Improving the food storage and inventory management of a military cadet institution: boosting students' problem-solving skills through collaborative applied research

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ABSTRACT: IE Research is a capstone course in the industrial engineering curriculum aimed at enabling graduating students to formulate a more comprehensive and holistic approach to real world problem-solving in an existing organisation. Under this course, the research team was able to formulate and apply solutions to the food storage and inventory management problems of a military cadet institution, using the tools the students have learned in their major courses. The case study method was used in the study, applying both qualitative and quantitative techniques. After implementation of solutions, the post-evaluation resulted to a *very satisfactory* rating in terms of storeroom functionality, safety, lot traceability, and application of 5S compared to the pre-evaluation rating of *moderately satisfactory*. Consequently, a smoother and more efficient flow of operations was observed in the storeroom. Student researchers were also able to improve their problem-solving skills by *very much* after the research. The study may serve as a guide for students and faculty who would like to pursue collaborative applied researches in their respective fields.

Keywords: Food storage, inventory management, problem solving, applied research, collaborative, industrial engineering

INTRODUCTION

The progressive approach to learning stresses that education is life itself, and not just the preparation for life. Even while at university, students should be involved in the problem-solving process and the use of the scientific method [1]. The involvement of students in the problem-solving process of real-world problems equips them with skills that better enable them to solve more complex problems in their future careers. Under the course IE Research of the industrial engineering curriculum, a research team composed of one faculty and eight graduating students, collaboratively search for a comprehensive and holistic approach to real-world problems in an existing organisation. This research team was able to focus on improving the food warehousing and inventory management of a military cadet institution through application of industrial engineering tools.

Inventory management is one of the important areas under industrial engineering. It provides the ability to meet customer demand, while avoiding production surplus, deficit and unnecessary costs [2][3]. The research team focused their study on the cadet mess storeroom of the Philippine Military Academy (PMA), a training institution for thousands of military personnel in the country. This department is mainly concerned with the planning, preparation, cooking and serving of food to 1,200 cadets daily. Serving a large population of customers at every meal involves crucial planning and preparation of supplies and ingredients to ensure provision of quality meals to the cadets three times a day.

From initial discussions with the PMA staff and officers, and through the ocular inspections conducted by the team, it was found that the cadet mess storeroom has been operating on a manual inventory system, and this has caused several problems including delays, monetary losses due to spoilage/expiration of food items, and safety hazards. The issue of inventory management for food is as important as it is in manufacturing. A study conducted in 2016 found that an improvement in effectiveness of inventory management in the food industry proved to be positively correlated with profitability [4].

In order to protect the goods from spoilage and other contamination, a storeroom must be maintained in a meticulously clean condition to keep the goods safe, wholesome and nutritious for as long as possible. These include the FIFO (first-in-first-out) and FEFO (first-expire-first-out) methods; maintaining optimal temperature and humidity with adequate ventilation; freedom from heat-producing equipment; stacking and placement of goods that must be at least six inches off the floor and at least 18 inches away from outer walls to reduce the chances of condensation; avoiding storage

of non-food items like poisons, cleaning supplies or other toxic materials in the same storeroom; and keeping the storeroom closed as much as possible to prevent entry of insects that might cause any damage to the goods [5-7]. The research team have seen that there was an opportunity to improve the flow and efficiency of operations in the institution's food storage area, which would also aid in the reduction of inventory costs brought about by improper ordering and storing, as well as spoilage of goods.

Statement of the Problem

From results of the initial walkthrough and observations, the research team addressed the following problems in their study:

1. What is the initial status of the food storage area of the PMA in terms of functionality, safety, application of 5S principles and lot traceability?
2. What solutions were implemented to improve the food storage and inventory management in the storeroom?
3. Is there a significant difference in the functionality, safety, application of 5S principles and lot traceability before and after implementing improvements in the food storage and inventory management system?

   Hypothesis: there is a significant difference in the functionality, safety, application of 5S principles and lot traceability before and after implementing improvements in the food storage and inventory management system.

4. How much have the students' problem-solving skills, communication skills and group skills improved after the research?

This study was conducted at the Philippine Military Academy (PMA) cadet mess storeroom at Fort Del Pilar, Baguio City, Philippines, from September 2017 to May 2018. Written permission and approval to conduct the study was obtained from the military institution as of September 2017. Permission and approval to publish the study was obtained in May 2018.

METHOD

The research team made use of the case study design, applying both qualitative and quantitative methods in the analyses of data. [8]. Initial observation and assessment was conducted by the research team and two cadet mess staff in the midterm period of the first semester. The questionnaire was developed by the research team and was based on the existing checklists on food storage facility requirements [6][7][9][10]. Reliability of the questionnaire was computed at 0.95 using equivalent forms method [8].

From the result of the pre-test, the research team were able to identify which aspect of the storeroom operations needed improvement. Focus was given to items that had scores of *moderately satisfactory* and *needs improvement*. From here, interventions were designed through industrial engineering applications, which included facilities and warehouse planning and design, inventory management, total quality management and information systems design. The recommended interventions that were doable within the second semester were discussed with the PMA Cadet Mess Commanding Officer, and approval to implement the interventions was granted in the midterm period of the second semester. At this time, the research team was able to implement the interventions and train the users of the storeroom on the new system for two weeks. One month after implementation, the nine researchers and two PMA staff once again evaluated the storeroom operations using the developed questionnaire (post-test).

Upon completion of the research, the students were asked to evaluate through a 4-point Likert scale how much their problem-solving skills, communication skills and group skills improved through a questionnaire (reliability = 0.93) on learning outcomes in collaborative projects [11][12].

Data Treatment

The research team used a 5-point Likert Scale for the evaluation of the questionnaire. The mean score of each item was interpreted based on the table below:

Table 1: Compliance rating of questionnaire items.

Score	Compliance level (CL)	Interpretation	Acronym
1.00-1.80	≤ 20%	Needs improvement	NI
1.81-2.60	21% to 40%	Moderately satisfactory	MS
2.61-3.40	41% to 60%	Satisfactory	S
3.41-4.20	61% to 80%	Very satisfactory	VS
4.21-5.00	81% to 100%	Excellent	E

Paired *t*-test was used to determine if there were significant differences in the functionality, safety, application of 5S principles and lot traceability before and after implementing improvements in the storeroom [13].

RESULTS AND DISCUSSION

Initial Assessment of the Storeroom of the PMA Cadet Mess

The 60-item food storage and inventory assessment questionnaire developed by the research team was used to evaluate the cadet mess storeroom in terms of functionality (11 items), food safety (7 items), application of 5S principles (30 items) and lot traceability (12 items). A copy of the full questionnaire is available with the lead author. Table 2 presents the combined mean ratings of the research team and the cadet mess staff:

Table 2: Food storage and inventory assessment result (initial).

Attribute	Rating	Interpretation
Functionality	2.10	Moderately satisfactory
Food safety	3.20	Moderately satisfactory
General 5S application	2.59	Moderately satisfactory
Lot traceability	2.00	Moderately satisfactory
Overall result	2.47	Moderately satisfactory

This implies that initially, the food storage and inventory system of the cadet mess was on the average, 30% compliant only of the required standards for a food storage facility. From this initial result, an opportunity was seen to improve the ratings of the food storage area.

Solutions Implemented to Improve the Food Storage and Inventory Management System

a) Layout revision of the storeroom. The research team came up with three alternative layouts that were presented to the PMA staff. The layouts were designed to improve the functionality and traceability of goods, while following the FIFO and FEFO system. The position and volume of space assigned to each product category was based on the average demand of the products for the past six months. ABC classification method of inventory was used to properly position the items in the storeroom based on their monthly peso-volume. The three alternative layouts were designed to minimise the total distance travelled by the storekeeper daily in locating and gathering the items demanded by the kitchen. The summary of computations is provided below:

Table 3: Total distance travelled per day per layout.

	Initial layout	Alternative 1	Alternative 2	Alternative 3
Total distance travelled per day	887.14 m	474.72 m	620.35 m	516.08 m

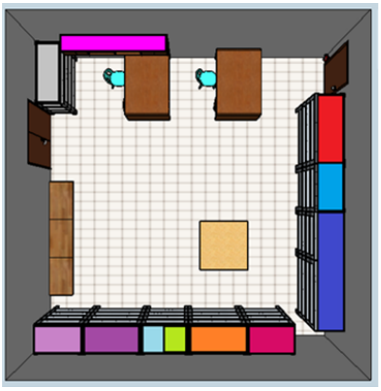
Alternative 1 includes the proposal of an alternative receiving area and a supermarket-style arrangement of shelves. By doing so, the distance travelled by the storekeeper in storing goods is reduced since they do not have to travel from the main entrance of the building to the respective racks.

Alternative 2 is a layout where racks are placed in a back-to-back arrangement. This allows more stability of the racks and permits higher levels of stocking. Releasing of goods is easier in this layout since the goods can be easily identified. In consideration to the restrictions and opinion of PMA cadet mess staff to have visual control and access over the display area, the research team proposed Alternative 3, which allows an l-shaped arrangement of shelves stacked six inches away from the walls.

Although alternative 1 offered the least distance travelled by the storekeepers in the discharge of their daily duties, the staff and commanding officer preferred Alternative 3 since it allowed more space for movement. With the help of some cadets, this layout was implemented by the research team on the first week of March 2018 (Figure 1).

b) Proper labelling and colour-coding. The research team designed colour-coded labels that were placed on each rack to guide the staff in the proper stacking and faster location of goods. Copies of the same labels were stuck on the wall near the entrance for a quick and easy guide for the users of the storeroom. This type of visual management aids in lot traceability, safety and practices 5S principles (Figure 1).

c) Inventory information system (IIS) design. Since the military institution currently does not have funding to purchase business software for its inventory management system, the research team designed a modified inventory information system (IIS) from EXCEL, which the staff can use to input data on item receipts and disbursements, get information on current item balances, get alerts from nearly expiring items and reorder points. The IIS was designed to replace the manual system to improve product traceability, keep records up-to-date and avoid losses due to discrepancies, overstocking and spoilage/expiration. The IIS has been turned over to the staff and is currently being evaluated for future integration.



Colour coding	Category
	Sauce and condiments/recipe mix
	Powdered seasoning/condiment mixes soup
	Hot and cold beverages
	Deserts and snacks
	Canned goods - vegetables and fruits
	Noodles and pasta products
	Sandwich spreads, cheese, salads
	Non-food stuff
	Herbs and spices

Figure 1: Alternative 3 - the implemented layout.

Evaluation of the Storeroom of the PMA Cadet Mess before and after Changes

Table 4: Food storage and inventory assessment result (initial and final).

Attribute	Initial rating	Final rating	*t*-test, one-tailed at 5% (*p*-value)	Interpretation
Functionality	2.10 (MS)	3.38 (S)	0.0008	Significant
Food safety	3.20 (MS)	4.29 (E)	0.0004	Significant
General 5S application	2.59 (MS)	3.89 (VS)	0.001	Significant
Lot traceability	2.00 (MS)	3.45 (VS)	6.63×10^{-7}	Significant
Overall result	2.47 (MS)	3.67 (VS)	6.60×10^{-14}	Significant

The 52 out of 60 items in the questionnaire demonstrated significant differences in the functionality, food safety, general 5S application and lot traceability in the storeroom, which contributed to the overall improvement of the food storage and inventory management of the institution. All mean ratings gave significant differences. The results of the study have been presented and discussed with the Faculty of Industrial Engineering of Saint Louis University, and with the Commanding Officer and staff of the military cadet mess.

Figure 2: Initial condition of the storeroom.

Figure 3: Final condition of the storeroom (snap shots).

Students' Learning Outcomes from the Research

Upon completion of the research, the student researchers were asked to indicate the progress they believe they had made in each of the following learning areas in terms of problem-solving skills (5 items), communication skills (4 items), and collaborative skills (7 items) after the conduct of research. Items were rated in a scale of: 4 (*very much*), 3 (*moderate*), 2 (*slight*) and 1 (*none*), depending on their learning experience in the course.

Table 5 Learning outcomes for collaborative research.

A. Problem-solving skills	Mean level of progress achieved in the course	Interpretation
1. Ability to identify what information is needed to solve a problem.	3.75	*very much*
2. Ability to apply an abstract concept or idea to a real problem or situation.	3.75	*very much*
3. Ability to divide problems into manageable components.	3.88	*very much*
4. Ability to develop several methods which might be used to solve a problem.	3.88	*very much*
5. Ability to use established criteria to evaluate and prioritise solutions.	3.75	*very much*
B. Communication skills		
6. Ability to describe a problem orally.	3.75	*very much*
7. Ability to describe a problem in writing.	3.75	*very much*
8. Ability to explain your ideas to others.	3.88	*very much*
9. Ability to use discussion strategies to analyse and solve a problem.	3.75	*very much*
C. Collaborative skills		
10. Ability to develop ways to resolve conflict and reach agreement in the group.	3.75	*very much*
11. Ability to be aware of feelings of other members of the group.	3.75	*very much*
12. Ability to listen to ideas of others with an open mind.	3.88	*very much*
13. Ability to work on collaborative projects as a team member.	3.75	*very much*
14. Ability to organise information into categories, distinctions or frameworks that will aid comprehension.	3.63	*very much*
15. Ability to ask probing questions that clarify facts, concepts or relationships.	3.75	*very much*
16. After evaluating the alternatives generated, the ability to develop a new alternative that combines the best qualities and avoids the disadvantages of the previous alternatives.	3.75	*very much*
Overall level of progress after the course	3.78	*very much*

The students believed that were able to improve *very much* in terms of problem-solving skills, communication skills and collaborative skills after the conduct of the research. The research process was truly a demonstration of learning by doing, where students and faculty moved out of their comfort zone to get involved in the dirty and messy work of problem-solving. They learned how to resolve conflict and at the same time work together as a team for a common goal. The team also learned to discuss and negotiate with military staff and officers for things that need to be accomplished in a limited time.

CONCLUSIONS

The implemented solutions in the food storage and inventory system drastically improved the food storage area rating from *moderately satisfactory* to *very satisfactory* in terms of functionality, food safety, implementation of 5S and lot traceability. Student researchers were able to progress by *very much* in terms of problem-solving, communication and collaborative skills as a consequence of conducting and implementing research findings as a team. A follow up study is recommended to assess the effectiveness of the designed inventory information system, hand in hand with the other implemented improvements, to evaluate the entire storeroom and inventory management improvement programme.

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BIOGRAPHIES

The lead author and researcher is Geraldine G. Nerona, a Professor of Industrial Engineering in the School of Engineering and Architecture at Saint Louis University, Baguio City, Philippines. She currently handles mathematics, industrial engineering, research, general engineering and some graduate studies. Before teaching, she worked as a production supervisor, then as an operations manager in two manufacturing companies. She pursued a Master's degree in education in 2005 (*magna cum laude*) and was a board topnotcher for the licensure examination for teachers in 2002. Her research team for this project include Jiheum Park, Kayzel T. Bogbog, Mariela C. Tamondong, Randell F. Apostol, Clarice C. Custodio, Jennica C. Enciso, Gerny A. Pacio and Philip A. Velasco, Jr.

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Kayzel T. Bogbog is a BS Industrial Engineering graduate of Saint Louis University in 2018, and is proficient in MS Office applications, AutoCAD and SketchUp. She had her on-the-job training at the Venus Parkview Hotel in Baguio under the Purchasing and Accounting Department. Her responsibilities included procurement, inventory and 5S application. On September 2018 she acquired her certification on Basic Occupational Safety and Health.

Mariela C. Tamondong is a BS Industrial Engineering graduate of Saint Louis University in 2018 and is a Certified Lean Six-Sigma Yellow Belt. She had her on-the-job training at Moog Controls Corporation (Baguio, Philippines) in 2017 under the Centerline Department and was responsible for identifying problems and suggesting solutions to reduce cost and processing time.