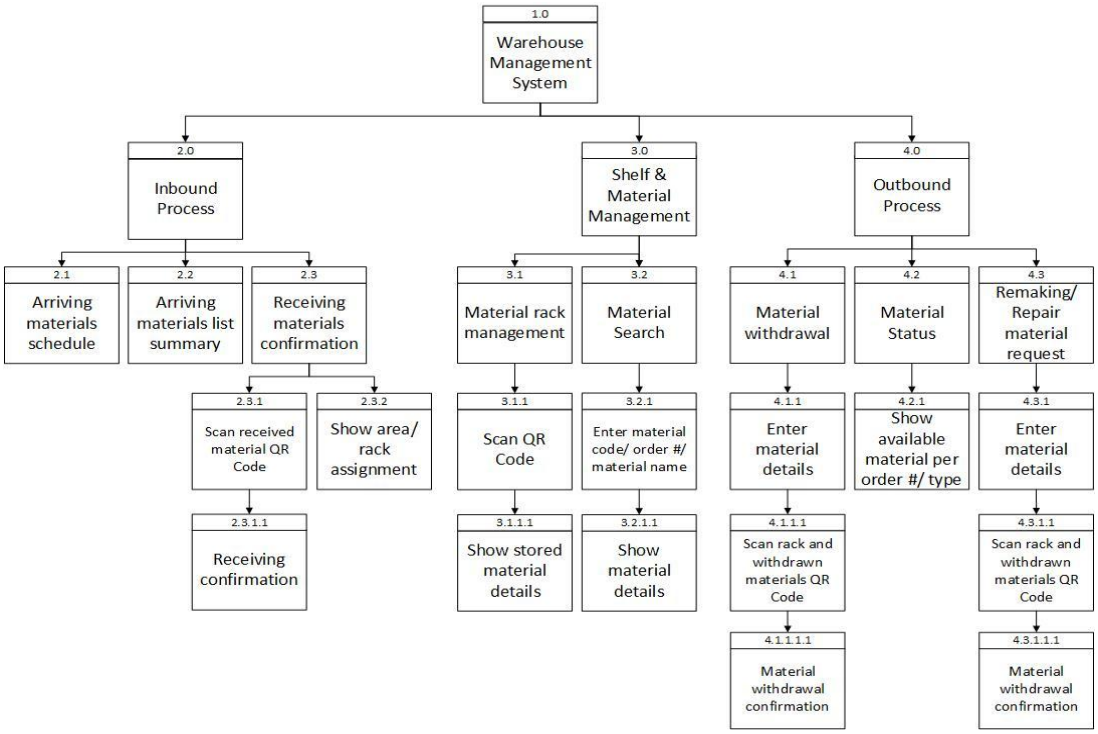

Figure 4: HIPO Chart of Shoe Warehousing

System/User Interface design was devised based on the generated HIPO chart. User Interface (UI) will start with login details of the user or employee. Users will need to register on the company database in order to grant access to Warehouse Management System (WMS). As demonstrated on Figure 5, the UI will require the employee's badge id and password for the purpose of accessing the WMS.

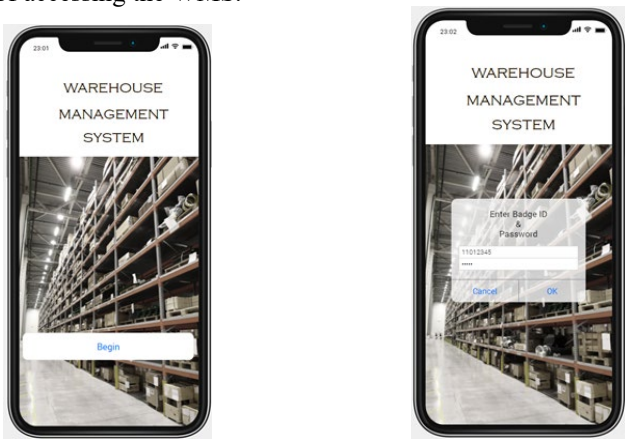

Figure 5: Log-in frame of Warehouse Management System

After supplying the employee's log in detail, the next frame will display the 3 major process steps as shown in Figure 6, Inbound, Outbound and Shelf & Material options. User has the option to select which process steps need to access and do necessary transactions.

Figure 6: Inbound, Outbound and Shelf & Material Option

Figure 7 is the Inbound Process frame, in here it will display the materials arriving list and schedule. The details of materials will be coming from suppliers and will be populated in WMS. Upon receiving, the material received date and rack assignment will be confirmed by using QR code scan as can be seen on Figure 8. After the QR code scan, details such as received date and rack assignment will be updated in the WMS database.

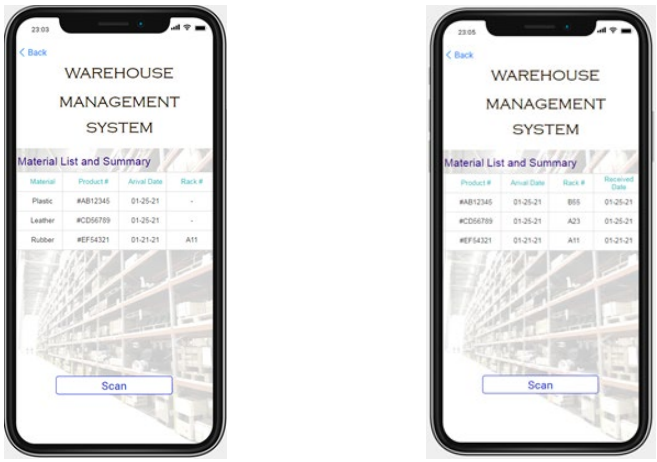

Figure 7: Inbound Process Frame

Figure 8: QR Code

Figure 9 is the Shelf & Material management whereas the user can enter material code/order#/ material name in the search engine of the application. Upon search, the application will sort and prompt the material details such as rack location, status and quantity. Apart from search engine, users also have an option to scan the QR code, see Figure 8, in transacting of the desired materials that production need to use.

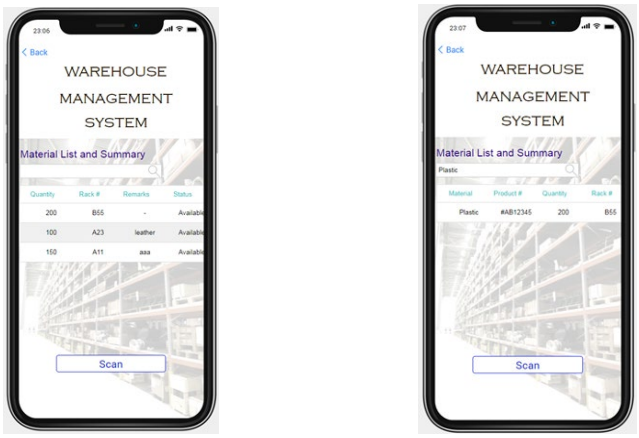

Figure 9: Shelf & Material Management

Figure 10 shows the details of the outbound process which comprises withdrawal and repair selection. After locating the material's rack number, users can select to withdraw the material accordingly. If a material needs to be sent for repair, the user can opt to choose the repair option in the WMS.

Figure 10: Outbound Process Withdrawal & Repair Option

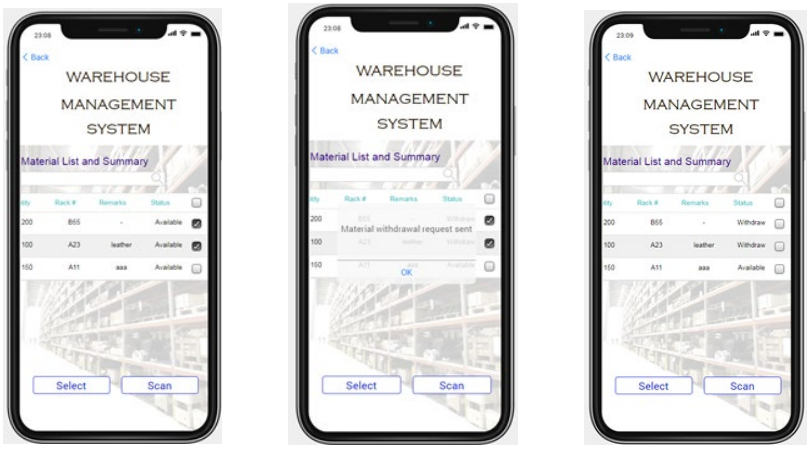

Figure 11: Outbound Withdrawal Material Process

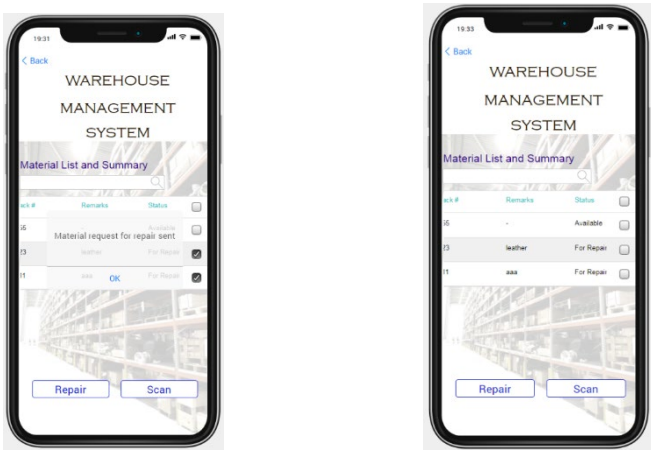

Figure 12: Outbound Repair Material Request

As seen in Figure 11, information available for outbound are material status, availability and rack location. Material can be withdrawn by selecting the tick button or scanning the rack QR code. Material withdrawal confirmation will

prompt, and the system will update the status. Figure 12 is the material repair request options. The request can be done by scanning the material QR code or by clicking the tick button. Upon execution the material repair request confirmation will prompt, and the system will update the material status as "for repair".

5.2 Software Outputs

5.2.1 Internal outputs

Monthly, quarterly, yearly material withdrawal summary report - This can be used to establish minimum and maximum inventory, reorder point and reorder quantity to avoid material stock out. This report can also be used to monitor the cost of warehouse operations to minimize expense and utilize resources as well as for budget justification and allotment for succeeding years. Real-time inventory viewing/report – This will monitor the expense of internal customers.

5.2.2.External outputs

Location – This will tell you if your customers are centrally located in one region, or are spread across the country if you have a large international customer base. Categorize and record quality issues - Track the actions taken to solve the issues.

5.2.3.Operational Performance Dashboard (Distribution & Inventory)

It will give transparency of distribution routes, numbers, and time. The goal is for the company to distinguish which area is positively or negatively affecting the overall performance. Acquire the reason for stock-outs which could be due to internal false reorder. Able to define the maximum stock needed to hold to avoid excess materials. Figure 13 shows the dashboards that the system can provide for visualization of inventory and issues.

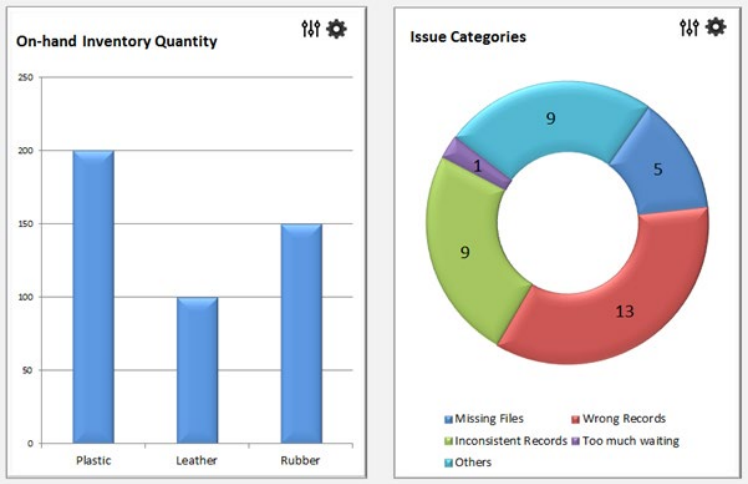

Figure 13. Application Dashboard

5.3 Cost-Benefit Analysis

5.3.1 Cost

The initial cost that will be spent on designing the system is PHP 25,000 and the monthly cost of mobile application usage and maintenance with unlimited access is PHP 27,000.

5.3.2 Benefits

The subject organization is set to benefit from the project by eliminating the following problems and associated costs for these 3 major losses; 1) Production line downtime, labor hours spent on inbound to outbound transactions, and material losses; 2) The production line downtime incurred an average of 4 hours monthly or an equivalent of 79,000 PHP, employing production personnel without output and the material went missing accounted 161,000 PHP; 3) average monthly, the paper consumption used on all the transaction cost 1,000 PHP and labor cost amounting to an average of 46,000 PHP. By implementing the new system these losses will be eliminated together with the paper consumption that is used to generate reports.

5.3.3 Cost to Benefit Ratio

Computing the benefits to cost ratio. It is presumably that in any project the benefits should be greater than the cost or the ratio between two factors must be greater than 1. Below is the computation of the benefits-cost ratio.
The benefits cost ratio can be computed by dividing the total cost by the total benefits. The total cost is PHP 52,000 and the total monthly benefit is PHP 96,000. The benefit-cost ratio is 5.42 in the first month of implementation. In the succeeding months of implementation, the initial cost will be removed from the total monthly cost. If only the monthly cost will be considered the benefit-cost ratio will increase to 10.4.

Table 5: CBA Analysis for Warehouse Management System

	Cost/ Benefits	Value (php)
Cost	Estimated Design & Development Cost	(10,000)
	Estimated System update	(10,000)
	The estimated cost of Printing and Installation of QR Code on Racks	(5,000)
	The estimated cost of Mobile application monthly maintenance and usage (unlimited access)	(27,000)
Benefits	Eliminated downtime due to stock out (Monthly average @4 hours)	79,000
	Material losses (monthly average)	161,000
	Paper consumption/month	1,000
	Labor reduction (Monthly average @ 920 hours)	46,000

6. Conclusion

The use of new emerging technology is promising and will significantly improve the performance of a business. It is a major factor that will help the firm to achieve a competitive advantage to competitors. In any industry with simplified operation will greatly increase efficiency and productivity. This will increase operational effectiveness. We can conclude that by using the warehouse application, most repetitive tasks such as encoding, and recording can be eliminated and will decrease the number of personnel needed to support the warehouse operations when it comes to inventory management and inbound/ outbound of materials. There has been additional use of the application aside from its main purpose, checking of inventory has been simplified and the margin of error in receiving and sending of materials quantity has been reduced greatly.

The cost benefit analysis also proves that the initial investment that will be spent on the system will be beneficial. The benefit-cost ratio will be 3.56 after the 1st month of implementation. The study only focuses on the 3 major processes in the shoe manufacturing warehouse and can be further extended to other processes such as: incoming material quality checking, regular material inventory, long term material tracking and many more. A more precise calculation on the cost and benefits analysis can be done if the warehousing system will be developed.

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Biographies

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