



WHY ISN'T THE QUEUE MOVING

POR QUE A FILA NÃO ANDA?

POR QUÉ NO SE MUEVE LA LÍNEA?

ABSTRACT

Dilemma: This Teaching Case addresses a management problem faced by the managers and owners of Baixa Verde Payment Centre, located in the city of Santa Cruz da Baixa Verde, in the interior of the state of Pernambuco, during the COVID-19 pandemic. In a strategic analysis, it is possible to visualise the threat the health crisis posed to the business, since the prevailing scenario at that time was beyond the company's control. In this circumstance, to minimise the adverse effects encountered, it is necessary to adopt measures that students can evaluate.

Educational Objective: The goal of the case is to guide students in developing mathematical solutions using data collected from on-site observations and direct interviews with managers, and to deepen the discussion of the dilemma at hand.

Contextualization: The case portrays the challenge that the owners faced in providing payments at the Payment Centre. João and Sanny try to decide on a more effective solution to improve their services.

Main Theme: The case aims to reflect on the difficulties and developments faced by the owners. Through subjective and objective questions, it is possible to make more informed decisions about the Payment Centre's operations.

Audience: The case can be used in the areas of Production Management, Production Planning and Control or Operational Research.

Originality: The case highlights tools that support student teaching and learning, since the subject is traditionally taught without active methodologies. There are no teaching cases in the literature involving Queueing Theory; they are usually case studies.

Keywords: Queueing theory. Teaching case. Management.

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RESUMO

Dilema: Este caso para ensino aborda um problema gerencial vivenciado, durante a pandemia de COVID-19, pelos gestores e proprietários da Baixa Verde Loterias, uma casa lotérica situada no município de Santa Cruz da Baixa Verde, no interior do estado de Pernambuco. Em uma análise estratégica, é possível visualizar a ameaça que a crise sanitária representou para o negócio, uma vez que o cenário vigente à época estava fora do controle da empresa. Nessa circunstância, com o intuito de minimizar as adversidades encontradas, foram adotadas estratégias emergentes que os discentes estarão aptos a avaliar.

Objetivo Educacional: O caso tem como objetivo principal levar os discentes a elucidar soluções matemáticas com base em dados coletados por meio de observação in loco e de entrevistas diretas com os gestores, a fim de aprofundar a discussão sobre o dilema que o envolve.

Contextualização: O caso retrata o desafio que os proprietários enfrentaram com os pagamentos na lotérica. João e Sanny tentam definir uma solução mais eficaz para aprimorar seus serviços.

Tema Principal: O caso visa à reflexão sobre as dificuldades e os desdobramentos enfrentados pelos proprietários. Por meio de questões subjetivas e objetivas, é possível tomar decisões mais assertivas sobre o funcionamento da lotérica.

Público: O caso pode ser utilizado nas áreas de Administração da Produção, Planejamento e Controle da Produção ou de Pesquisa Operacional.

Originalidade: O caso evidencia ferramentas que favorecem o ensino-aprendizagem dos discentes, pois, tradicionalmente, o assunto é lecionado sem a aplicação de metodologias ativas. Na literatura, não há casos de ensino que envolvam Teoria das Filas; geralmente são estudos de caso.

Palavras-chave: Teoria das filas. Caso para ensino. Administração.

RESUMEN

Dilema: Este caso práctico aborda un problema

de gestión que experimentaron los gerentes y propietarios de Baixa Verde Loterias, una lotería ubicada en la ciudad de Santa Cruz da Baixa Verde, en el interior del estado de Pernambuco, durante la pandemia de COVID-19. Mediante un análisis estratégico, se visualiza la amenaza que la crisis sanitaria representó para el negocio, ya que el escenario imperante en ese momento escapaba a su control. En esta circunstancia, para minimizar las adversidades, se adoptaron estrategias emergentes que los estudiantes podrán evaluar.

Objetivo educativo: El objetivo principal del caso es guiar a los estudiantes a la hora de elucidar soluciones matemáticas, utilizando datos recopilados mediante observación in situ y entrevistas directas con los gerentes, con el fin de profundizar en el debate sobre el dilema planteado.

Contextualización: El caso retrata el desafío que enfrentaron los propietarios al realizar pagos en la lotería. João y Sanny intentan encontrar una solución más eficaz para mejorar sus servicios.

Tema principal: El caso busca reflexionar sobre las dificultades y los desarrollos que enfrentan los propietarios. Mediante preguntas subjetivas y objetivas, es posible tomar decisiones más asertivas sobre la operación de la lotería.

Audiencia: El caso puede utilizarse en las áreas de Gestión de la Producción, Planificación y Control de la Producción o Investigación Operativa.

Originalidad: El caso destaca herramientas que favorecen la enseñanza-aprendizaje de los estudiantes, ya que la materia abordada se imparte tradicionalmente sin la aplicación de metodologías activas. No existen casos de enseñanza en la literatura que involucren la Teoría de Colas; generalmente son estudios de caso.

Palabras clave: Teoría de colas. Caso práctico. Administración.

THE TEACHING CASE

Introduction

It was March 2020, when the entire world found itself in a severe global health crisis caused by the coronavirus (SARS-CoV-2), responsible for the COVID-19 pandemic—a completely



atypical and desperate scenario. The disease's high transmissibility led to the implementation of social distancing measures and even a lockdown to control its spread.

In view of this, micro and small businesses, in particular, were affected by the drop in demand, which led to the interruption of their activities or their permanent closure. Brazil's economy suffered severe impacts, reflecting social inequality, which increased considerably and directly affected the low-income population, who survive in precarious conditions and are exposed to a range of risks and vulnerabilities.

On April 2 of that same year, Law No. 13,982 was enacted, establishing additional parameters for characterising situations of social vulnerability for purposes of the Continuous Cash Benefit (BPC), as well as establishing exceptional social protection measures, such as the Emergency Aid. Caixa Econômica Federal (CEF), Banco do Brasil (BB), Payment Centre, and other banks were responsible for paying the benefit to citizens who met the criteria set out in the law.

This was one of the measures used to minimise the consequences of the COVID-19 pandemic, aimed at containing the health crisis by maintaining social distancing, reducing inequalities, and enabling the economy to continue circulating, thereby avoiding a worsening of the situation prevailing at the time.

On April 9th, João, owner and manager of Baixa Verde Payment Centre, was getting ready for another day of work with Sanny, his wife, despite the circumstances that, for undeniable reasons, had disrupted the flow of business. They put on their masks and got into a business car to work. When they arrived, they were faced with an unusual situation, about which Sanny asked:

– What's going on?

Sanny was aware that the first instalment of the emergency aid was due that day. However, the number of people waiting in line at work was the number of people waiting in line.

– Will we be able to serve all these people?
– asked Joana, the teller.

The day was beginning. No one present had a proper answer to that question yet. Payments depended on both the limited amount provided by the banks for this purpose and the daily cash flow, which was affected by the isolation measures. Moreover, the establishment could not fit all those people inside, and the line just kept growing.

– Why isn't the line moving? – Some customers remarked while waiting to be served.

By the end of the day, despite the effort to serve all customers, cash transactions were still not enough, and, unfortunately, João had to tell customers to come back the next day. Zacarias, who was in line, retorted:

– That can't be! I've been waiting for so long.

That day, the doors were closed, and the staff had to leave. However, everyone felt a sense of powerlessness at not having been able to meet that demand, even though the will to do so was not lacking. On the way home, João and Sanny kept talking about the situation and the need to find a solution.

– Why isn't the line moving? – The couple wondered.

CASE CONTEXT

Baixa Verde Payment Centre

Clistenys Payment Centre began operating in the city of Santa Cruz da Baixa Verde, in the interior of the state of Pernambuco, on July 24, 2002. However, it was only on August 14, 2007, that it began to be called Baixa Verde Payment Centre (Figure 1), when new owners acquired it.



Figure 1
Baixa Verde Payment Centre



Source: The authors (2024).

João, 61, holds a degree in Mathematics, has an MBA in Business Management, and has experience as a Service Manager at Banco do Brasil, and is already retired. Sanny, 53, holds a degree in Language and Literature and had previously been the manager and owner of a video rental store and a supermarket. The couple saw an investment opportunity, given that the Payment Centre unit in a small town of around 13,000 inhabitants that lacked banks was, at the time, responsible for providing a wide range of banking services that simplified the population's daily life.

Baixa Verde Payment Centre' portfolio of services and products includes transactional services – account management (balance inquiries, statements, withdrawals, transfers,

and deposits); collection of payment slips, bills, invoices, and taxes; mobile phone top-ups – social benefit services – payment of Bolsa Família, unemployment insurance, FGTS (severance indemnity fund), INSS benefits, PIS, and emergency aid – relationship banking products – opening checking and savings accounts; loans; credit cards; insurance; consortiums – as well as lottery games (Mega-Sena, Lotofácil, Quina, etc.).

All the material needed to carry out the work is supplied by companies contracted through CAIXA and paid for by it, such as the betting slips for the games, made available during the relevant drawing periods, equipment maintenance, and paper rolls for the terminals, supplied according to the establishment's needs whenever reported by the owners.



The staff consists of two workers, in addition to the owners, who are responsible for serving the public with all matters related to the Payment Centre's services. Service is offered from Monday to Friday, operating in the morning and afternoon shifts, between 8 a.m. and 5 p.m., with a break of 1 (one) hour and 30 (thirty) minutes.

Baixa Verde Payment Centre's customers are mostly individuals: Bolsa Família beneficiaries, INSS retirees, and those who use the Payment Centre to open a CAIXA savings account, pay bills and agreements, or make deposits and withdrawals. During the pandemic period, the establishment served an average of 734 customers daily, 100 (one hundred) of whom were, exceptionally, emergency aid beneficiaries.

Customers have their needs met without having to travel to other cities, since it is the only Payment Centre in the city and is easily found in the centre of Santa Cruz da Baixa Verde, PE. It serves both residents of the town and the surrounding rural areas, as well as occasionally people from other places who were unable to obtain the services they needed at the Payment Centre where they live. In addition, the quality of service provided by the company, as well as the security and guarantee offered by Caixa Econômica Federal, are also reasons that lead customers to seek out the unit.

More Threats

In another week of work, when the managers arrived at the Payment Centre, they noticed that the line was even longer, with people stretching around the block. The concentration of social benefit payments on the same dates caused the situation. Chaos on the same dates kept many of those people from leaving, so as not to lose their place in line. They had spent the night there. From the church near the Payment Centre, they received a call from a priest:

– How can I help? Some people spent the night out in the rain. – asked Father Gilberto.

– We weren't expecting this. We're doing everything we can to resolve the situation. — João replied.

As if that weren't enough, the health surveillance authority showed up at the site, since inspections of banks, Payment Centre, and other establishments had been stepped up during the COVID-19 pandemic to combat the spread of the coronavirus. Those crowds in line could not be allowed to happen. It was essential to maintain proper social distancing and follow other preventive health measures correctly. The establishment could be fined or even shut down.

Emerging Strategies

Given the scale of the problem, largely due to the pandemic, the city government mobilised and set up a team that people would not have mobilised themselves. On top of everything, faced with all these events, João and Sanny had some insights.

– Let's hand out tickets! – said Sanny.

Together, they began producing tickets, duly signed and stamped, on which the number and the estimated time of service for each emergency aid beneficiary were noted. These tickets were handed out by the managers at the end of the day so that customers would not have to stay in line until the next day. The quantity produced, 100 (one hundred) tickets per day, matched the potential daily demand the business could handle and the respective benefits it could pay out.

The managers believed that, in this way, it would be possible to avoid overcrowding and allow customers to go home rather than spend the night on the streets. However, even with this strategy in place, there were always customers without tickets who hoped to receive their benefit at the last minute.

Because he was a mathematician, João realised that there was a more effective way to solve the problem, or to anticipate it in future occurrences. Thus began the collection of a data set (Table 1) that would serve to establish parameters for analysis—selected through direct observation and the establishment's security camera footage during the first half of 2024.

Table 1
Collected data

Servers	2servers
Number of customers	734customers day
Time available for service	7h30min

Source: Research data (2024)

Case Dilemma

Clistenys Payment Centre is responsible for providing quality service linked to decent work. In this teaching case, the strategies and actions taken can completely change the way the service is delivered. This teaching can be applied to operationalised processes or production processes that generate queues and require control, whether in banks, supermarkets, hospitals, pharmacies, public agencies, beauty salons, gyms, or industry.

Case Closing

Management finds itself facing a decisive moment. With the data collected, it is necessary to understand the importance of managing it. Strategic, economic, and organisational aspects of decision-making can be examined, along with other ways of managing the dilemma in this case, such as scheduling, service segmentation, staggered hours, customer communication, institutional partnerships, and quantitative analysis.



TEACHING NOTES

The teaching notes provide information about the teaching case to assist providers in applying it. The subtopics for assistance are relevant because there are few teaching cases in production management education, and specifically in Queueing Theory. There are always traditional exercises, but practical application is rarely demonstrated. There are specific timeframes for conducting the class, alternatives for analysis, and reflection questions, given the complexity of some of the questions and students' frustration.

Case Summary

This Teaching Case addresses a management problem faced by the managers and owners of Baixa Verde Payment Centre, located in Santa Cruz da Baixa Verde, in the interior of the state of Pernambuco, during the COVID-19 pandemic. In a strategic analysis, it is possible to see the threat that the health crisis posed to the business and how the situation extended beyond the company. In this circumstance, to minimise the adverse effects from the perspective of Queueing Theory, mathematical solutions are developed based on data collected through

in loco observation and direct interviews with the managers, to deepen the discussion of the dilemma "Why isn't the queue moving?" The case can be used in the areas of Production Management, Production Planning and Control, or Operational Research, given the content explored, which is part of the respective courses. Interviews were conducted with the company's employees, and both subjective and objective solutions to the case are presented.

Keywords: Queueing theory. Teaching case. Management.

Educational Objectives

In this context, Queueing Theory has different applications that can help with the effective management of production capacity, through queueing models that, through mathematical formulas, show how an equivalent queueing system should operate under specific conditions.

Chart 1 below shows the associations between tasks and educational objectives.

Chart 1
Associations between tasks and educational objectives

Educational Objectives	Tasks
a) More assertive decision-making and less superficial analyses, since instinctive actions can lead to errors, risks, and losses.	Through building a decision strategy for which management approach to choose to solve the case.
b) The applicability of the method will allow for reflection and discussion on the dilemmas that afflict managers when facing the formation of long lines in businesses.	Realising that quantitative analysis is necessary for robust decision-making.
c) As well as on the possibilities found in the study of Production Management for solving similar organisational situations.	Realising that Production Management has more objective approaches that focus on building a realistic view of data implementation for process optimisation.
d) Discerning the importance of quantitative methods for decision-making.	Recognising the combined use of qualitative and quantitative approaches.
e) Assessing the trade-offs between cost, capacity, service quality, and customer satisfaction, enabling the start of broader managerial discussions.	Evaluation of various factors that contribute to solving the case.



Student Profile

The case was developed to be applied, preferably at different levels of education, both undergraduate and graduate, depending on the course's focus and objectives. Below are the student profiles that can benefit from reading and analysing this case. However, it can also be applied by practitioners in corporate training in the relevant field.

a) Business Administration, Accounting, and Economics students.

Level: undergraduate and graduate.

Reason: The case addresses fundamental topics in operations research and, specifically, Queueing Theory. Business students can explore how good management directly affects the quality of the service provided.

Courses: Operations Research and Production Planning and Control

b) Production Engineering and Computer Science students

Level: Undergraduate.

Reason: The case allows analysis of practical production and operations problems in a commercial establishment, highlighting the importance of forecasts and simulations of various scenarios, which can model the mathematical structure required for sensitivity analysis.

Courses: Operations Research and Production Planning and Control

These student profiles benefit from studying the case because it offers a practical, applied view of theoretical concepts, connecting strategic decision-making to a company's everyday reality. This enables the development of analytical and practical skills to solve complex problems across a variety of contexts.

Data Sources

The data obtained for this Teaching Case were collected through unstructured, in-person interviews conducted with the managers and owners – Sanny and João – between October 2, 2023, and April 5, 2024. In addition, social media

helped with the exchange of information, photos, and videos that contributed to the development of the case, and in loco observation made it possible to see and understand how the establishment operates, as well as its service flow on a normal working day. That said, some information was adapted to facilitate understanding and analysis of the facts.

Questions for Classroom Discussion

1. What was Baixa Verde Payment Centre's system utilisation rate?
2. What was the probability that there were no customers at the Payment Centre?
3. What was the average number of customers waiting in line at the Payment Centre?
4. What was the average time a customer waited in line at the Payment Centre?
5. What was the average number of customers in the Payment Centre's system?
6. What was the average waiting time in the Payment Centre's system?
7. How would adding one more server impact the system's utilisation rate?
8. What potential factors would cause the line to grow after hiring a new server?
9. Regarding the psychological aspects of individuals waiting in a queue, would it have been possible to include external elements to help minimise customers' negative perception of waiting time?
10. What could influence a customer's decision to stay in line or not?
11. How could such questions help a manager solve a problem with service queues?

It can be assumed that the size is either infinite or finite (so that the source of arrivals is also said to be unlimited or limited). Since calculations are much easier in the infinite case, this assumption is usually the starting point, even when the actual size is a relatively large finite number. It should be taken as an implicit assumption in any queueing model that does not state otherwise. The finite case is harder

to analyse analytically, since the number of customers in the queueing system affects the number of potential customers outside the system at any given moment (Hillier & Lieberman, 2013, p. 751).

From this perspective, it seems necessary to assume that arrivals to the queueing system (Table 2), in accordance with the Poisson distribution, occurred randomly and independently of the number of customers already present — that is, the size of the arrival source was infinite.

Table 2
Arrivals to the queueing system

Average customer arrival rate (λ)	$\frac{734customers}{450minutes} = 1.63customersperminute$
Average time elapsed between arrivals ($1/\lambda$)	$\frac{1}{\lambda} = \frac{1}{1.63customers} = 0.61minute$

Source: Research data (2024)

In addition, service at the Payment Centre was normally quick, but could occasionally take longer. “An exponential distribution of service times would be quite plausible for this type of service situation” (Hillier and Lieberman, 2013, p. 759).

Corrêa and Corrêa (2022, p. 328) also note that, in queues of people, there is a basic and commonly accepted ethical rule of FIFO (First In, First Out), meaning the first to arrive is the first to be served. In accordance with this queue discipline, customers waiting in line at Baixa Verde Payment Centre were selected for service (Table 3). Each server served an average of 367 customers.

Table 3
Service

Average service time ($1/\mu$)	$\frac{450minutes}{367customers} = 1.22minutespercustomer$
Average service rate (μ)	$\frac{1}{\mu} = 1.22$ $\mu = \frac{1}{1.22}$ $\mu = 0.82customerperminute$

Source: Research data (2024)

“M/M/s models can be understood as the general queueing model” (Virgillito, 2018, p. 320). The model adopted in the case was M/M/2, with exponential arrivals and service, and the number of servers responsible for handling the queue was equal to 2 (two).

Literature Review

“One of the problems we frequently encounter is queues of various kinds” (Virgillito, 2018, p. 303). During the COVID-19 pandemic, Baixa Verde Payment Centre experienced long lines due to seasonal demand, driven by the concentration of payments intended for beneficia-

ries, mainly Emergency Aid.

According to Eghbali, Mousavi, and Salimian (2023), queueing theory is essential for managing long waiting times and staffing levels, as well as optimising system operations. Thus, the use of Queueing Theory could have supported the Payment Centre managers’ decision-making process from the outset, before any subjective solution, such as the ticket system, even though that system was useful as a contingency measure.

According to Bodnar et al. (2018, p. 2), “the objective of queueing theory is to establish a relationship between the nature of the applica-



tion's flow, the performance of certain channels, the number of channels, and service efficiency." Queues were not limited in the number of items that could be stored simultaneously, but rather by how processors could optimise the flow (Zabielka et al., 2023).

"The existence of queues is a bad sign from the standpoint of customer service and a good sign from the strict standpoint of resource utilisation" (Corrêa & Corrêa, 2022, p. 334). The establishment had 2 (two) workers, who managed to keep the system in balance. This, in turn, remained busy approximately 99.39% of the time, with an idle probability of only 0.3%.

On the other hand, 163 customers remained in the Payment Centre's queueing system for 1 hour, 40 minutes, and 18 seconds before being served. Of that time in the system, only 1 minute and 14 seconds corresponded to the average service time. Queueing theory is a mathematical representation of waiting entities, in which indicators such as the average queue length, the average waiting time, the maximum queue length, and the average waiting time are evaluated over the long term to analyse the efficiency of the system (Ala, Yazdani, Ahmadi, Poorianasab & Attari, 2023).

When calculating Baixa Verde Payment Centre's system utilisation rate with the addition of one more server, the system would have had more slack, as its average utilisation would be approximately 66.26%. As a result, customers' waiting time would decrease.

In contrast, it is worth noting that, although this would be an effective strategy, since service delivery would occur with a reduced waiting time, it could be inefficient if the cost increase caused by adding more servers exceeded the company's financial capacity. "Providing excess service capacity to operate the system involves high costs. However, not providing sufficient service capacity results in excessive waiting and all its regrettable consequences" (Hillier & Lieberman, 2013, p. 750). From this perspective, the applicability of Queueing Theory in this case proves significant for obtaining a systemic view of the situation and for recognising the importance of these analytical models in managing production capacity.

Case Analysis and Discussion

In this section, all mathematical solutions were based on the formulas in the chapter on Queueing Theory in the book *Operations Research: Quantitative Modelling Methods for Decision-Making* by Salvatore Benito Virgillito (2018).

1) What was Baixa Verde Payment Centre's system utilisation rate? See Equation 1 below.

$$U = \frac{\lambda}{s\mu} \quad (1)$$

$$\frac{1,63}{2 \times 0,82} = 0,993902439 \cong 99,39\%$$

In queueing systems, a system utilisation rate below 1 is a necessary condition for the system to reach equilibrium. At Baixa Verde Payment Centre, the average system utilisation was 0.993902439. This means the system was busy for approximately 99.39% of the operating time; that is, it was practically out of control, although the workers' efficiency may have helped keep the system balanced.

2) What is the probability that there are no customers at the Payment Centre? See Equation 2 below.

$$P_0 = \left(\sum_{n=0}^{s-1} \frac{\left(\frac{\lambda}{\mu}\right)^n}{n!} + \frac{\left(\frac{\lambda}{\mu}\right)^s}{s!} \left(\frac{s\mu}{s\mu - \lambda}\right) \right)^{-1} \quad (2)$$

$$= \left(\frac{\left(\frac{1,63}{0,82}\right)^0}{0!} + \left(\frac{\left(\frac{1,63}{0,82}\right)^1}{1} \times \frac{2 \times 0,82}{2 \times 0,82 - 1,63} \right) \right)^{-1}$$

$$= (1 + 326)^{-1} = 0,003058103 \cong 0,3\%$$

Hillier and Lieberman (2013, p. 763) argue that the most basic queueing models assume that arrivals and departures from the queueing system follow a birth-and-death process. While birth refers to the arrival of a new customer, death refers to the departure of a customer who has already been served. Once the system utilisation rate (U) is defined, it is possible to determine the probability that the system is empty (P₀), that is, no customers are arriving in the queue or being served. Therefore, Baixa Verde Payment Centre was idle only 0.3% of the time.



3) What was the average number of customers in line at the Payment Centre? See Equation 3 below.

$$L_q = \frac{P_0 \left(\frac{\lambda}{\mu}\right)^{s+1}}{(s-1)! \left(s - \frac{\lambda}{\mu}\right)^2} \quad (3)$$

$$\frac{0.003058103 \times \left(\frac{1.63}{0.82}\right)^{2+1}}{(2-1)! \left(2 - \frac{1.63}{0.82}\right)^2}$$

$161.5106138 \cong 161 \text{ customers in queue}$

"Average number of customers in the queue corresponds to the average queue length (not counting customers who are being served)" (Moreira, 2017, p. 317). At Baixa Verde Payment Centre, while 2 customers were being served, approximately 161 more customers were waiting in the queue.

4) What was the average time a customer waited in line at the Payment Centre? See Equation 4 below.

$$W_q = \frac{L_q}{\lambda} \quad (4)$$

$$\frac{161.5106138}{1.63} 99.08626613 \cong 99.08 \text{ or } 1 \text{h } 39 \text{ mins in queue}$$

"Average time a customer waits in the queue: not counting service time" (Moreira, 2017, p. 317). At Baixa Verde Payment Centre, before a customer was served, they had to wait in line for an average of 1h39min04s.

5) What was the average number of customers in the Payment Centre's system? See Equation 5 below.

$$L = L_q + \frac{\lambda}{\mu} \quad (5)$$

$$161.5106138 + \frac{1.63}{0.82}$$

$163.4984187 \cong 163 \text{ customers in system}$

"Average number of customers in the system encompasses customers who are in the queue and those who are being served" (Moreira, 2017, p. 317). It is estimated that, at Baixa Verde Payment Centre, the average number of customers in the queueing system during the COVID-19 pandemic was 163.

6) What was the average waiting time in the Payment Centre's system? See Equation 6 below.

$$W = W_q + \frac{1}{\mu} \quad (6)$$

$$99.08626613 + \frac{1}{0.82}$$

$100.3057783 \cong 100.30 \text{ minutes or } 1 \text{h } 40 \text{ mins in system}$

"Average time a customer waits in the system: counting queue time plus service time" (Moreira, 2017, p. 317). It can be inferred that a Baixa Verde Payment Centre customer completed their service after 1h40min18s spent in the queueing system.

7) If there had been one more server at the Payment Centre, what would the system's utilisation rate have been? See Equation 7 below.

$$U = \frac{\lambda}{s\mu} \quad (7)$$

$$\frac{1.63}{3 \times 0.82} = 0.662601626 \cong 66.26\%$$

"The number of servers can be changed to reduce waiting time in queues" (Corrêa & Corrêa, 2022, p. 334). Therefore, if Baixa Verde Payment Centre had added one more server, the system's average utilisation would have been approximately 66.26%. The queueing system would have remained balanced but would have operated with more slack; nevertheless, the probability that a customer would need to wait to be served upon arriving at the establishment would have been reduced.

8) What are the potential factors that could cause the line to grow after hiring a new server?

Increasing the number of servers could lead to a new rise in demand if the result were a reduction in waiting time, since customers would perceive the quality and speed of service differently. Increasing capacity may not be the solution to the problem of waiting lines.



9) What would influence a customer's decision to stay in line or not?

According to Sabbaghtorkan, Batta, and He (2025), whether a server is available when a customer arrives, the customer may join the queue or leave the establishment at their own discretion. Waits without explanation or without a predicted service time are less tolerated than those that are explained or have a known time-frame for the customer. Customers who keep busy or place greater value on the service tolerate waiting time better.

10) Considering the psychological aspects of individuals waiting in line, could external elements be incorporated to help reduce the negative perception of waiting time?

The sensation of "time is passing faster" is common for many people when dopamine levels, which influence this perception, are elevated. In line with Soutschek, Jetter, and Tobler (2023), it is believed that dopamine plays a crucial role in cost-benefit decision-making, but, so far, there is no consensus on dopamine's precise role in this type of decision-making. In this way, creativity in managerial decisions, which can lead consumers' brains to understand and view the queue as something more beneficial than frustrating at that moment, due to the pursuit of the desired outcome, is fundamental to managing a business.

11) How would these questions help the manager solve the problem?

Estimating probabilities for the average size, average time spent in the system, and the utilisation or idleness of a queueing system is essential to support rational decisions that optimise flows. By applying modelling to systems involving waiting time and determining performance measures that enable analysis of productivity through Queueing Theory, decision-making becomes possible, whether at the level of raising awareness of the current state of the process or in projects to improve the observed system.

Teaching Plan

The Teaching Case strategy, as an active methodology, helps narrow the perceived gap between academic and organisational settings by integrating theory and practice, which favours the teaching and learning process. This case is typically preceded by the instructor's presentation of the theoretical concepts and, immediately afterwards, by its practical application, aiming to foster students' argumentation, communication, and management skills when faced with the managerial problem.

Suggested steps for carrying out the methodological procedure:

Step 1: Lecture on the content and presentation of the relevant case;

Step 2: Brainstorming or Brainwriting with student teams, to bring out their creative potential through the spontaneous sharing of alternatives for the problem.

Furthermore, for more reliable results, the instructor's approach may consider other interventions, such as discriminatory queue disciplines, which were not explored in the aforementioned case. Hillier and Lieberman (2013, p. 752) note that "queueing models normally adopt the first-come, first-served criterion." However, this rule is no longer applied when older adults, pregnant women, people with infants, and others who require priority service arrive at the service queues. As a result, the system's average performance can also be affected by these sequencing disciplines.

Guide for Applying the Case

Chart 2 below shows the estimated time for applying the case, serving as a guide for the instructor during this stage of teaching.



Chart 2
Case application time

Activity	Application time
Prior reading of the case	Before class
Kahoot or Mentimeter quiz as a content review	30 minutes
Explanation of the dynamic, introducing the teaching case within the context of the subject	15 minutes
Individual, careful reading of the teaching case	30 minutes
Splitting into groups for case discussion and problem-solving	30 minutes
Application of theoretical concepts (queueing theory)	30 minutes
Correction of queueing theory calculations	15 minutes
The instructor will lead a closing discussion of the activities	30 minutes
Total Class Time	3 hours

Source: Prepared by the authors (2025).

Therefore, each stage of the application is relevant to understanding the case. First, the reading is essential because without it, one cannot grasp the case's insights. Administering an online quiz precisely gauges the depth of knowledge about the content to be applied in solving the case. A general explanation of the case is necessary so that students can jointly understand how to solve it. Splitting into groups fosters a more intimate discussion, which may diverge from the rest or bring new perspectives to the case's solution. Applying the case is necessary to describe

the options debated within the group. Correcting the qualitative and quantitative analyses is necessary to resolve the case. And finally, the instructor's closing discussion to ensure understanding and validation of the activities.

Chart 3 presents a suggested evaluation rubric, used to define the criteria and relevant points for assigning grades in the case analysis, should the case study be used as a supplement to a course's final grade (Azevedo, Machado, Araújo & Silva, 2024).

Chart 3
Suggested Evaluation Rubric

Evaluation criterion	Definition	Maximum score
Problem diagnosis	Clear identification of the factors leading to inadequate control of queue length	1 point
Proposed solutions	Quality of suggestions and correct execution of calculations	1 point
Application of theoretical concepts	Ability to use queueing theory concepts and behavioural aspects	1 point
Feasibility and detail	Presentation of alternative solutions with simulation of changing or adding new parameters	1 point
Clarity and organization	Clear and coherent structure of the responses, including a synthesis of the information and consistency in the presentation of ideas.	1 point
Total Score		5 points

Source: Prepared by the authors (2025).



Scores are assigned as suggested in Chart 3 to ensure responses across different contexts are fairly validated for all students. The instructor may present the evaluation criteria before or even after grading the case.

REFERENCES

- Ala, A., Yazdani, M., Ahmadi, M., Poorianasab, A., & Attari, M. Y. N. (2023). An efficient healthcare chain design for resolving the patient scheduling problem: queuing theory and MILP-ASA optimization approach. *Annals of Operations Research*, 328(1), 3-33. <https://doi.org/10.1007/s10479-023-05287-5>
- Azevedo, I, Machado, A. G. C., Araújo, H. S. V. R. & Silva, G. C. (2024, 16 a 18 de setembro). Transformação à vista ou a prazo? O caso da 'Nordeste Eletro'. [XLVIII Encontro da ANPAD – EnANPAD], Florianópolis - SC, Brasil.
- BRASIL. Lei nº 13.982, de 2 de abril de 2020. Altera a Lei nº 8.742, de 7 de dezembro de 1993, para dispor sobre parâmetros adicionais de caracterização [...]. Brasília, DF: Presidência da República, 2020. Disponível em: https://www.planalto.gov.br/ccivil_03/_ato2019-2022/2020/lei/l13982.htm.
- Bodnar, B. E., Ochkasov, O. B., Bodnar, E. B., Hryshechkina, T. S., & Ocheretnyuk M. V. (2018). SIMULATION OF LOCOMOTIVE REPAIR ORGANIZATION BY THE METHODS OF QUEUE SYSTEMS THEORY. *Science and Transport Progress*, (5(77), 28–40. <https://doi.org/10.15802/stp2018/147740>
- Corrêa, H. L. & Corrêa, C. A. (2022). Administração de produção e operações: manufatura e serviços: uma abordagem estratégica. 5. ed. São Paulo: Atlas, 480 p.
- Eghbali, S. K., Mousavi, S. M., & Salimian, S. (2023). Designing blood supply chain networks with disruption considerations by a new interval-valued fuzzy mathematical model: M/M/C queueing approach. *Computers & Industrial Engineering*, 182, 109260. <https://doi.org/10.1016/j.cie.2023.109260>
- Hillier, F. S. & Lieberman G. J. (2013). Introdução à pesquisa operacional. 9. ed. Porto Alegre: AMGH, 1023 p.
- Moreira, D. A. (2017). Pesquisa operacional: curso introdutório. 2. ed. São Paulo: Cengage Learning, 356 p.
- Sabbaghtorkan, M., Batta, R., & He, Q. (2025). Adding servers to reinforce facilities in a spatially distributed queueing system. *Computers & Operations Research*, 173, 106862. <https://doi.org/10.1016/j.cor.2024.106862>
- Soutschek, A., Jetter, A., & Tobler, P. N. (2023). Toward a unifying account of dopamine's role in cost-benefit decision making. *Biological Psychiatry Global Open Science*, 3(2), 179-186. <https://doi.org/10.1016/j.bpsgos.2022.02.010>
- Virgillito, S. B. (2018). Pesquisa operacional: métodos de modelagem quantitativa para a tomada de decisões. 1. ed. São Paulo: Saraiva, 366 p.
- Zabielska, A., Jacyna, M., Lasota, M. & Nehring, K. (2023). Evaluation of the efficiency of the delivery process in the technical object of transport infrastructure with the application of a simulation model. *Eksploatacja i Niezawodność – Maintenance and Reliability*, 25(1), 1. <https://doi.org/10.17531/ein.2023.1.1>

Recommended Bibliography

As recommendations for studying and understanding the topic discussed, it is worth highlighting the work of Frederick S. Hillier and Gerald J. Lieberman, as well as that of Salvatore Benito Virgillito. The first – Introduction to Operations Research (2013) – was a reference in the field for Business Administration and Production Engineering courses, and the second – Operations Research: Quantitative Modeling Methods for Decision-Making (2018) – presented several cases and exercises on Queueing Theory, which helped in developing the mathematical solutions for this Teaching Case.