Renewal Process Streamlining of a Government Service Facility through Simulation: A TRIZ Approach in Facilities System Design

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Abstract. Government offices plays an important role in ensuring effective implementation of policies and regulations. Management must ensure an efficient system to provide quality service to their clients. This study describes the renewal process of a certain government facility and aims to provide a reengineered facility design intended to streamline the service queue and improve the efficiency of the process identified since long waiting time per transaction has been observed specially in high volume seasons. This study considered M/M/s model to analyze the server utilization which has been validated through ProModel Process Simulator application. To come up with the recommended facility layout, this study utilized the combination of TRIZ methodology and concepts in product layout to resolve contradictions and come up with a low cost yet elegant solution. The two alternative designs also apply concepts of line balancing and queuing theory to solve problem in work allocation. In choosing the best design, the study considered multiple constraints and utilized the trade-off matrix to measure the importance of the relative constraints to their function and operation. The chosen design yields the shortest cycle time and has the least implementation cost.

Keywords: TRIZ, facility design, queueing, simulation, efficiency

1. INTRODUCTION

The Philippines has become one of the fastest growing economies in Asia due to an impressive Gross Domestic Product (GDP) growth average of 5-6% over the last five years. This steadfast growth fueled by improved political economy, the country is now considered a regional showcase of socioeconomic progress.

However, the country is now challenged in sustaining this impressive development which place a pressing demand to run a political environment conducive to promote transparency, efficiency in the delivery of government services, and avenue for multisectoral competitiveness. Such demand requires streamlining of all government processes together with the optimization of the role of Information and Communications Technology (ICT) and facility design in governance.

The Philippine population steadily grows from year 2006 up to present as seen in Figure 1. With this consistent growth in population, the government also needs to deal with the increasing volume of people acquiring government services. Based on a study conducted in America, different population growth rates will lead to different levels of demand for government services. Changes in population can have a substantial impact on requirements for public services as well as on the availability of resources to meet them (The Rockfeller Commission Report, 2010).

Figure 1. Philippine Population from 2006 to 2015

Thus, the application of an advanced technology together with optimization of the facility design is vital to increase the productivity of the government service under study as the volume of application and renewal increases and would require a more efficient service. Unable to adapt to this trend can cause long queues thus unsatisfied customers. With electronic governance, there is the hope of making government services more convenient, efficient, and transparent for the citizens (Bhatia, et.al).

Today, an often forgotten touch point is the transition from the virtual to the physical world. The government should establish a bridge on that gap by integrating the virtual and physical world to create seamless customer journeys. Queuing is one of the biggest dis-satisfiers in government institutions and a structured approach to address queuing is being expected by a large number of customers and citizens.

Identified root cause of the problem was non-optimal service line and work allocation of employees. Probable solutions to these problems identified are streamlining the renewal process through improvement in facility design and implementing a more advance queuing management system.

In this study, the researchers focused on the application of a queuing management system to ensure that both clients and their customers make the most of every visit to a government agencies by allowing customers to book online, to utilize their smart devices to manage their place in the queue, to self-check-in, to receive personalized service based on preferences and profile and to provide the customer's feedback in real-time. This study aims to create a satisfactory facility layout design intended to streamline processes and improve the agency's productivity as well as increase customer's satisfaction which also at the same time satisfy constraints such as economic, ergonomic, sustainability and productivity.

2. RELATED LITERATURE

2.1 TRIZ Methodology (Theory of Inventive Problem Solving)

In redesigning processes and facilities, this research utilizes the methodology called TRIZ or "Theory of Inventive Problem Solving" to facilitate the designing process. The method was developed by a Russian Patent Engineer named Genrich Altshuller in the 1940's. In a book by Yeoh Teong San (2014) entitled TRIZ: Systemic Innovation in Manufacturing, TRIZ is defined as a philosophy, a process, and a series of tools based primarily on the concept of resolving contradictions in design parameters. The proponents adapt this design methodology to prevent waste (resources, time, man power, etc.) from the usual trial-and-error technique in system and facilities design conceptualization. Figure 2 shows the stages of development using TRIZ compared to other design methodologies.

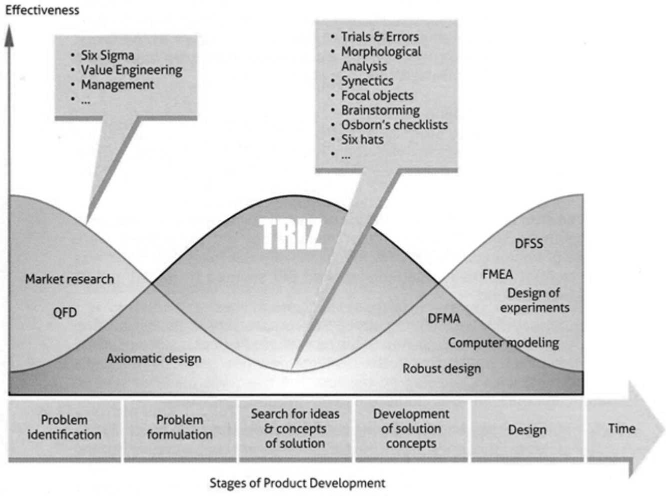

Figure 2 Stages of Product Development (Source: Guin et. al, 2014)

The main distinction of TRIZ, as compared to nearly every other design methodology, is that TRIZ, in addition of situation analysis and problem formulating tools, offers a plethora of problem solving tools and approaches. TRIZ fills the void, inherent to other conventional product development tools, in the area of the idea generation and concept development. Rather than leaving a designer with his own, TRIZ delivers the wealth of inventive experiences of many inventors and innovators from various fields' human activity.

2.2 TRIZ Way of Problem Solving

Unlike usual problem solving methodologies, the strategy used by TRIZ revolves on procedures atypical from the normal problem solving process. In most cases, typical solutions are formulated in form of a compromise but that's not the case in TRIZ. The TRIZ problem solving process works towards resolving contradictions or conflicts while providing an inventive solution. The method starts with the specific problem then proceeds directly to find a specific solution which makes the process straightforward, simpler and direct to the point.

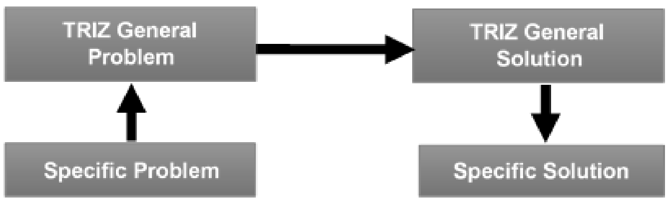

Figure 3. TRIZ Way of Problem Solving

2.3 Service Design, Development and TRIZ

There are a variety of service development models that have been proposed in the past to find solutions to certain problems in the service industry. Most of these models might have some degree of formalization but still hard to implement on operational levels. In the latest new service design (NSD) process cycle proposed by Johnson et al. (2000), the model only focused on the classification of service development process into four phase stages: (1) design, (2) analysis, (3) development and (4) full launch. However, there is no discussion and procedure on how to operate the involved development activities at each stage in order to achieve stage goals. This is was actually a long existing common gap in most service design process.

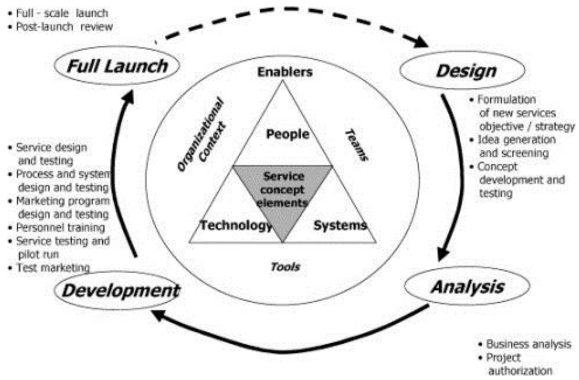

Figure 4. The NSD process cycle, adapted from Johnson et al. (2000)

3. RESEARCH DESIGN AND METHODOLOGY

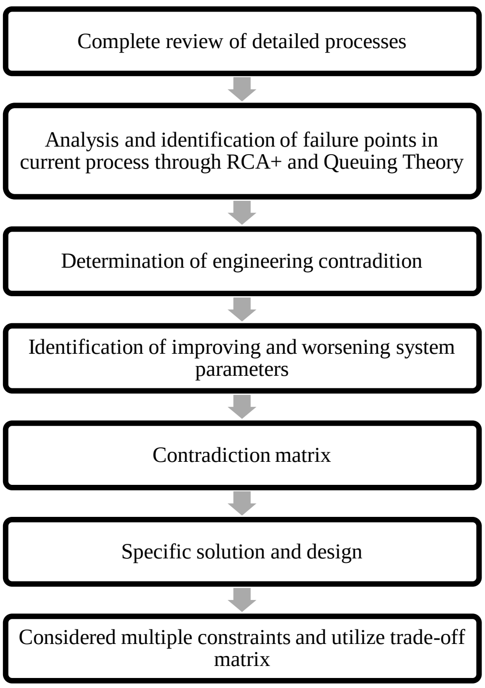

Figure 5. Methodology

3.1 Complete Review of Detailed Processes

The first stage of service design process is to conduct a thorough review of the existing process to determine the bottleneck of the system. In this study, process flow was presented through flow charts for better visualization of the system being studied. Activities were also listed and summarized alongside with the cycle time to complete each step.

3.2 Analysis and Identification of Failure Points in Current Process

3.2.1 Root Conflict Analysis (RCA+)

Root Conflict Analysis (RCA+) is a technique for analyzing inventive problems and situations developed as a result of combining the methods for causal problem decomposition such as Root Cause Analysis, Theory of Constraints and the TRIZ philosophy of problem definition. The difference with traditional cause-effect approaches is that RCA+ is targeted at extracting and presenting contradictions that contribute a general problem in a structured tree-like way rather than exploring negative causes only in a random manner. One of the main advantages of RCA+ is that one can stop at the level in which a cause is found to significantly contribute to the problem at hand, without exploring every possible cause.

3.2.2 Queuing Theory

Queuing theory is a mathematical approach to the analysis of waiting lines (Stevenson, 2009). In 1953, D. G. Kendall first suggested a standard system used to describe and classify the queuing system. This approach, called Kendall's notation9 is utilized in this study to create a model for the berthing and quay operations.

$$A/S/c/K/N/D$$

wherein:

A denotes the time between arrivals to the queue
S the size of jobs
c the number of servers at the node
K is the capacity of the queue
N is the size of the population of jobs to be served
D is the queuing discipline

3.3 Engineering Contradiction

Engineering contradiction is an attempt to improve one characteristic of the engineering system resulting in degradation of another characteristic (Yeoh et. al, 2009). It is usually stated in statement "if parameter x improved then…., but parameter y worsens". The formulation of the "if-then-but" statement makes the problem easier to understand and what the parameters are in contradiction to each other. As mentioned earlier, engineering contradiction usually arises when current features cannot suffice the requirement of users. The identified potential root cause of the product deliberated can be converted into an engineering contradiction by converting the various parameters into one of the 39 system parameters created by Altshuller.

3.4 Improving and Worsening System Parameters

In order to provide solution for the design contradiction, Contradiction Matrix (or Altshuller's Matrix) must identify the improving and worsening system parameters. Once system parameters (improving and worsening) are clearly specified, plotting these parameters into the 39 System Parameters. Table 2 illustrated the summary of the system parameters matched for the project development based on the above engineering contradiction.

3.5 Contradiction Matrix

When system parameters were identified (improving and worsening), the contradiction matrix is then used to map potential Inventive Principle solutions (Altshuller, 1994). Altshuller derived the contradiction matrix from approximately 40,000 innovative patents. The inventive principles (solutions) can be obtained from the matrix cells and the suggested Inventive Principles from the contradiction matrix are based on the most probable Inventive Principles suited to solve the contradiction. Table 1 illustrated the recommended Inventive Principle from the identified system parameter of Table 2.

3.6 Specific Solution and Discussion

Based on the suggested Inventive Principles, all Inventive Principles were considered as the basis of design considerations.

3.7 Multiple Constraints

The multiple constraints presented helped in the decision in choosing the best design for a cost-efficient, reliable and high quality service. The constraints in this study are economic, sustainability, and productivity.

3.7.1 Productivity

This constraint was considered to evaluate which design gives high productivity as this greatly affect the company. The constraint considered in this study is the cycle time of the process.

3.7.1 Economic

This constraint was considered to identify the capital investment needed to implement the design. It shows which of the two design alternatives yields the least cost that will create a quality service through facility design and queue management system.

3.7.2 Sustainability

The proponents considered sustainability constraint to identify which design has the least maintenance cost for the queue management system considered in the study.

3.7.3 Trade-Offs

A trade-off matrix is used to measure the importanc e of the relative constraints to their function and operati on. The applicable constraints included by the researchers are productivity (cycle time), economic (project cost), and sustainability (maintenance cost). Each criterion's level of importance was based on the designers' perspective. The corresponding level of significance is shown below.

Criterion's Level of Importance

5 – Very Important
4 – Fairly Important
3 – Important
2 – Slightly Important
1 – Not Important

The interval distance between values is implicitly identical with Likert scales. The choice of the number of integers used is somewhat arbitrary, as is the definition of the scale, e.g., lowest to highest, highest to lowest. The rating technique allowed the decision makers to place each criterion on a scale by assigning a number to each criterion (Charles Yoe, Ph.D., 2002).

4. RESULTS AND DISCUSSION

4.1 Complete Review of Detailed Processes

Current layout of the system is presented in Figure 6 while the summary of process activities can be found in Table 1. Information such as activity number, cycle time in seconds and capacity per hour are given in the diagram. The process starts with assessment followed by evaluation, photo and signature, payment, and finally releasing. The evaluation process currently has three servers. One of the counters is reserved for the seniors. Other customers are serviced by the two servers in accordance with their surnames.

Table 1. Summary of Process and Cycle Time

Activity No.	Description	Cycle Time (sec)
I. Assessment	- Provides form - Briefing (how to accomplish the form) - Assigns queue number	120
II. Evaluation	- Review documents - Verifies record - Accomplishes routing slip	600
III. Photo and Signature	- Captures photo and signature of applicants - Accomplishes routing slip	300
IV. Payment	- Prints receipt - Accomplish routing slip	600
V. Releasing	- Releases the license - Applicants signature in the log sheet	300
Total		**1,920 sec or 32 min**

Table 2 Service Standards of the Process

Steps	Duration (min)	In-charge
I Assessment	120	Customer Service Rep
II Evaluation	600	Evaluator
III Photo and Signature	300	Clerk
IV Payment	600	Cashier
V Releasing	300	Releasing Clerk
Total duration of service	**1,920 sec or 32 min**	

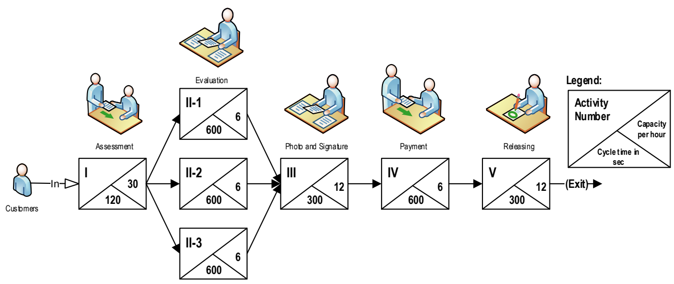

Figure 6. Process Flow Diagram with Cycle Time and C apacity

4.2 Analysis and identification of failure points in current process

4.2.1 Root Conflict Analysis (RCA+)

After doing the RCA+ on the identified problem of long queues in the system, contradicting effects from increase in service efficiency are employees experience fatigue and more customers served.

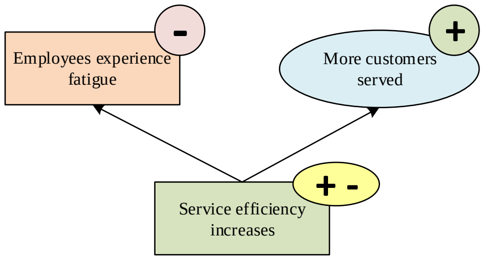

Figure 6. Part of Root Conflict Analysis Diagram

4.2.2 Analysis of Service Line Bottleneck through Queuing Theory and Simulation

This study utilized the M/M/s Queueing Model to analyze the server utilization of all the processes. It was found out that the evaluation and payment processes consume most of the time in the transaction. Thus, these were considered as the bottleneck.

Table 3. Summary of Simulation of the Process

Activity No.	Utilization (%)	Probability that a Customer Waits
From I to II	166.67	2.45
From II to III	150	1.5
From III to IV	200	2.0
From IV to V	50	0.5

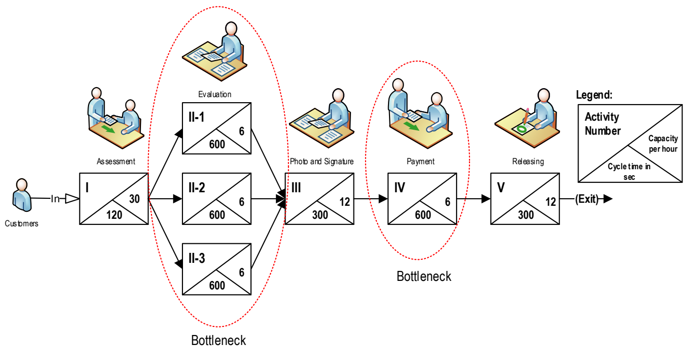

Figure 7. Diagram of Service Line Bottleneck

4.3 Engineering Contradiction

Engineering contradiction for this system improvement is outlined below:

> "**IF** service efficiency increases, **THEN** more customers served **BUT** employees are more likely to experience fatigue."

4.4 System Parameter

Table 4 illustrated the summary of the system parameters matched for the service design based on the above engineering contradiction. Improving parameter would be #39 productivity while the worsening parameter would be #19 use of energy of moving object.

Table 4. System Parameter

Engineering Contradiction		System Parameter
Improving	Service line efficiency	#39 Productivity
Worsening	Employees experience fatigue	#19 Use of energy of moving object

4.5 Contradiction Matrix

After the system parameters were identified (improving and worsening), the contradiction matrix is then used to map potential Inventive Principle solutions (Altshuller, 1994). Table 1 illustrated the recommended Inventive Principle from the identified system parameter of Table 5.

Table 5 Contradiction Matrix

Improving Parameter	Worsening Parameter	Suggested Inventive Principles
#39 Productivity	#19 Use of energy of moving object	#35 Parameter change #10 Preliminary action #38 Strong oxidants #19 Periodic action

4.6 Specific Solution and Discussion

Based on the suggested Inventive Principles presented in Table 6, inventive principles were considered as the basis of design considerations and suggested solutions are summarized in the table below.

Table 6. Inventive Principles with Suggested Solutions

Inventive Principles	Description	Suggested Solutions
#35 Parameter change	Use of numerical simulations for modeling complex phenomena and testing virtual prototypes.	A. Change an object ‘s or system’s physical state - Numerical simulation B. Change the concentration or consistency - Process structure change
#10 Preliminary action	Assuring quality, reliability and safety is an integral part of product development	A. Pre-arrange an object or system so that if comes into action from the most convenient place and without losing delivery time. - Change process flow

4.2 Service Designs and Solution

4.2.1 Design Proposal 1

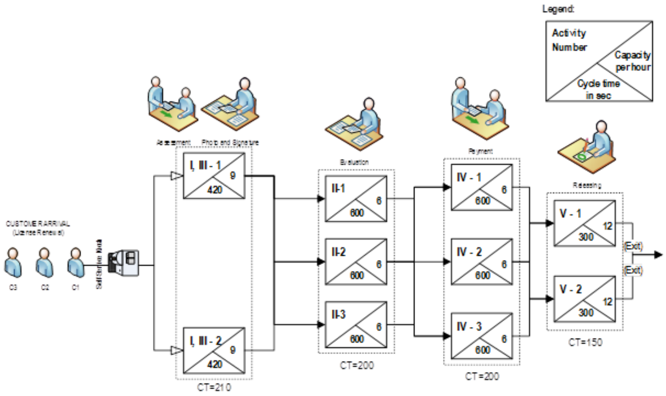

Figure 8. Work Allocation Computation – Design 1

To make the line more efficient, the proponents reduced the cycle time by identifying the number of workstations necessary to match the service rate with the arrival rate for each process. Figure 8 shows the proposed work allocation for the renewal procedure. The proponents decided to combine the assessment and photo and signature. Two workstations were proposed for the combined steps. The cycle times of these processes were added and since the recommended workstation is two, the cycle times were also divided into two. This resulted to a cycle time of 420 seconds per transaction. The proponents utilized the M/M/s queuing theory to model the system and find out the impact of the proposed allocation of work.

Table 7. Summary of Queuing Analysis of Design 1

Steps	Utilization (%)
Step I,III to Step II	100
Step II to IV	100
Step IV to V	75

Table 8 Summary of New Activity Flow for Design 1

No.	Activity	Cycle Time (sec)
1	Step I,III Assessment & Photo/Signature	210
2	Step II Evaluation	200
3	Step IV Payment	200
4	Step V Releasing	150
	Total	**760 sec or 12.67mins**

Table 7 shows the summary of the new activity flow for design 1. The cycle time of steps I to IV was added and results to a cycle time of 760 seconds or 12.67 minutes per application for the renewal procedure. Thus, the cycle time of the renewal procedure was reduced to 12.67 from the original 32 minutes per application.

4.2.2 Design Proposal 2

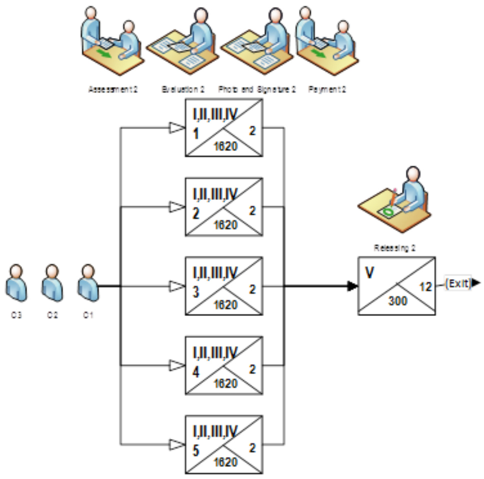

Figure 9. Work Allocation Computation for Design 2 using Line Balancing

In this design, the researchers utilized the line balancing to identify the minimum number of workstations and processes to be combined. The purpose is to balance the system by assigning tasks to workstation so that each process will have the same time requirements. Figure 9 shows the final layout for design 2. Results of the incremental utilization method found out that there should be two workstations. The first workstation has 5 counters for the combined steps I to IV while the second workstation has only 1 counter for the releasing process. This results to a cycle time of 10.4 min per application. The results also show that utilization of workstation 1 and 2 are 94% and 50% respectively.

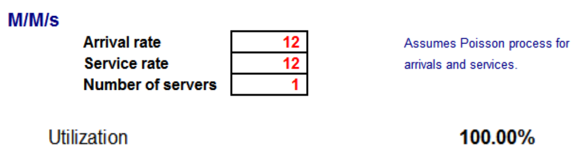

Figure 10 Queuing Analysis from Step I,II,III,IV to Step V

Table 9 Activity Summary for Design 2

Activity	Cycle Time (sec)
I,II,III,IV Assessment, Evaluation, Photo/Signature, Payment, Payment	324
V Releasing	300
Total	**624 sec or 10.4 min**

Table 9 shows the activity summary for design 2. A cycle time of 324 seconds for workstation 1 was obtained by adding the cycle time for steps I to IV. The sum was then added to the cycle time of step V which is 300 seconds per application. This results to a cycle time of 624 seconds or 10.4 minutes per application for the renewal procedure.

4.3 Constraints and Trade-offs

Table 10. Decision Criteria

Decision Criteria	Criterion's Level of Importance	Design consideration to satisfy the criterion
1.Productivity (Cycle Time)	5	The proponents analyzed this constraint by identifying the cycle times of the proposed layout and system. It was given a rate of 5 because it shows the efficiency of the system.
2.Economic (Capital Investment)	4	The proponents determined the capital investment based on the costs of transactions, queue management system and maintenance. It was given a rate of 4 in terms of its importance because it will determine how much money is needed to execute the designs.
3.Sustainability (Maintenance cost)	3	The proponents gave a rate of 3 in this constraint. Sustainability was based on the annual maintenance cost of the system.

Table 10 shows the decision criteria that served as a basis in this study. The applicable constraints include productivity (cycle time), economic (project cost), and sustainability (maintenance cost). Each criterion's level of importance was based on the designers' perspective.

5. RECOMMENDATIONS

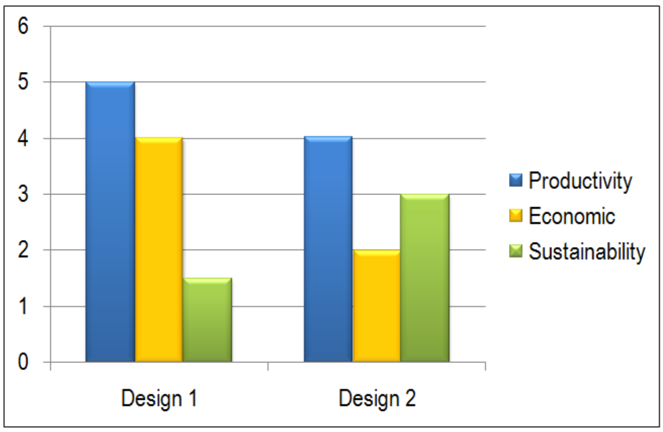

Figure 11 Decision Criteria Summary

Figure 13 shows the summary of the decision criteria. The overall rank in table 4.2 shows that Design 1 got a higher rank of 4 compared with Design 2 3.01. Since the main objective of this study is to provide quality service through efficient facility layout and queue management system, productivity was given the highest rank of 5. Economic constraint was given second consideration because it shows the amount of money needed to create the designs and it is for the client to decide how much they are willing to invest to achieve the objective. Since Design 2 has satisfied most of the constraints, the proponents conclude that Design 1 is the most favorable design alternative for the client.

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