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A Goal Programming Model for Optimizing Production Quotas, Productivity, and Profit in Girl's Hat Manufacturing Firm

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Abstract

Every company struggles to manage frequent, inevitable problems such as delays, resource allocation, and strategies intended for profitability and operational efficiency. The study utilized goal programming techniques, employing MATLAB software, to solve manufacturing company problems. The objectives were to determine the daily quota for Design 1, minimize processing hours in the coloring, packing, and sewing departments, and achieve the profit per piece of hat daily. The proposed approach for operations and profit improvements in the hat industry using multiple-goal programming aids in achieving the company's present goals. The application of goal programming techniques is crucial in identifying solutions for department-specific goals in three operations and profit outcomes, ultimately benefiting the hat manufacturing company. The results demonstrate success through a 25% machine efficiency and a quota increase to 154, which is a 2% improvement over the existing method. These goals were achieved through data analysis, constraint formulation, and MATLAB-based goal programming. To generate developing research and implement methodologies to address current issues observed in industries, future studies are recommended. Numerical analysis can be applied to study patterns and trends in the marketing world, helping define data from the target population, develop models that summarize insights, and incorporate these into strategies to improve company processes and eliminate overtime analysis.

Keywords

Operations Research, Multiple Goal Programming, MATLAB Software, Hat Manufacturing, and Optimization

Introduction

The emergence of divergent problems in companies was evident in every business-related entity. Addressing the challenges faced by distinct organizations in terms of processes, profitability, minimization, maximization, delays, and more using operations research allowed companies to solve escalating dilemmas. Several methods were used to solve different types of organizational problems; operations research broadened the aspects of solving problems in various fields, including governmental, commercial, and industrial systems (Holstein et al. 2024). The purpose of operations research was to provide possible solutions to decisions, analyze data, utilize different software to solve problems, apply all considerations to possible solutions, and anticipate predictable and unpredictable instances such as risk and weak company strategies. It offered ways for organizations to enhance overall strategies in solving issues

(Lewis 2019). Operations research served as a guide to identify whether methods, algorithms, strategies, and realistic models benefited the organization. Implementing possible solutions and providing alternative options ensured the organization could face recurring problems and present challenges (Petropoulos et al. 2023).

According to Khan (2019), the different techniques or tools used in operations research included linear programming, queuing theory, inventory control models, network analysis, replacement problems, sequencing, integer programming, assignment method, transportation problems, decision theory, game theory, Markov analysis, simulation, dynamic programming, goal programming, and symbolic logic. These tools were utilized by different entities to solve problems relevant to the nature of the organization, enhancing business in the long run and achieving desired goals. This study incorporated the use of goal programming, considered an extension of linear programming. It involved approaches like single-goal objectives and multiple goals, focusing on multi-objective goals. Although conflicting, systematic evaluation using goal identification deviational variables, such as overachievement and underachievement, allowed the achievement of several company goals (Qahtani et al. 2019). In a hat manufacturing company, common issues included difficulties, problems, imperfections, and delays. Implementing multiple-goal programming helped achieve main objectives without compromising product quality, profitability, or worker effort.

In a hat manufacturing company, six consecutive processes were involved in making sinamay hats, categorized as big and small. This study highlighted problems in three operations—coloring, packing, and sewing—which were crucial to operations. Each constraint corresponded to achieving desired goals in terms of daily target profit and target yield for each design. Common issues in manufacturing businesses included forecasting demand, managing inventories, enhancing plant efficiency and return on investment, finding trained personnel, handling sales, and adapting to new technology advancements (Hashmicro 2022). Some of these problems existed in the hat manufacturing company, proving that prioritized objectives were beneficial to success and provided solutions. The hat manufacturing company experienced difficulties in operations, leading to delays and profitability problems. This study aimed to solve problems related to overtime, company yield based on updated time and motion study data, delays, and profitability, using the operations research tool of goal programming. Identifying solutions to problems in the hat manufacturing company addressed numerous present-day issues faced by manufacturing organizations, such as supply chain disruptions, increased material costs, employee shortages, technological advances, environmental regulations, sustainability, energy costs, market fluctuations, and security (Slyman 2024).

1.1 Problem Statement

The renowned Hat Manufacturing industry company is dedicated to crafting exclusive fashion hats from natural fiber fabrics within the Philippines. Despite the decreased popularity of fashion hats locally, the company operates one store in the Philippines while targeting international markets. The intricate process of hat production unfolds through six steps: coloring, cutting, blocking, stiffening, sewing, and packing. The enterprise offers two distinct designs. Both undergo similar production processes but differ in their production durations. The company faced operational challenges that resulted in delays and impacted overall profitability, including difficulties in meeting the expected production quota for hats. The coloring, sewing, and packing departments experienced overtime due to a shortage of workers and a number of errors. To enhance profitability, the company sought methods to improve hat production cycles. This study aimed to address issues related to overtime, quotas, and company yield by utilizing updated time and motion study data and employing multiple-goal programming as an operations research tool.

This study will focus on the strategic operation research approach in the hat manufacturing company to achieve production quotas, enhance workforce productivity, and increase profit. The study is limited to addressing issues related to productivity, quotas, and profitability management. It will not explore other variables, such as marketing, as the company focuses on improving productivity, minimizing overtime, and enhancing profitability. The use of multiple goal programming with the present average labor processing times per day for two distinct hat designs provided quota, and profit data will undergo MATLAB simulation. Thus, inefficiencies found or unachieved goals are aimed to improve by proposing data that will result in addressed unachieved goals in the present data. Addressing these issues using an operation research approach, aimed to streamline processes, reduce inefficiencies, and ultimately boost overall company priority goals.

1.2 Objectives

The objective of this study is to develop comprehensive solutions to enhance the workforce, optimize operational methodologies to reduce overtime and increase profitability in a hat production company. Using an operations research

approach along with other relevant tools, the study aims to systematically tackle the identified challenges, ensuring efficient workplace functioning while promoting productivity and resource utilization. The technique that will be used in this study is the Multiple Goal Programming. It is a variation of the goal programming approach where different goals can be achieved simultaneously, with the MGP being applied in many different ways in order to analyze the current problems and formulate a solution to improve the standards of a system or approach in an organization (Sen 2020). Employing Multiple Goal Programming as operation research approach alongside other pertinent tools, the study endeavors to systematically address the identified challenges, devise comprehensive solutions aimed at improving the workforce, refining operational methodologies to mitigate instances of overtime, and better quota, and profit in a hat production company. To ensure the efficient functioning of the workplace while fostering productivity and resource utilization, the study aims the following:

1. To achieve the target quota of 150 units for Design 1 or Large Hat.
2. The secondary goal of the study is to minimize overtime in the coloring department.
3. To reduce the idle time in the packing department where workers often exceed working hours due to a lack of manpower.
4. The fourth goal of the company is to reduce overtime in the sewing department to support older workers who have difficulty working late hours, which leads to decreased productivity and delays.
5. To achieve a profit above 332 per hat in a day, if possible, during production periods.

The study aimed to get solutions to the present unachieved goals in the company which will prove efficient present data from the simulation and increase target quota by 2% per hat of design 1 and 25% to improve the coloring department using multiple goal programming.

2. Literature Review

Throughout history, hats played a prominent role in the world of fashion, it is a versatile accessory that reflects the cultural, social and personal identity of the person. Originally as a symbol of wealth and status, hats have evolved to more than just fashion, as it serves a wide range of functions such as shielding the wearer from elements such as sun rays, rain etc. Hats began to transcend from rigid class and gender boundaries, as it is easily accessible and adopted by everyone as an everyday accessory (Zhang 2019). In order to improve the production of hats, the study will apply the goal programming. This approach played a vital role in production optimization in the evolving manufacturing company. Due to the growing pressure of customer demand, goal programming was used to strategically prioritize various production goals, not only it streamline the operation but provided frameworks for future studies, essentially providing a guide for sustainable growth and improved performance in the competitive market (Jong et al. 2018). Additional methods such as time and motion study will be applied in the study, according to Bhargo et al. (2014), it is a method of observing and identifying idle time and delays during the operation, it comes in two parts: time study for rate setting and motion study for method improvement, with a purpose of finding the most efficient method and understanding the importance of time-motion management.

Proper implementation of TMS not only enhances the efficiency of the work process, but it can also strengthen the tactics and strategies that will save time and resources streamline the business interface and improve the company's ability to execute work (Tarsilli 2023). Prakash et al. (2020) demonstrated the effectiveness of time and motion study by applying it to a construction company, the observed activities in present was identified flaws and delays that affect the process and the workers; after formulating a new method, the results show improvement in productivity by 218.03% and work efficiency of employees with a decrease of idle time of 40.24%. Recent studies focus on how goal programming techniques contribute to scheduling. The study found balancing manpower resources complex and time-consuming, leading to the development of a goal programming model to optimize scheduling (Maranan and Curbano 2022). In a paper by Komsiyah et al. (2018), goal programming enables the creation of a decision-making tool that ensures the company produces goods that meet market demands. The study focused on production planning issues involving cost factors, including material costs, production expenses, and profit margins.

In the paper by Tyas et al. (2021), the application goal programming to aggregate production planning to balance competing objectives like reducing costs and meeting production targets. The paper provides a methodical strategy for handling the multi-product, multi-market aggregate production planning issue. It emphasizes how crucial it is to model alternatives, conduct scenario analysis, and consider the effects of decision variables (such as weights) while creating production schedules that are optimized for the demands of the business. In another study of Moloto et al. (2023), a slight variation of linear programming called mixed integer linear programming was applied in a fast-moving

consumer goods (FMCG) industry along with six-sigma implementation, in order to optimize the profitability and productivity of the company. Both techniques made an impact as it reduced the number of failures and defects improved the quality of products and maximized the output with minimum re-work, while the study focuses on productivity and profitability of the industry, the demand as well as quota and overtime were never discussed thoroughly in the proposal.

3. Methods

The study employed a mixed-methods approach, incorporating both quantitative and qualitative analyses to gather comprehensive data. Utilizing multiple-goal programming, the study collected data through real-time observations and time and motion studies. These methodologies were used to evaluate the current state of overall production, focusing on productivity and profitability.

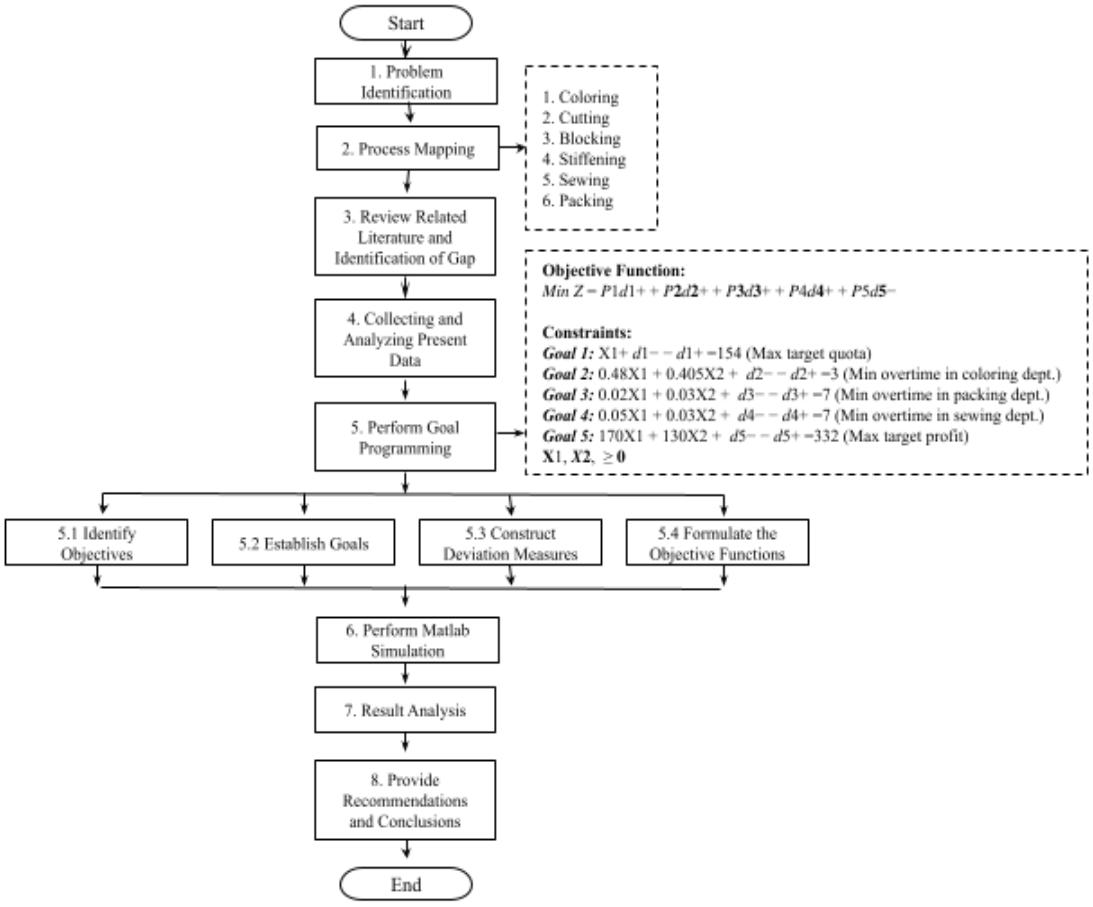

Figure 1. Case methodology utilizing Goal Programming in Hat Manufacturing Company

As the manufacturing sector evolved, insights from goal programming became invaluable, guiding businesses toward sustainable growth and better performance in a competitive market (Jong et al. 2018). In this study, multiple goal programming was utilized to solve various entrepreneurial issues, such as meeting quotas, minimizing delays/overtime, and maximizing profits. As shown in Figure 1, the study identified the objectives and goals of the enterprise's current strategy. Constraints were prioritized, and deviational variables were introduced to measure the underachievement and overachievement of each goal. These variables allowed the model to quantify deviations from the desired targets. Through MATLAB simulation, the conditions of the current manufacturing system related to the goals were calculated and validated. By evaluating the results, the study provided the best possible solution based on a precise analysis of departmental workflows.

3.1 Data Collection

The primary sources of data that this study uses are the interviews with factory owner and workers. The data that was gathered in the interviews was guided by the presence of the company supervisor as well as the company owner, which validates the gained information. Next is the observation, where the time and motion study were done over a 10-day visit to the company to determine the precise time and delays of each process. Table 1 shows the two different designs for time study; design 1 represents the large hat, and design 2 represents the small, which has a different time of process. The total of ten observations enables this study to generate the time constraints needed to calculate the delays and productivity of workers, as it shows the outliers, normal time and cycle time of the operation. The study utilized several inputs for the profit and quota of the hat manufacturing company. The data gathered for profit and quota per day was based on the interview, and the detailed representation shown in Table 2 indicates a total of 170 pesos in profit for design 1, 130 pesos in design 2, and 332 pesos for both of the designs, which explains that when both of the designs are sold, it has a bigger profit. Next is the quota, which shows that the company has a goal of reaching 150 pieces of large hats per day, while zero in design 2, which indicates that the quota per day was designated only for one design, which is the large hat. These two inputs were utilized in achieving the production quotas and increasing profit.

Table 1. Time Study Design 1 and Design 2

Legend	
	Outliers in Elements
	Outliers in Cycle Time (CT)

Design 1											
Process	**Ob 1**	**Ob 2**	**Ob 3**	**Ob 4**	**Ob 5**	**Ob 6**	**Ob 7**	**Ob 8**	**Ob 9**	**Ob 10**	**NT**
Coloring	38.4	38.5	37.51	37.44	38.02	37.4	38.47	38.52	37.53	38.49	**38.04**
Cutting	1.67	1.63	1.75	1.8	1.85		1.81	1.92		1.74	**1.8**
Sewing	2.95	2.98	3	3.3	3	2.97	3.2	3.2	2.95	2.94	**3**
Blocking		1.75	1.76	1.78	1.8	1.88	1.75	1.85	1.8	1.79	**1.8**
Stiffening	1.2	1.09	1.07	1..44	1.65	0.89	1.67	1.17	1.28	1.02	**1.2**
Packing	1.18	1.21		1.15	1.16		1.22	1.17	1.16	1	**1.2**
CT		**9.432**		**7.82**	**7.91**		**8.02**	**7.97**		**7.83**	
Design 2											
Process	**Ob 1**	**Ob 2**	**Ob 3**	**Ob 4**	**Ob 5**	**Ob 6**	**Ob 7**	**Ob 8**	**Ob 9**	**Ob 10**	**NT**
Coloring	31.52	34.6	34.02	35.4	30.43	32.1	30.08	30.3	30.1	33.2	**32.4**
Cutting	0.95	1.06	1.42	1.08	0.88		1.18	1.16	1.13	1.62	**1.2**
Sewing	1.65	1.49	1.67	2.1		1.16	1.82	1.9	1.86	2.1	**1.8**
Blocking	1.18	1.09	1.24	1.5	1.12	1.1	1.01		1.24	1.68	**1.2**
Stiffening	0.53	0.81		0.62	0.41	0.62	0.69	0.81	0.52	0.57	**0.6**
Packing	1.8	1.79		1.73	1.89	1.78	1.82	1.83	1.76	1.81	**1.8**
CT		**6.81**		**7.07**			**6.10**			**6.83**	

Table 2. Profit per piece and Quota per day

Profit per piece daily				**Quota per day**			
Profit	Design 1	Design 2	Total	Quota	Design 1	Design 2	Total
	1701	130	332		1	0	150

3.2 Goal Programming Formulation (Present Process)

The study focused on the multiple goals of the company, as shown in Table 3, the company have five priorities that are related to production quota, time constraints for workforce productivity and profit per piece. The hat manufacturing company offers two designs: Design 1 (large) and Design 2 (small), the hat process has six steps with prioritization given to coloring, sewing and packing. The company aimed to reach a daily quota of 150 large hats to satisfy its demand and online orders. The time constraints for these prioritized processes were as follows: coloring required 0.64

hours for Design 1 and 0.54 hours for Design 2; sewing took 0.05 hours for Design 1 and 0.03 hours for Design 2; and packing needed 0.02 hours for Design 1 and 0.03 hours for Design 2. The production working hours for coloring is 4 hours, for sewing and packing is 7 hours. The total profit per hat was 170 pesos for Design 1 and 130 pesos for Design 2, with an overall daily target profit per piece of 332 pesos for both designs. The data that was gathered through observation and interview is interpreted using multiple goal programming and Matlab simulation.

Table 3. Present Priority Goals

Priority	Description
P1	The primary goal of the hat company is to achieve the expected quota of 150 hats per day for Design 1
P2	The secondary goal of the company is to minimize overtime in the coloring department.
P3	The tertiary goal of the hat company is to reduce the idle time in the packing department where workers often exceed working hours due to a lack of manpower.
P4	The fourth goal of the company is to reduce overtime in the sewing department to support older workers who have difficulty working late hours, which leads to decreased productivity and delays.
P5	The final goal of the hat manufacturing company is to achieve a profit above 332 per hat in a day, if possible, during production periods.

Deviational Variables:

The company is unconcerned with d_1^+, d_2^-, d_3^-,d_4^- and d_5^+ exclusion of these variables from objective function may have minimal impact and concentrating on more significant variables will result to an efficient outcome.

d_1^- = Underachievement of the Design 1 target quota per day
d_1^+ = Overachievement of the Design 1 target quota per day
d_2^- =Idle time in coloring department (underutilization)
d_2^+ =Overtime in coloring department (overutilization)
d_3^- = Idle time in packing department (underutilization)
d_3^+ =Overtime in packing department (overutilization)
d_4^- =Idle time in sewing department (underutilization)
d_4^+ = Overtime in sewing department (overutilization)
d_5^- =Underachievement of the target profit per piece
d_5^+ = Overachievement of the target profit per piece

Goal Programming Problem Model

Decision Variables

$\boldsymbol{X}_1$= Design 1 or Large Hat
$\boldsymbol{X}_2$= Design 2 or Small Hat

Objective Function

$$Min\ Z = P_1 d_1^- + P_2 d_2^+ + P_3 d_3^+ + P_4 d_4^+ + P_5 d_5^-$$

Goal Constraint

(1) $\boldsymbol{X}_1 + d_1^- - d_1^+ = 150$
(2) $0.64\boldsymbol{X}_1 + 0.54\boldsymbol{X}_2 + d_2^- - d_2^+ = 4$
(3) $0.02\boldsymbol{X}_1 + 0.03\boldsymbol{X}_2 + d_3^- - d_3^+ = 7$
(4) $0.05\boldsymbol{X}_1 + 0.03\boldsymbol{X}_2 + d_4^- - d_4^+ = 7$
(5) $170\boldsymbol{X}_1 + 130\boldsymbol{X}_2 + d_5^- - d_5^+ = 332$

Non-negativity Constraint

$\boldsymbol{X1}, \boldsymbol{X2} \geq \boldsymbol{0}$

3.2 Goal Programming Formulation (Proposed Process)

As illustrated in Table 4, the goals in proposed method shows changes in goal one and two, where goal one has a total of 2% increase in daily quota, from 150 to 154 pieces of large hat per day, and the second objective which is minimization of the idle time in coloring department, the implementation of cotton pad batch dyeing machine helps

the manufacturing of hat increase its efficiency by 15% to 25% (Singh and Verma 2017). The existing process was subtracted by 25%, manual operation shifts to machine will enhance the process that will result in a total time of 0.48 hours in large hat, 0.405 hours in small hat and 3 hours for overall process, priority 3 to 5 remained the same since all of these processes are achieved in the present method.

Table 4. Proposed Priority Goals

Priority	Description
P1	The first goal is to achieve less than 154 hats per day but 150 pieces should be X1 or design 1
P2	The second goal is to implement a cold pad batch dyeing machine to lessen overtime in the coloring department.
P3	The third goal is to reduce the idle time in the packing department
P4	The fourth goal is to minimize overtime in the sewing department.
P5	The fifth goal is to achieve a profit above 332 pesos per hat daily.

Deviational Variables:

The business is unconcerned with d_1^-, d_2^-, d_3^-,d_4^- and d_5^+ these components may be omitted from objective function, which reduce complexity and prioritize important deviational variables for achieving company goals.

d_1^- = Underachievement of the Design 1 target quota per day
d_1^+ = Overachievement of the Design 1 target quota per day
d_2^- =Idle time in coloring department (underutilization)
d_2^+ =Overtime in coloring department (overutilization)
d_3^- = Idle time in packing department (underutilization)
d_3^+ =Overtime in packing department (overutilization)
d_4^- =Idle time in sewing department (underutilization)
d_4^+ = Overtime in sewing department (overutilization)
d_5^- =Underachievement of the target profit per piece
d_5^+ = Overachievement of the target profit per piece

Goal Programming Problem Model

Decision Variables

$\boldsymbol{X}_1$= Design 1 or Large Hat
$\boldsymbol{X}_2$= Design 2 or Small Hat

Objectives Function

$$Min\ Z = P_1 d_1^+ + P_2 d_2^+ + P_3 d_3^+ + P_4 d_4^+ + P_5 d_5^-$$

Goal Constraint

$$\boldsymbol{X}_1 + d_1^- - d_1^+ = 154$$
$$0.48\,\boldsymbol{X}_1 + 0.405\,\boldsymbol{X}_2 + d_2^- - d_2^+ = 3$$
$$0.02\,\boldsymbol{X}_1 + 0.03\,\boldsymbol{X}_2 + d_3^- - d_3^+ = 7$$
$$0.05\,\boldsymbol{X}_1 + 0.03\,\boldsymbol{X}_2 + d_4^- - d_4^+ = 7$$
$$170\,\boldsymbol{X}_1 + 130\,\boldsymbol{X}_2 + d_5^- - d_5^+ = 332$$

Non-negativity Constraint

$$\mathbf{X}1, \boldsymbol{X2}, \geq \mathbf{0}$$

4. Results and Discussion

Data from interviews and observations revealed methods to reduce unproductivity, increase profit per piece, and meet daily quotas. The study proposed strategies to address limitations and enhance outcomes. MATLAB simulations, aligned with goal programming models, were employed to analyze these results. Table 5 highlights the present and proposed priority constraints, a comparative analysis reveals that the proposed method addresses the present constraints, in the priority 1 and 2, to meet the goal 150 hats, the company should modify the output to 154 large hats to align the present objectives. Moreover, for priority 2, the processing time per unit was reduced from 0.64 to 0.48

hours in Design 1, and from 0.54 to 0.405 hours for Design 2, resulting in 3 hours of operation time per day. These changes will help to enhance the operational efficiency and profitability in hat manufacturing company.

Table 5. Present and Proposed Constraints Table

Present				**Proposed**			
Priority 1				**Priority 1**			
Quota	**Design 1**	**Design 2**	**Total Quota (Per day)**	**Quota**	**Design 1**	**Design 2**	**Total Quota (Per day)**
Design 1	1	0	150	Design 1	1	0	154
Priority 2 to 4				**Priority 2 to 4**			
Department	**Design 1 (hours)**	**Design 2 (hours)**	**Total hours**	**Department**	**Design 1 (hours)**	**Design 2 (hours)**	**Total hours**
Coloring	0.64	0.54	4	Coloring	0.48	0.405	3
Packing	0.02	0.03	7	Packing	0.02	0.03	7
Sewing	0.05	0.03	7	Sewing	0.05	0.03	7
Priority 5				**Priority 5**			
Profit	**Design 1 (₱)**	**Design 2 (₱)**	**Total Profit**	**Profit**	**Design 1 (₱)**	**Design 2 (₱)**	**Total Profit**
Profit per hat	170	130	332	Profit per hat	170	130	332

Present

```
% Hat Manufacturing Company Problem
% Goal Programming
% Multiple Goal
z =  [0; 0; 1; 0; 0; 1; 0; 1; 0; 1; 1; 0]; % Define Objective function (negative for maximization problem, positive for minimization)
A= [0.64, 0.54, 0, 0, 0, 0, 0, 0, 0, 0, 0;
  0.02, 0.03, 0, 0, 0, 0, 0, 0, 0, 0, 0;
  0.05, 0.03, 0, 0, 0, 0, 0, 0, 0, 0, 0];% Inequality constraints (Resource constraints)
B= [ 4; 7; 7;]; % Define RHS of the inequality constraints
Aeq= [1, 0, 1, -1, 0, 0, 0, 0, 0, 0, 0;
    0.64, 0.54, 0, 0, 1, -1, 0, 0, 0, 0, 0;
    0.02,0.03, 0, 0, 0, 0, 1, -1, 0, 0, 0;
    0.05, 0.03, 0, 0, 0, 0, 0, 0, 1, -1, 0;
    170, 130, 0, 0, 0, 0, 0, 0, 0, 0, 1, -1]; % Define GOAL constraint
beq= [150; 4; 7; 7; 332];  % Define RHS Of GOAL constraint
% Define lower bounds for variables (non-negative)
lb = zeros(12, 1);
% Define upper bounds for variables (unbounded)
ub = []; % No upper bounds specified
% Linear Programming function
[x,objective_value]=intlinprog(z,[],A,B,Aeq,beq,lb,[])
```

Proposed

```
% Hat Manufacturing Company Problem
% Goal Programming
% Multiple Goal
% Define Objective function (negative for maximization problem, positive for minimization)
z = [0; 0; 0; 1; 0; 1; 0; 1; 0; 1; 1; 0]; % Minimize the sum of all variables
% Define inequality constraints (Resource constraints)
A = [0.48, 0.405, 0, 0, 0, 0, 0, 0, 0, 0, 0;
   0.02, 0.03, 0, 0, 0, 0, 0, 0, 0, 0, 0;
   0.05, 0.03, 0, 0, 0, 0, 0, 0, 0, 0, 0];
% Define RHS of the inequality constraints
B = [3; 7; 7];
% Define GOAL constraint
Aeq = [1, 0, 1, -1, 0, 0, 0, 0, 0, 0, 0;
     0.48, 0.405, 0, 0, 1, -1, 0, 0, 0, 0, 0;
     0.02, 0.03, 0, 0, 0, 0, 1, -1, 0, 0, 0;
     0.05, 0.03, 0, 0, 0, 0, 0, 0, 1, -1, 0;
     170, 130, 0, 0, 0, 0, 0, 0, 0, 0, 1, -1];
% Define RHS Of GOAL constraint
beq = [154; 3; 7; 7; 332];
% Define lower bounds for variables (non-negative)
lb = zeros(12, 1); % Set lower bounds to a small positive value
% Define upper bounds for variables (unbounded)
ub = [];
% Add constraint to ensure that the sum of decision variables equals beq
Aeq_sum = ones(1, 12);
beq_sum = sum(beq);
% Concatenate the sum constraint with existing equality constraints
Aeq = [Aeq; Aeq_sum];
beq = [beq; beq_sum];
% Linear Programming function
[x, objective_value] = intlinprog(z, [], A, B, Aeq, beq, lb, ub)
```

Figure 2. Present and Proposed Matlab Script

Figure 2 illustrates the Matlab script used in solving the present and proposed method, the script for objective function changes from z = [0; 0; 1; 0; 0; 1; 0; 1; 0; 1; 1; 0] to z = [0; 0; 0; 1; 0; 1; 0; 1; 0; 1; 1; 0], and the script for priority 1 and 2 was adjusted from beq= 150, 4 to beq= 154, 3 Aeq=0.64, 0.54 to Aeq= 0.48, 0. 405. The modification of the scripts allows the company to achieve all of the five objectives. Figure 3 details the result of MATLAB simulation for current method. The total of $\boldsymbol{X}_{1=}$ 6.25, and $\boldsymbol{X}_{1=}$ 0, with an objective value of 143.45 hats manufactured in a day, while the total of P2= 0, P3=6.875 hours. P4=6.6875 hours and P5=730.5 pesos per piece daily. The unachieved goal is the P1 and P2 which is the quota per day and the time constraints in the coloring department. This explains that P1, P2, P3, P4, and P5 have interconnectedness and once one or more of those priorities are unsatisfied it can affect the overall operation. According to Singh and Verma (2017), cold batch dyeing enhances dye penetration and fixation by 15% to 25%, reducing water and electricity use. The proposed method in Figure 4, shows that using a new machine in the coloring department reduces the time by 25%, where subtraction of 25% in each time constraints, indicates faster

production, and for the quota, 2% adjustment was incorporated. The result shows the value of X_1= 3.9186, and X_1= 0, with an objective value of 0, while the total of P1= 150.0814, P2= 1.1191, P3=6.1=216 hours. P4=6.8041 hours and P5=334.1152 pesos. The proposed method achieved all of the five goals, by optimizing quota, saving process time, and improving overall company efficiency.

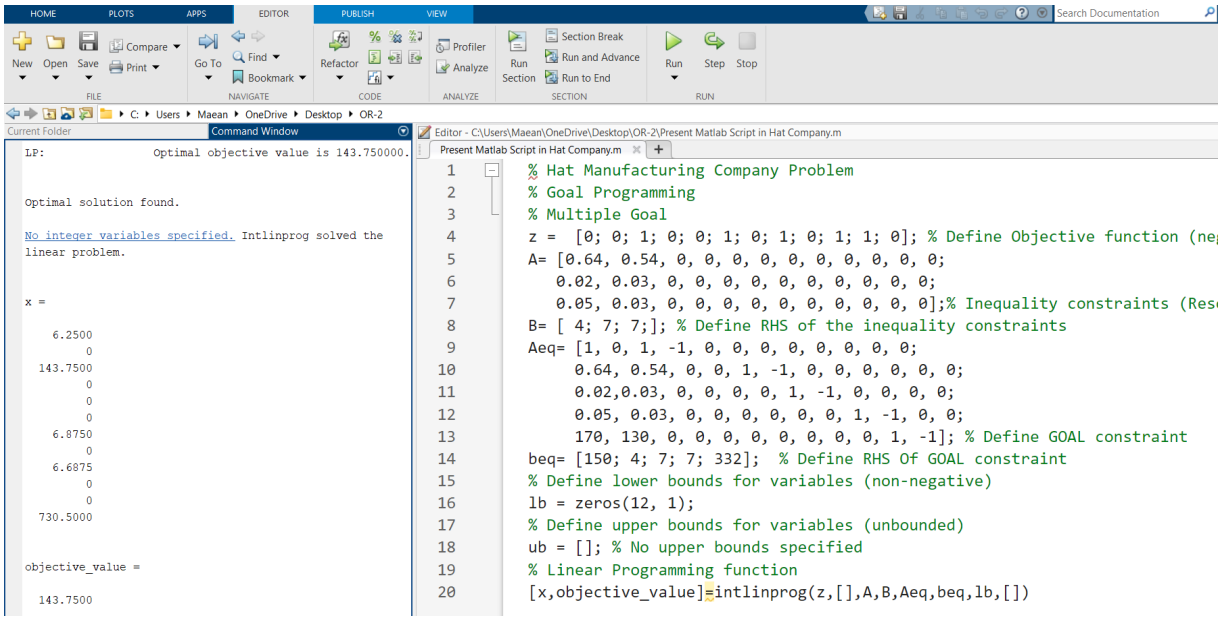

Figure 3. Present Matlab Result

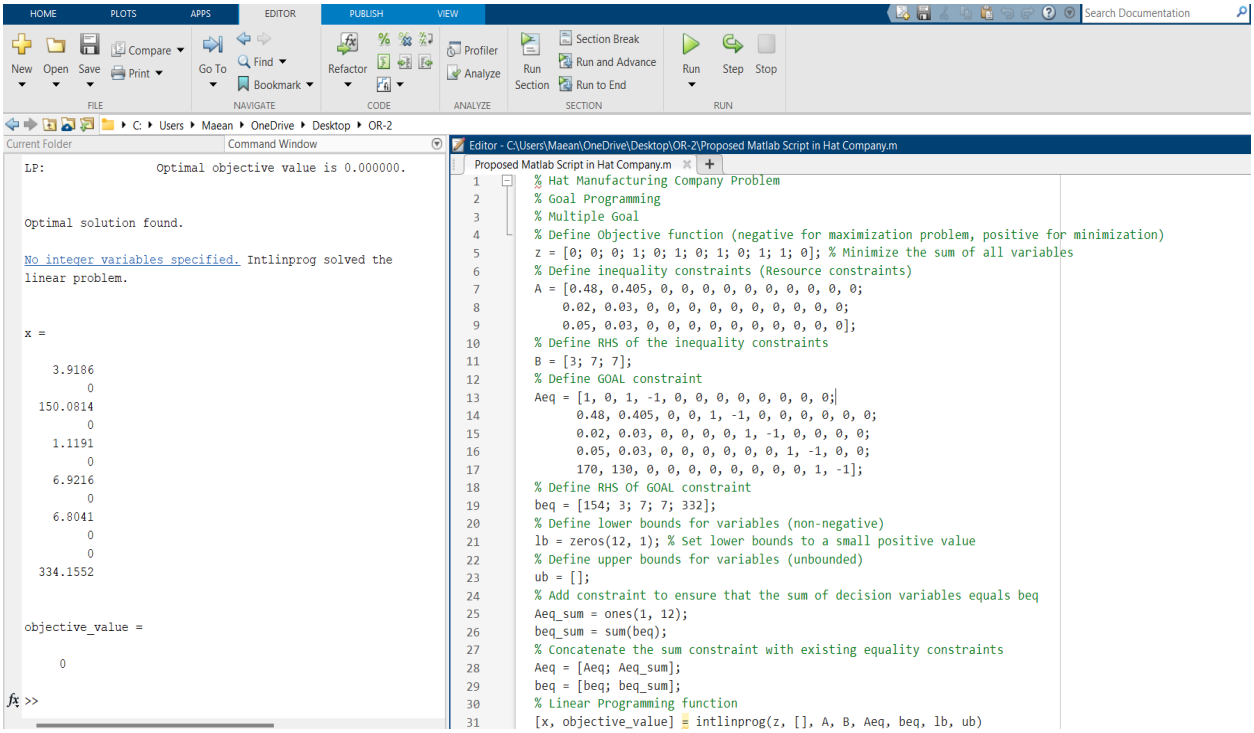

Figure 4. Proposed Matlab Result

Table 6. Summary of Results

Result							
Present				Proposed			
Priority	**Goal**	**Result**	**Status**	**Priority**	**Goal**	**Result**	**Status**
P1	P1 ≥ 150	143.75	Unachieved	**P1**	P1 ≤ 154	150.0814	Achieved
P2	P2 ≤ 4	0	Unachieved	**P2**	P2 ≤ 3	1.1191	Achieved
P3	P3 ≤ 7	6.8750	Achieved	**P3**	P3 ≤ 7	6.9216	Achieved
P4	P4 ≤ 7	6.6875	Achieved	**P4**	P4 ≤ 7	6.8041	Achieved
P5	P5 ≥ 332	730.50	Achieved	**P5**	P5 ≥ 332	334.1552	Achieved

Table 6 shows the comparison of the Matlab results in current and proposed, the findings in present method demonstrates the (P1 to P5) offers higher profit per piece and fails to meet the daily quota of 150 and 0 process time for coloring department, in proposed solution the adjustment of 154 quota per day and 3 hours for coloring department. The summary highlights both achieved and unmet goals which reflect the company's satisfaction and dissatisfaction with its objectives. In conclusion, the present method is adjustable and the proposed solution will enhance the overall operation of the hat manufacturing company and improve long-term efficiency.

4.1 Validation

The study focuses on the problem of idle time, meeting quota per day and profit per piece, factors that affect the productivity and efficiency of production hours which causes delay. The proposed method shows significant improvement, increasing the quota from 150 to 154 units. In the coloring department, the duration of processing was decreased from 0.64 hours to 0.48 hours for Design 1 and from 0.54 hours to 0.405 hours for Design 2. The Matlab results show $\boldsymbol{X}1 = 3.9186$, $\boldsymbol{X}1 = 0$, $d1^- = 150.0814$, $d2^+ = 1.1191$, $d3^+ = 6.9216$, $d4^+ = 6.8041$ hours, and $d5^- = 334.1552$ pesos. This proves that the current method of the company is adjustable, optimizing time allocation and reducing unnecessary worker activities to enhance productivity, profitability, and meet consumer demands.

5. Conclusion and Recommendation

The study presents a comprehensive analysis of the quota, operation processes, and profit in a hat manufacturing company, highlighting inefficiencies and proposing solutions to enhance productivity and profitability. By leveraging industrial engineering methodology like Time and Motion Study, the study identifies areas for improvement and offers tailored recommendations. Additionally, conducting gap analysis from various studies, the study was able to find its significant purpose and distinctiveness through the use of Multiple Goal Programming in the manufacturing industry. The focus on simplifying tasks across various operations, underscores the commitment to improving workflow without compromising worker safety or comfort. This approach promises to elevate productivity levels, align production with customer demands, and ultimately drive higher profits. However, it is crucial to acknowledge the potential challenges associated with implementing these changes, including the investment of time, resources, and finances but can prove efficient present data from the simulation and increase target quota by 2% per hat of design 1 and 25% to improve the coloring department. Creating an operations strategy that aligns with business objectives is essential for organizations aiming to achieve operational efficiency, customer satisfaction, and a competitive edge. By adopting the suggested strategies, the organization has an opportunity to improve productivity, profitability, overall delay, and customer satisfaction (Oyetoro 2024).

5.1 Practical Implications of the Study

This study is beneficial to manufacturing companies that have several company goals relating to operational efficiency, productivity and profitability of the organization. The interviews and observations will serve as a guide to the implementation of improvements that every business organization needs and the journal articles in literature review will guide the enterprise on the possible solutions to the problems and objectives related to the study.

5.2 Proposed Improvements

This study focused on recommendations that will satisfy the company objectives. The following significantly alter the company's approach addressing limitations and problems in performed goal programming.

1. Increase Profit.
The study will increase profit by implementing marketing strategies, expanding market reach, enhancing operational efficiency, and optimizing sales. This led to a 0.64% daily profit increase for the hat manufacturing company, aligning with Bi et al. (2022), which reported a 3.25% profitability increase through optimization, demonstrating these strategies' effectiveness.

2. Implement New Machine. The study will increase the quota from 150 to 154 units, a 2.63% increase, to enhance productivity and profitability. This adjustment is based on the need to meet quotas, which improves efficiency by producing more with the same or fewer resources. Achieving these quotas is crucial in the manufacturing industry for driving revenue, supporting organizational growth and maximizing employee performance (Aguilera et al. 2023).

3. Minimize Delay. Implementing a cotton pad batch dyeing machine will enhance productivity by reducing the dyeing process time of 15-25%, compared to traditional methods (Singh and Verma 2017). This efficiency gain allows for faster production cycles, increasing hat output and overall productivity. The machine's suitability for open-width fabric and its ability to maintain consistent production rates will improve yield and product quality, positively impacting profitability while supporting the existing workforce.
4. *Improve Workers Productivity*. The study will improve productivity by focusing on working with effective time management, making a conducive environment, employee engagement and motivation, and technology and productivity tools. Implementing these strategies will create a positive domino effect, enhancing overall hat manufacturing productivity (Padhi 2022).

5. Training and Retraining for Workers. The study will enhance productivity by recommending comprehensive training and retraining for workers. This includes Compliance and Safety Training, Lean Manufacturing Training, Quality Control Training, and Technical Skills Training. As noted by Smith (2022), these training programs are associated with increased productivity by enabling workers to better meet organizational goals and improve manufacturing processes.

5.3 Limitations and Future Research

The limitations of this study, focused on exploring the company's three major operations which is the coloring, packing, and sewing, the inclusion of all of the steps will generate more improvement in the company, which shows that integrating all several tools and techniques is limited, the prioritization of a much bigger problem in the company such as cost, salary and company arrangement can be further explored, aiming to solve the overall manufacturing problems. Further study will help this case study to improve the proposed solutions and give a broader interpretation of the company problems, in which the enhancement of production quotas, productivity, and profitability will be achieved in a more efficient way that will allow the company to achieve every goal.

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