

How a Reactive Inventory Can Be Improved with a Computerized Work Tool

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Abstract — *An effective inventory management and reagent tracking control enable the company to reduce cost, save time, and reduce waste, while increasing productivity and business efficiency. It is proposed to create an inventory management tool that helps the continuous monitoring of the reagent inventory in a service analytical laboratory. The project proposes to implement a tool that allows analysts to continuously identify the laboratory inventory and the tracking of reagents within the laboratory. It will be a user-friendly tool, which will maintain an organized laboratory environment, in order to increase analyst performance, and eliminate test delays due to lack of reagents or additional charges in orders. The tool will give useful information to the analyst about where the reagent is or who has the reagent within the work area, but it will also alert the administrator when the reagent is about to run out or is close to its expiration date.*

Key terms — *computerized tool, inventory management, laboratory inventory system, reagent tracking*

PROBLEM STATEMENT

Each organization aims to have an organized work environment that facilitates the performance of the employee and thus avoid waste that affects their finances. The ideal scenario for any organization would be to avoid wasted time and keeping an inventory in order to better track and control the organization, especially for laboratories that offer analytical testing. In addition, there are certain conditions that make it difficult for these objectives to be reached, since there are no easy-to-use tools that can make it simpler for the employee to identify the flow of each item when they perform their work. A good example of this would be service companies in which delivery times exist. In these companies it

is essential to avoid wasting time when performing tests due to the lack of organization. In such organizations, there are determined areas of storage, but many times the reagents are currently in use and that is where problems arise, since the analyst would have to look at what areas the reagent is located or who may be using it.

This design project proposes to implement a new work tool that allows the analyst to identify the flow of reagents within small analytical laboratories dedicated to analytical testing. With this proposed tool, a continuous tracking of the reagents inventory can be maintained. In addition, it would help small businesses to obtain statistical information that would be useful in maintaining inventory of the reagents in order to satisfy the demand of the company. This control could reduce delays in tests (due to lack of available reagents) and/or eliminate extra charges for urgent orders.

Research Description

The management and control of the reagent inventory and the tracking of its use is essential to avoid loss of time and money. Maintaining a continuous inventory monitoring sustains the correct balance between what we have, what we need and how it flows within the laboratory, hence creating these tools is essential for keeping control. The tool in development will function as a means of inventory management, in which the analyst will be able to know the complete status of each reagent, where it is, if it is in use, who uses it, how much the laboratory has, or if the purchase of the reagent is necessary. Inventory management including control, flow and use is key to the profitability of any business.

Research Objectives

This project proposes to develop a new computerized work tool in order to help the analyst

with the flow of reagents within analytical laboratories dedicated to analytical testing in order to increase efficiency. Currently, there is a need for tools that allow the continuous monitoring of reagent inventory. With the development and implementation of the proposed computerized design, the objective is to increase employee performance within the work environment, eliminate inventory expenses and use the information in order to maintain an inventory control of the reagents that meet the demand of the company.

Research Contributions

Previous research has shown that poor organization and poor planning of inventory within service organizations can affect business finances considerably. The proposed research aims to introduce a computerized design, which will directly affect the operation and management of the inventory for the continuous improvement of the organization's finances. This tool, a spreadsheet on Excel serving as a database, combined with functions and forms will help the employee to keep track of the use of reagents within the laboratory, improving its productivity and avoiding the repercussions of loss of time. This tool will also help in generating data for inventory planning which will help to reduce the extra charges of priority deliveries and avoid delays in the tests. Therefore, this research will provide a contribution to the profitability of companies and can increase the customer satisfaction.

LITERATURE REVIEW

Previous studies concluded that many companies, such as those dedicated to the analytical testing service, lack control over their inventories [1], [2], [3], [4], [5], [6], [7]. These deficiencies could translate into poor profitability of the organization. Therefore, in order to support the organization and reduce expenses, it is substantial that companies implement systems for the inventory management. The implementation of computerized systems capable of keeping inventory under control

will provide economic improvements to any organization. Previous research focuses its objectives on ensuring the effective operation of inventory control, exposing the importance of implementing computerized tools and engineering elements (software) for the improvement of its processes [1], [2], [6], [7]. The implementation of technology has contributed to improving inventory movement within small businesses, resulting in competent inventory management, improving costs, reducing time loss and increasing the performance of its employees.

Studies about the implementation of software carried out in small companies for their inventory control, have established a detailed order of the value and importance of these tools [2]. Computerized inventory control has generated a positive scope in the profitability of those companies that have implemented the use of technological tools as alternatives to control their processes [2]. The study investigated the implementation of user-friendly software, a program designed to control sales and purchases, which also issued detailed reports on product movements, customers and suppliers [2]. In the research methodology, the company made a diagnosis that revealed the poor structural organization, emphasizing the need to use tools of inventory management [2]. According to [2], "when carrying out the application of the software, a favorable result was obtained, since the efficient control of the sale of oils in the company was achieved, thus being able to visualize the products that are running out for subsequent purchase; thus carrying a computerized control of the entry and exit of merchandise from the warehouse." These types of programs allowed inventory tracking to improve processes, increase productivity and performance, and decrease costs.

As per [6], "an effective inventory control system can provide process organization and reduce inventory related expenses." Efficient and profitable systems that control the inventory of reagents within analytical laboratories will avoid delays in tests, thus avoiding economic losses. Modern programs will help reduce waste, using databases that monitor,

track, and forecast reagent levels. The development of management tools for the registration of the inventory, in companies dedicated to the service of laboratory tests (clinical or analytical), will always guarantee the availability of reagents. In addition, it will be essential to add tools within the inventory management system for the tracking of reagents within the work area, either, who has the reagent, where it is moving or the quantity of the reagent that it has been consumed. A complete management system must contain information capable of monitoring, tracking and following up on the reagent inventory within the laboratory. These management systems are critical to any facility that uses and stores reagents, or chemicals. In previous studies of inventory control systems within laboratories, research was focused on the development of computerized systems that maintain control of reagent purchases to ensure adequate reserves, thus avoiding priority delivery expenses (emergency purchases) or delay in tests [1], [3], [6], [7]. These systems contain a database that includes the reagent name, lot number, expiration date, revision data, current quantity, usage history and other useful information [1], [3], [6], [7]. Computer systems are used by the investigators to design management systems that would track the history of each reagent and their performance. Although there is numerous management system software, each company must assess its inventory needs in order to sustain an efficient management system. The inventory management projects in the laboratory that were analyzed incorporated different computerized systems, which showed the benefits and effectiveness of using profitable systems, which are easy to use and implement [1], [3], [6], [7]. The methodology also included a physical control of the reagent flow in order to guarantee that the inventory is used in order (first in, first out) and before its expiration. These researched management systems facilitate an accurate reagent tracking and flow, but also included functions for audits, inspections, and inventory reporting [1], [3], [6], [7]. These tools incorporated into the laboratories in turn managed to increase the speed at which a company can operate.

In addition, various studies have investigated how the implementation of a management system can significantly improve productivity within the company. Research carried out in various companies, Chemical Industry and Fishing Company, determined that the applications of inventory management systems improved their productivity, and increasing the performance of its employees [4], [5]. Furthermore, it improved the results in the delivery of orders, so its increased customer satisfaction. The techniques used in the investigations were based on the observation of the behavior of the operations (this included the performance of employees), then they were documented the observations and they were analyzed the data in order to establish strategies that increased productivity [4], [5]. Both studies found the need to implement inventory management systems to eliminate the problems that caused low productivity [4], [5].

METHODOLOGY

The purpose of the proposed research project is to implement a computerized tool in order to reduce time loss within small laboratories dedicated to analytical testing. The design of the research project will seek to resolve those factors that affect employee performance, in order to reduce loss. Low productivity in employees, is not the only consequence of the lack of control in the inventory, the problem also causes delays on the delivery of customer results, or loss of product due to poor planning. Poor inventory with excess of reagents can lead to a loss of products due to expiration.

Each analyst has individual tasks, therefore standardizing cycles times or certain tasks in the laboratory is not a real option. After reviewing the literature, it was established that the use of validated inventory systems would not help to resolve the factors that influenced the poor performance of employees within the laboratory. The limiting factors with the greatest influence on decreasing the analyst's performance were not finding the reagent in its place (whether someone was using it or it was not

in their corresponding place) and reagent expired or completely consumed. To have a cycle time with added value, inefficiency in the time to perform the task of searching reagents had to be reduced.

The inventory system will be developed so that it can track the daily consumption of each reagent, alerting the inventory custodian when a reagent is about to expire or be completely consumed. The tool will be easy to use, which does not increase the waste time of the analyst. At the same time, the system must be able to track reagent movements through the laboratory, so that the analyst knows where the reagent is and who uses it.

To comply with the performance levels established by the company, each employee must complete a minimum of five daily tests in 8 hours of work, that is, 25 tests in 40 hours of work. Although, in the project it is considered that the duration of the analytical processes will depend of the test, in an ideal scenario an analyst should perform each test in an approximately time of 1.6 hours. To optimize the workflow, the cycle time was estimated, to establish the approximate time that the analyst took to acquire the reagents necessary to perform the test. To estimate the time, a worst-case scenario was chosen, the test that had the greatest number of reagents was selected. Then, proceeded to measure the total time took for each analyst to complete the reagent search task. The analyst takes approximately 21 minutes to find nine reagents, so considering the selected worst case the analyst loses 1.75 hours of the workday in the reagent search task.

The proposed tool will be implemented utilizing Visual Basic for Applications (VBA), which is an implementation of Microsoft's programming language Visual Basic that is built into most Microsoft Office applications, specifically to this project, in Excel. This combination of Excel as a database and VBA user defined functions and forms will enable the analyst to monitor the tracking of the reagents within the laboratory in a more structured manner. The tool will consist of two sheets: Use Sheet (table 1) and Inventory Sheet (table 2).

Table 1
Use Sheet

Reservation ID	CAS #	Reagent	Analyst Name	Date of Use	Return Date or Finished Reagent	Quantity Used	Name of the Test

Table 2
Inventory Sheet

Reservation ID	CAS #	Reagent	Receiving Date	Quantity of Reagent	Expiration Date	Location	Manufacturer

Both sheets' primary function is to work as a database, in which all required data will be stored in their belonging table and cells. The Inventory Sheet will store information as the Reagent name, their Chemical Abstract Service (CAS) registry number, manufacturer, quantity of the reagent package, where will be stored within the laboratory, expiration date and the date of when it was received. The Use Sheet will work mostly as a journal to track the information of how the reagent is used in the laboratory. The required data for the Use Sheet is the CAS registry number, the reagent name, the name of the analyst which will be using the reagent, date of use, quantity used, name of the test the reagent is going to be used and the date the reagent was returned to its location. Additionally, there will be a third sheet with a Menu form, in which the user would be able to add new reagents, reserve reagents to be used in tests and search reagents currently on the inventory.

RESULTS AND DISCUSSION

This section summarizes the findings and contributions obtained through the execution of the project. Will be discussed the results accomplished in this project that aimed to implement an inventory management tool that encouraged a more organized environment within small analytical laboratories dedicated to analytical testing. An easy-to-use computerized tool was proposed, to promote the control of the reagent inventory.

A computerized inventory tool was developed to establish an appropriate method as part of inventory management and to solve the problem of reagent tracking within the laboratory. The first

approach was to establish a design of the menu windows and the information that will compose each spreadsheet in the tool. The feedback of the analysts, the literary reviewed and the observation of the behavior of the inventory within the laboratory were used to establish the design of the tool (figure 1).

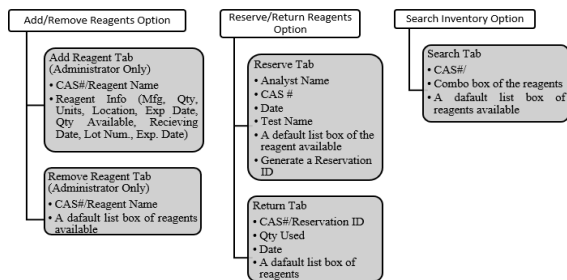


Figure 1
Design of the Menu Windows

A menu window and two spreadsheets compose the system; each setting was programmed to correlate to each other. The programming executed on VBA was used to correlate all the contexts of the project, in order to cover the greatest number of situations within the work area.

The tool allows us to:

- Know the exact amount of the reagent is available.
- The data recorded in the system is displayed in real time.
- Filter the complete information of the reagent:
- Vision of the reagent movements through the laboratory.
- Search information of reagents, by name or CAS #.
- Reserve and return reagents.
- Add, edit, or remove reagents from inventory (by administrator).
- It has a screen that alerts when the purchase of reagents is needed.

How the tool works:

- Add/Remove Reagents Option
- Add Reagents Tab (figure 2): In the option we can add new reagents that the laboratory receives, only an administrator (or a person in charge of the inventory) can perform this action.

The CAS # will be used to search the reagents that already exists. By default, the tool will provide information of the reagent, this information can be edited by the inventory administrator. To complete the operation, it is necessary to fill all the text boxes. Once pressed the save button, the system will notify if the reagent was added (figure 3).

Figure 2
Add Reagents Tab

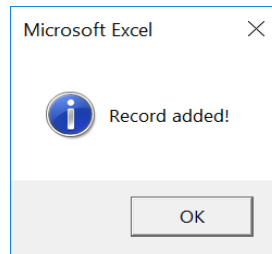


Figure 3
Record Added Notification Window

- Remove Reagents Tab (figure 4): This option will be used when is completely necessary, only an administrator (or a person in charge of the inventory) can perform this action. The CAS # will be used to search the reagents that already exists. Once pressed the remove button, the reagent will be permanently removed from the inventory, it is important to select the correct reagent and provide confirmation to proceed with the removal of the reagent (figure 5). A window will appear, to confirm the transaction was completed (figure 6).

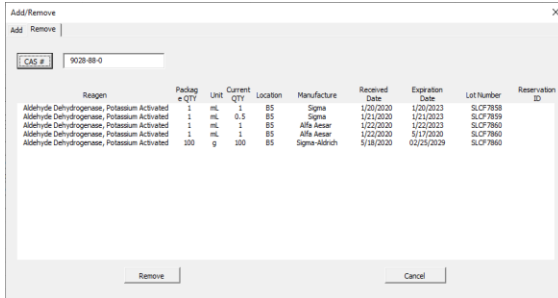


Figure 4
Remove Reagents Tab

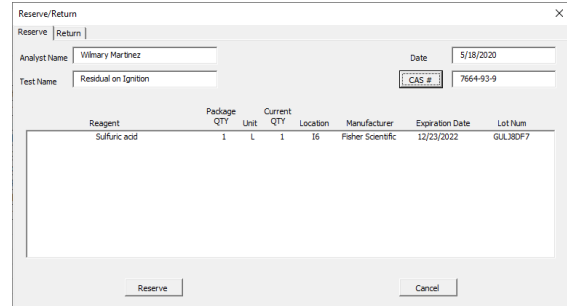


Figure 7
Reserve Reagent Tab

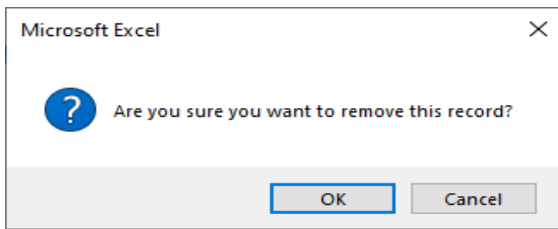


Figure 5
Remove Confirmation Window

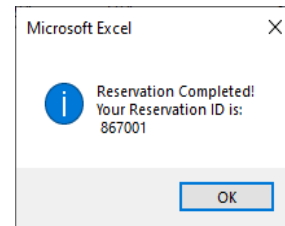


Figure 8
Reservation Completed Window



Figure 6
Remove Completed Window

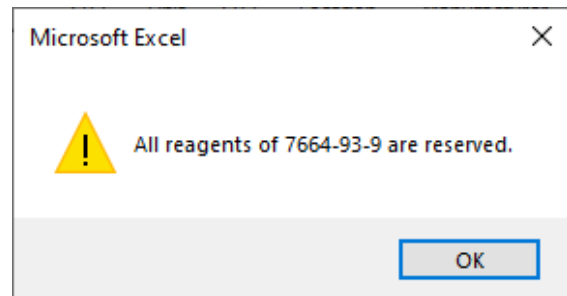


Figure 9
All Reagents Reserved Window

- Reserve/Return Reagents Option
- Reserve Tab (figure 7): This option allows the analyst to reserve the reagent (or the reagents) needed to perform the analysis (test). The CAS # will be used to search the reagent; by default, a list of the selected reagent will appear. To complete the reservation, the name of the analyst and the test name is needed. Once the reserve button is selected, the system will generate a unique number of the transaction called Reservation ID (figure 8). If all the reagents of a same CAS # are reserved, the system will display a notification (figure 9).
- Return Tab (figure 10): This option allows the analyst to return the reagent (or the reagents) utilized to perform the analysis (test). The reservation ID number or the CAS# will be used to search the reagent. If the analyst uses the CAS#; by default, a list of the selected reagent will appear. The consumed quantity of the reagent is required to complete the transaction. Once the return button is selected, a window will appear to confirm the transaction is completed (figure 11). The system will enter the reagent to the inventory, and after the confirmation, the reagent will be available.

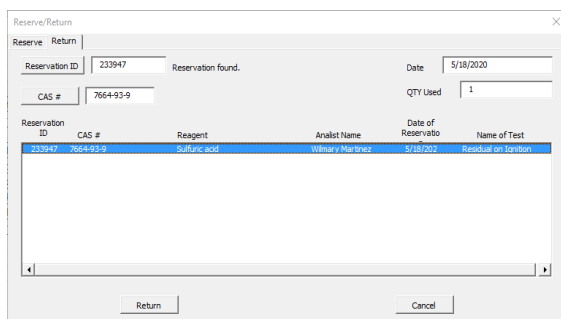


Figure 10
Return Reagents Tab

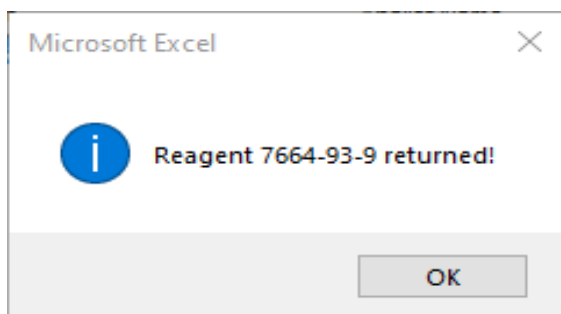


Figure 11
Return Completed Window

- **Reagent Search Option (figure 12):** This option allows a direct search of the information of the reagents available in the inventory. The alternative provides two search methods, utilizing the reagent CAS # or selecting the reagent name in the combo box of one of the reagents that already are in inventory.

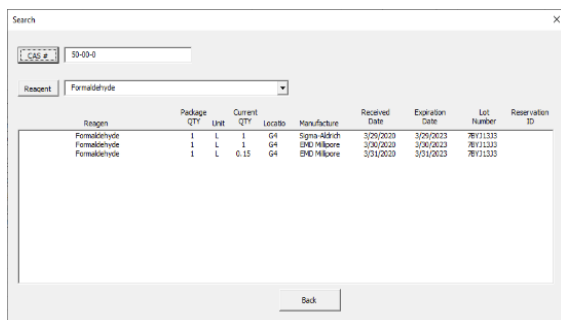


Figure 12
Reagent Search Option

In the results obtained in the project, we can observe that the implementation of the inventory management system provides a structured control of the tracking of the reagents. The tool controlling the

inventory of reagents, the inputs and the outputs of the inventory area, the movements of the reagents through the laboratory and the available quantities of the reagents. In addition, the inventory tool provides feedback about the reagents that need to be purchased, avoiding excess of inventory and unnecessary purchases; the laboratory will only purchase what it is necessary. This is possible with the control panel sheet, the system exposes as a warning mode the reagents that are close to expire, or to be fully consumed. It should be noted that all reagents have an expiration date and others are not used regularly, consequently having an excess of reagents in inventory can lead to money losses. When comparing the tool with the literature reviewed, it is confirmed that an inventory management system must be an essential part of the organization's improvement strategies. Management systems allow to compliance with the adequate inventory amounts, inventory organization and minimizing unnecessary purchase costs. In addition, by incorporating the reagent tracking option, analyst loss of time is minimized, increasing their performance and productivity.

As part of the strategies to improve performance in the workplace and improve the profitability of the company, the laboratory, where the tool was implemented, assesses the productivity of the employees daily. This company generated metrics that were used as a reference to determine whether the inclusion of a computerized inventory system could add value to the laboratory. These statistics gives the company a guide on how and where they can improve. As was mentioned in the Methodology section, to comply the performance levels established by the company, each analyst must complete a minimum of five daily tests in eight hours of work. In addition to this, ≤ 4 hours of overtime in general would be accepted. The productivity of the employees was measured for three months, February to April, during these months the productivity of the employees increased by 2 (figure 13). Minitab was used to confirm the impact of the computerized tool on the employee productivity. The P value obtained in the statistical analysis was 0.000 which is less than

the 0.05 level of significance, with a 95% confidence value, which indicates that our results are statistically significant. The results conclude that the impact on productivity was approximately 2%.



Figure 13
Employee Productivity (Tests)

The metric for the on-time delivery must comply with the $\geq 95\%$ test on time posted 2 days before due. Laboratories dedicated to the analytical testing service debit profits by delivered results and documentation to their clients. Therefore, we will take as a reference the delivery metrics to conclude, the profitability of the company. The delivery metric is assessed daily by the company, for the project the delivery was measured for three months, February to April. After the implementation of the tool, the delivery of the company remained in compliance, thus sustaining the profitability of the company (figure 14).

To maintain the success of the inventory computerized tool, and that it continues to drive productivity performance and laboratory efficiency, a use and handling procedure will be included in the company's training program. This system gives retraining from time to time, and any update performed to the inventory tool, the system provides a new training.

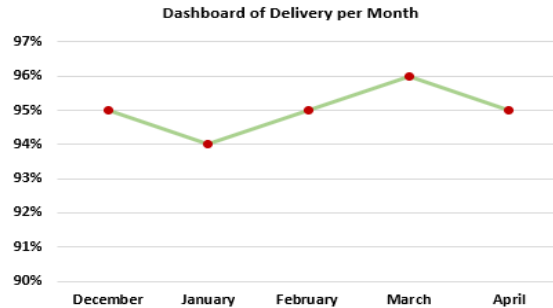


Figure 14
Delivery per Month

CONCLUSION

Inventory management systems are essential tools for a laboratory to achieve its objectives of maintaining an appropriate and organized work environment and contributes to reducing waste. The implementation of the computerized tool proposed demonstrated its effectiveness; the developed method was a solution to the problem for the continuous monitoring of the reagent inventory throughout the laboratory, as show in the Results section. The proposed inventory management tool improves the fundamental problems of the organization, by correlating tracking, purchased orders, and inventory control, and consequently guarantying the ideal tracking of reagents. The tool managed to establish an appropriate approach to the problems that arise from not implementing adequate management systems, as well as a reagent monitoring system. In addition, the developed method would help the inventory administrator to detect the capacity of the inventory, as well as to replace general information of each reagent in a more standardized process. The tool is proficient to monitor the amount available of reagents, improving the delivery time of test results.

Contributions

- A user-friendly tool was developed, which allowed the laboratory to be dedicated to analytical tests to improve the control and organization of its inventory.

- One of the most remarkable characteristics of the tool is its simplicity, decreasing implementation and training costs.
- The inventory management system managed to correlate inventory control, reagent tracking, and future purchases in a general and simple method.
- The implementation of the tool offers a standard process that minimizes the loss of time and avoids excess inventory.
- The project increased the capacity of the laboratory, offering a complete information of the available reagents and eliminated the problems of the reagents in use. With the tool, the analysts know the location of the reagent, laboratory capacity was increased by 19.6% in three months.
- The control panel sheet added to the management system could reduce additional charges for urgent orders or the delay of tests due to lack of reagents.

Limitations

The tool will be limited to what Excel offers, it will depend on a Share Point to guarantee that a copy of the saved information is constantly executed, and its performance will depend on the equipment used to run the tool.

Future Contributions

This data will be useful to maintain an inventory control in order to satisfy the demand for reagents of the company. The data collected by the tool can be analyzed to estimate the use of each reagent in a determined period, for example quarterly, this would make it possible to estimate the demand for reagents in that specific period. This estimate will ensure that the correct demand is maintained, as well as avoiding last minute purchases, delays in testing and maintaining high levels of quality in the laboratory.

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