Volume 25 • Number 2 • April 2025

Cilt 25 • Sayı 2 • Nisan 2025

Contents

EGE AKADEMİK BAKIŞ / *EGE ACADEMIC REVIEW*

Cilt 25 • Sayı 2 • Nisan 2025
SS. 351/360
Doi: 10.21121/eab.20250207
Başvuru Tarihi: 03.02.2024 • Kabul Tarihi: 26.03.2025

Article Type: *Research Article*

Solving Queue Problems in a Campus Dining Service with Discrete Event Simulation

Furkan Onur USLUER[1]

ABSTRACT

Waiting in long queues is a common experience. Prolonged waiting times inevitably result in the formation of queues. While queues are a natural part of service systems, excessive waiting times can reduce customer satisfaction. Campus dining service (CDS) facilities are particularly susceptible to queuing issues when their capacity is insufficient. Long wait times can negatively affect customer experience, making effective queue management essential. To enhance operational efficiency and improve the dining experience, appropriate measures should be implemented to reduce congestion. In this research, a discrete event simulation model of a CDS was developed and analyzed. The study aims to devise low-cost solutions for queue problems through scenario-based analysis. Hypotheses were derived from existing literature and adapted to the specific characteristics of the system under study. Various scenarios were tested to assess the effectiveness of different queue management strategies. The results indicate that capacity reallocation strategies are the most effective in mitigating long queues and improving overall system performance. The findings provide practical recommendations for optimizing CDS operations, offering insights that can be applied to similar service environments facing queuing challenges.

Keywords: Discrete Event Simulation, Campus Dining Service, Operations Research, Queue Management, Capacity Reallocation.

JEL Classification Codes: C15, C44, C61

Referencing Style: APA 7

INTRODUCTION

Queues are a common part of daily life, yet they often cause frustration and dissatisfaction. In some cases, customers may even abandon the queue and seek service elsewhere. Prolonged waiting can lead to anxiety (Osuna, 1985). Queue systems have a significant impact on customer satisfaction (Firmansyah & Saputra, 2021). These factors highlight the importance of minimizing waiting times. While queues may be unavoidable in resource-limited and time-intensive services, analyzing them and implementing strategic solutions is essential for both operational efficiency and customer satisfaction.

University student enrollments in Turkey have increased in recent years (Habibi, 2017). This rise has exacerbated capacity constraints in campus facilities, including dining services. Student satisfaction with campus dining services (CDS) plays a crucial role in their overall university experience (Wooten et al., 2018). To accommodate growing demand and reduce long queues, CDS must implement strategies that enhance efficiency and service quality.

Campus Dining Services (CDSs) are common on university campuses worldwide, regardless of whether they are publicly or privately operated. These services play a vital role in meeting students' nutritional needs while operating within budgetary constraints, typically on a cost-recovery basis with affordable pricing. Studies have shown that factors such as food quality, service quality, value for money, and ambiance significantly influence students' satisfaction with on-campus dining services, which in turn affects their dining frequency (Smith et al., 2020). Balancing service quality and cost efficiency presents a significant challenge for CDSs, particularly as demand continues to grow. Therefore, understanding and optimizing queue management in these facilities is essential to improving student satisfaction.

Personnel are a crucial component of the CDS system, including cooks who prepare meals, staff who oversee payments, assist with electronic card issues, and ensure smooth daily operations. Effectively utilizing personnel within the broader system is key to achieving both operational efficiency and service quality.

[1] PhD Candidate, Bursa Uludag University, Faculty of Economic and Administrative Sciences, Department of Econometrics, Bursa, Türkiye f.onurusluer@gmail.com

Long queues at CDSs directly influence students' overall satisfaction with their university experience. Several studies propose various approaches to addressing long queue problems in CDSs (Ning et al., 2023). Given that students expect a certain level of service, effective management of CDSs is critical in shaping their overall experience.

Many CDSs charge students a reasonable fee and serve as affordable dining options. A primary objective of these services is to offer affordable meals to students. However, excessively long queues may discourage students from using these services, thus hindering their effectiveness.

To enhance student satisfaction, achieve the goals of CDSs, and ensure effective service delivery, it is crucial to conduct a thorough analysis of potential queues and implement strategic decisions based on the findings.

Facilities facing similar problems may not always employ analytical methods for problem-solving, often relying on managerial intuition instead. However, existing literature challenges this approach, emphasizing analytical techniques while largely disregarding or excluding intuitive methods. This study seeks to bridge the gap between these perspectives by exploring how scientific approaches can be integrated without completely rejecting intuition. In doing so, this research contributes to the literature by proposing a methodological approach for addressing similar challenges in service facilities.

This study examines queue problems caused by capacity constraints and high demand in a campus dining service (CDS) operating in Turkey. The sources and locations of queues were analyzed, and potential low-cost solutions were explored. A discrete event simulation model of the CDS was developed using JaamSim version 2023-02. Findings were derived from scenario-based analysis.

LITERATURE REVIEW

Simulation studies on CDSs vary in scope, problem-solving methods, and analysis techniques. This section systematically examines and presents these differences.

Kambli et al. (2020) developed a discrete event simulation model of a CDS. They emphasize that effective resource management is crucial due to high labor costs in developed countries. Their study applied the DMAIC (Define, Measure, Analyze, Improve, and Control) methodology and proposed recommendations to enhance service efficiency. Additionally, they introduced resource reallocation strategies to optimize operations.

Resource allocation solutions have gained increasing attention in the literature. Ghaleb et al. (2015) developed a CDS simulation model using Arena. Their study analyzed queues using scenario-based methods, measuring average waiting times and providing recommendations for future research.

The impact of class scheduling on queues in CDSs and other student dining environments is a significant topic in the literature. Studies on class scheduling yield varying and sometimes contrasting results. Ivan (2021) exemplifies this research, analyzing the efficiency of a college dining hall using a discrete event simulation model. The study utilized Simio simulation software and identified a correlation between class schedules and peak hours, providing recommendations based on this finding. Research analyzing balanced student arrival scenarios falls within this category. Aslan and Özderir (2021) emphasize that addressing queue problems requires systematic improvements in the CDS system.

Some studies employ measurement methods beyond total average waiting time. Sensitivity analysis is commonly used as a measurement tool. Lillo et al. (2022) exemplifies this approach, modeling a campus dining hall using a discrete event simulation. The researchers analyzed the dining hall's capacity and concluded that it sufficiently meets demand. Additionally, they found that waiting in queues induces anxiety.

CDSs are sometimes explored as project topics. For example, Curin et al. (2005) developed a campus cafeteria simulation model as part of an engineering project. Their study focused on resource utilization and employed a scenario-based analysis.

METHODOLOGY

Discrete Event Simulation

Simulation provides a representation of a system based on defined analytical rules. This method can reveal new ways to improve a system by uncovering hidden features not easily observed by other investigative methods. Simulation is widely used to redesign processes across various fields, including manufacturing, defense, healthcare, and management (Pidd, 2004).

Discrete models form the foundation of discrete event simulation. These models primarily focus on examining waiting times and queue lengths (Taha, 2018). The discrete nature of the method arises from the simulation's time progression, where time moves from one event to the next (Raczynski, 2022). An 'event' serves as the main component of a discrete event simulation model, with the sequence of events being a critical element in its operation. Entities in a discrete event simulation model resemble materials moving along a production line, progressing sequentially from one event to the next until they reach the final stage, akin to becoming the finished product. At each event, they spend a specified amount of time, based on the parameters defined by the researcher. Data from each event are recorded and analyzed.

In this research, the discrete event simulation method was used as a modeling approach.

Software

The simulation model was developed using JaamSim, an open-source discrete event simulation software (Harrison et al., 2016; King & Harrison, 2013). The software version used in this study is 2023-02 (64-bit). (Lang et al., 2021) compared open-source and commercial simulation software, highlighting JaamSim as a viable alternative to commercial options. JaamSim provides a user-friendly interface and 3D modeling capabilities, enabling the efficient creation of complex models. Its open-source nature offers users greater control over the software, making it a flexible and powerful tool for this kind of study.

Hypotheses

The goal of this study is to identify low-cost solutions for queue problems through scenario-based analysis. Hypotheses are formulated based on existing literature and tailored to the specific systems targeted for improvement.

H_1: Capacity reallocation solutions are effective in reducing queue problems in a CDS.

H_2: Class scheduling solutions are effective in reducing queue problems in a CDS.

H_3: Combining capacity reallocation solutions can decrease the effectiveness of a solution in a CDS.

System Description

The system investigated in this study is a campus dining service (CDS) facility. Approximately 3,000 to 3,500 students use this facility between 11:00 AM and 2:00 PM on working days. Students are required to use their student cards to access the service. If a student's card balance is insufficient, funds can be added through card machines located at the facility entrance. Four card machines are available within the facility, with additional machines located around the campus. Despite this, many students arrive at the facility without sufficient funds on their cards. To reduce queue times, the administration installed four card machines at the facility. Approximately 80 percent of students use these machines before lunch to top up their cards.

The CDS facility is a two-story building. Students with sufficient balance on their cards can join the lunch queues on either floor. A majority of students prefer to have lunch on the first floor, with approximately 60 percent choosing this floor, while 40 percent opt for the second floor.

Students must use a card reader machine with their student cards to select where to have lunch. When a card is processed by the reader, it releases a barrier, allowing one student to pass through. To ensure proper use of the cards, a worker is stationed at each card reader. In total, two workers are assigned to this task.

After the card reading process, students collect their trays and join the lunch queue. Cooks provide the daily menu to students, with one cook required to be available for each student. The facility employs a total of 12 cooks.

After receiving the menu, students move to the dining area, where they sit on a chair to have lunch. The facility

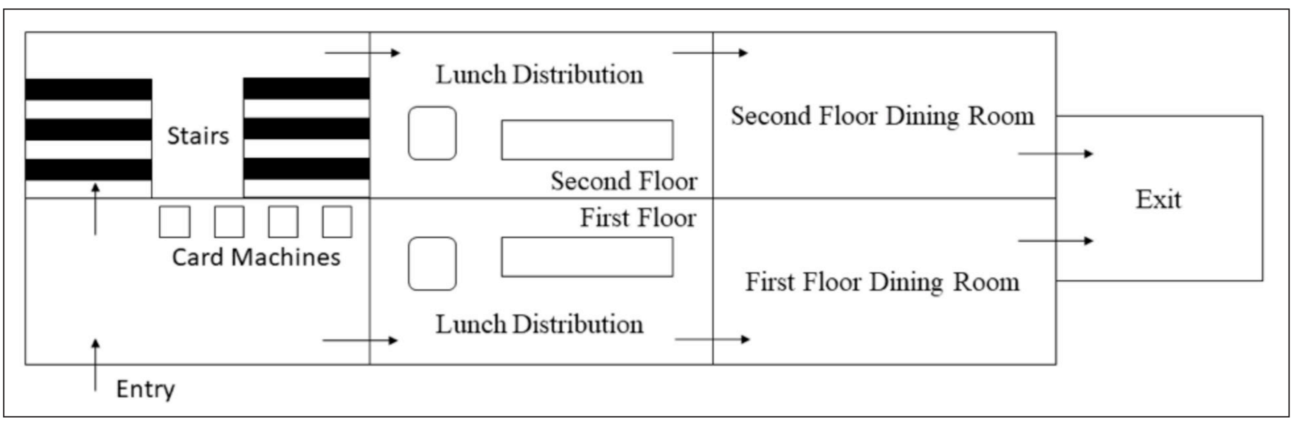

Figure 1: Layout of the CDS Facility

has a total of 870 chairs. If no chairs are available, students must wait until one becomes free. After finishing their meal, students leave the facility.

Data

The system under investigation is a CDS. Data related to the system were collected through interviews with workers and managers, as well as direct observations. Additionally, limited capacity data were sourced from the internet and considered during model development. Observational data were gathered by examining the facility and conducting focus group discussions.

Model

As shown in Figure 2, 80% of students visiting the facility proceed to use the card machines. Each student (or entity) utilizes one card machine, with transaction times following a triangular distribution of (9, 15, 17) seconds. Once the transaction is complete, students select the floor where they will have lunch. There is a 60% probability of choosing the first floor and a 40% probability of choosing the second floor. Arrival times at the first-floor card reader are 20 seconds, while arrivals at the second-floor card reader take 60 seconds. Upon arrival at the card reader, a student joins the queue to use the card, requiring both a worker and a card reader machine. After this, students proceed to the lunch queue. When their turn arrives, they receive their lunch from a cook. The time to receive lunch follows a triangular distribution of (30, 40, 45) seconds. If a chair is available, students begin their meal; if no chair is free, they wait until one becomes available. The time to have lunch follows a triangular distribution of (25, 30, 60) minutes. After finishing their meal, the student leaves the facility.

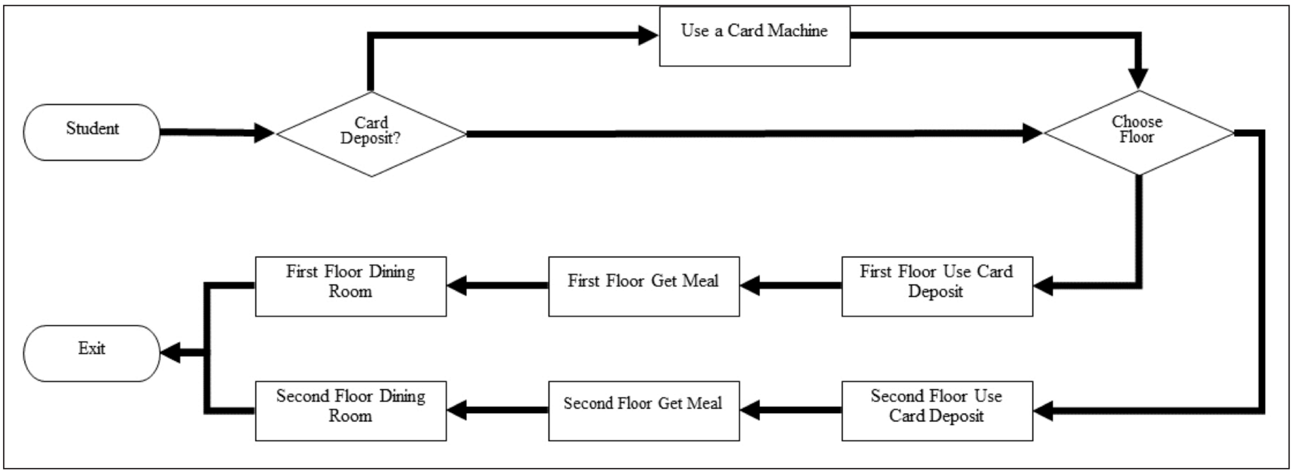

Figure 2: Flowchart of the System

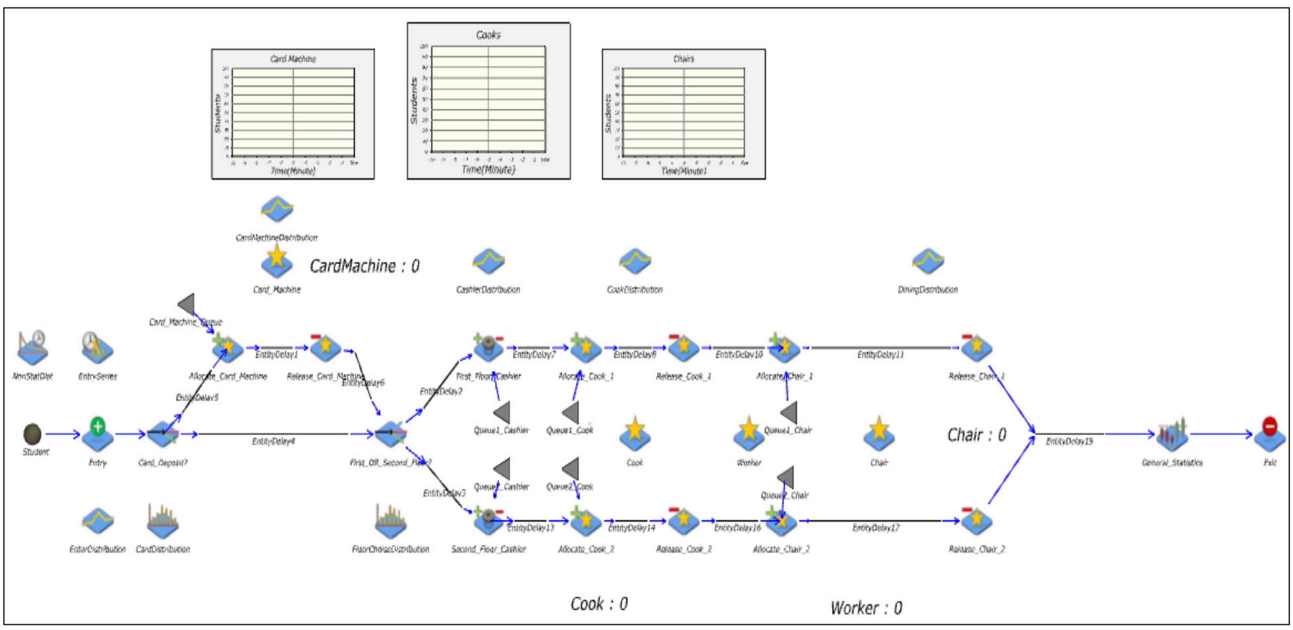

Figure 3: Processes Flow of the System with JaamSim

Model Verification, Validation

Advancements in technology and the availability of affordable computing resources have made simulation models more accessible. However, validating these models is crucial to ensure they accurately reflect the dynamics of real-world systems. Without proper validation, simulation studies may be deemed questionable, as there could be a significant gap between the modeled system and the actual system it aims to represent. Validation helps to bridge this gap, thereby improving the model's credibility and reliability.

A study discussing validation methods in terms of different eras is presented by Sargent and Balci (2017). In this study, the baseline model was shown to experts and managers at the facility through interviews, and they were asked whether the model accurately represented the system. Their feedback was positive. Furthermore, the model's student arrival data for the hours between 11:00 and 14:00 were 1500, 1200, and 600, respectively. The total number of arrivals in the facility on a typical day is approximately 3500. Although variations in the arrival rate exist during each active hour, specific data on these fluctuations were not available. A t-test revealed no significant statistical differences between the observed and modeled arrival numbers.

Baseline Model & Proposed Scenarios

The baseline model represents the current system, which is subject to improvements. This model incorporates all the features described in previous chapters. In the baseline model, there is no queue for chairs, indicating that the chair resource is sufficient for the system. Similarly, there are no queues for card reading processes, as the number of workers is adequate for this task. However, queues do form at the card machines and for the cooks. Due to the design of the system, any improvements made to reduce card machine queues would lead to longer queues at the cook stations. As shown in Table 1, the total average waiting time across all queues in this model is 14,429 minutes.

Scenario 1 examines the effects of reduced reliance on card machines within the system. Although card machines are available across the campus, many students prefer to use them at the facility just before lunch. In this scenario, it is assumed that the university launches a campaign to encourage students to use card machines outside of lunch hours by offering incentives such as bonuses and advertisements. As a result, the usage rate of card machines decreases from the baseline model's 80 percent to 50 percent.

Scenario 2 explores the situation in which an additional card machine is added to the facility. There is sufficient space available in the location of the card machines to accommodate another one. Some card machines on campus are infrequently used, and it is assumed that one of these rarely used machines is relocated to the facility.

Scenario 3 examines the impact of changes in students' behavior regarding their floor choices. Generally, students tend to prefer the first floor of the facility. The assumption is that, with proper guidance, the distribution of students across the floors would become evenly split, with 50 percent choosing each floor.

Scenario 4 explores a capacity-reallocation approach. In the baseline scenario, two workers are assigned to the card reading machines to ensure every student uses their card properly. Since almost all students use their cards, the income generated from these processes is low. In this scenario, the workers are reassigned to assist the cooks with lunch distribution. The need for workers at the card reading machines is removed, and the number of cooks is increased to 14.

Scenario 5 examines the impact of class scheduling on facility demand. The total number of students per week ranges from 3,300 to 3,500, but student arrivals vary significantly throughout the day. The peak hour is between 11:00 and 12:00, during which the facility's capacity is insufficient to meet demand in such a short time. The assumption is that students arrive at the facility immediately after their classes end. In this scenario, all university classes are rescheduled so that students' arrivals at the facility are evenly distributed across different hours.

Scenario 6 combines Scenario 2 and Scenario 4 to analyze the effects of all capacity reallocation scenarios simultaneously.

ANALYSIS

To address the queue problems in the facility, some proposed scenarios focus on capacity reallocation (Scenarios 2 and 4), others aim to change students' behavioral intentions (Scenarios 1 and 3), and one targets class scheduling (Scenario 5).

Although there is a dramatic decrease in waiting times at the card machine queues in Scenario 1, there is almost no change in the total average waiting time. As shown in Table 1, the total average waiting time in the queues

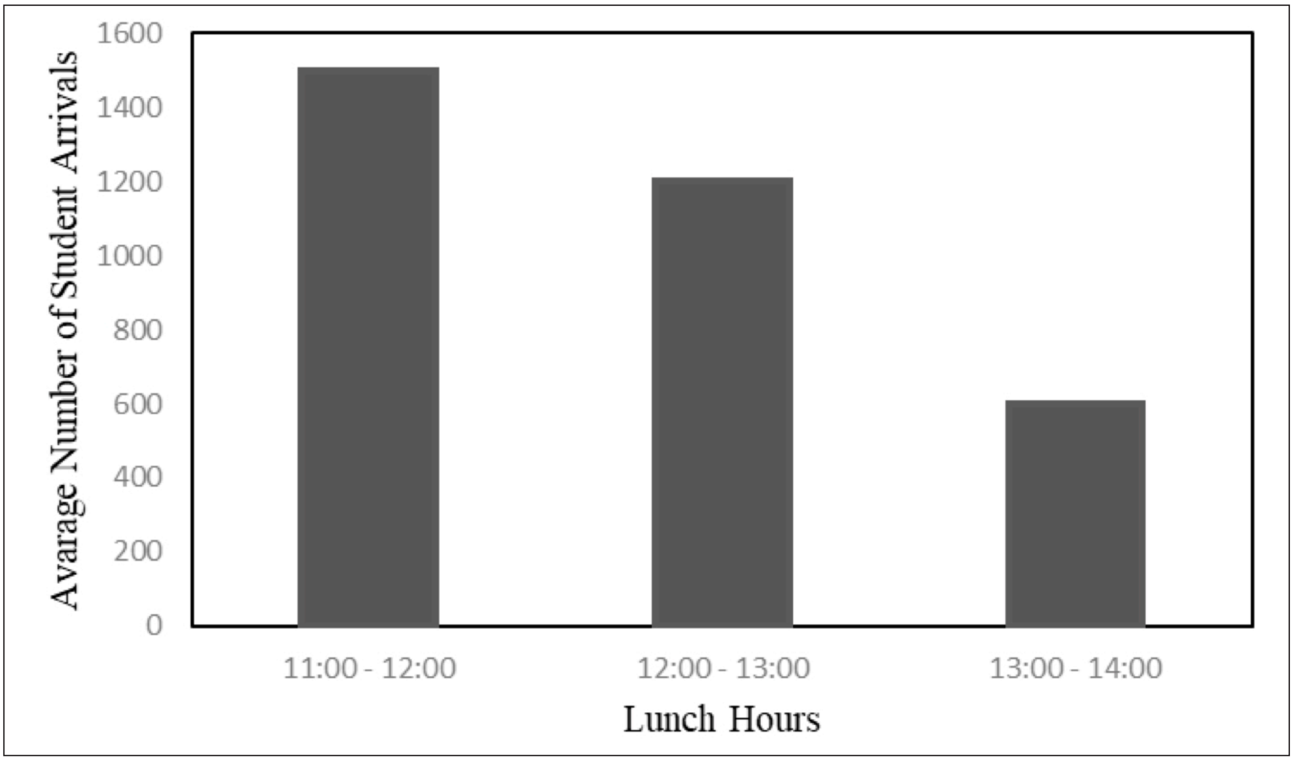

Figure 4: Baseline Model Average Number of Student Arrivals

Table 1. Total Average Waiting Times of Scenarios

	Average Waiting Time(min)	Difference with Baseline model(min)
Baseline model	14,429	N/A
Scenario 1	14,378	-0,051
Scenario 2	14,4	-0,029
Scenario 3	14,427	-0,002
Scenario 4	4,3502	-10,0788
Scenario 5	1,0487	-13,3803
Scenario 6	4,1922	-10,2368

is 14,378 minutes in Scenario 1. The reduction in waiting times at the card machine queues led to an increase in the number of students in the lunch queues. This represents a low-cost solution to reduce queues at the card machines.

Scenario 2 introduces an additional card machine in the facility. The results are similar to those in Scenario 1. As shown in Table 1, the total average waiting time is 14.40 minutes. This also serves as a low-cost capacity reallocation solution to address the card machine queue issues.

As shown in Table 1, the total waiting time in scenario 3 is 14,427 minutes. Change in floor decision possibilities doesn't change waiting times significantly.

Scenario 4 involves a capacity reallocation, where workers at the card reader machine areas assist cooks at lunch distribution. As shown in Table 1, the average waiting time in this scenario is 4.36 minutes. The queue at lunch distribution decreased by 80 percent. Waiting at the card reader machine may not be the most efficient option. If workers help cooks with lunch distribution, they

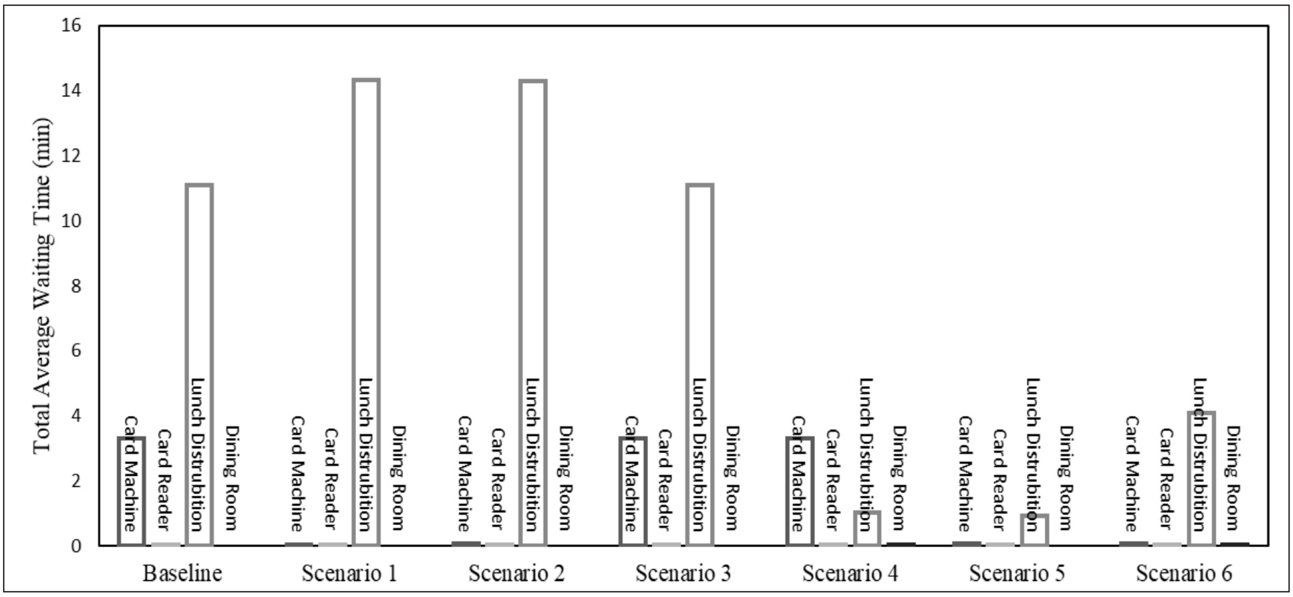

Figure 5: Total Average Waiting Times of Scenarios and Queue Locations

would provide greater benefits to the facility. If waiting at the card reader is not essential, this becomes a low-cost solution to address queue problems.

A hypothetical measure was examined in scenario 5, where it was assumed that all university classes were scheduled in such a way that student arrivals during lunch hours would be evenly distributed. Students typically enter the facility around 11:00. According to Table 1, the average waiting time in this scenario is 1.04 minutes. All resources are sufficient, and the few capacity issues that remain lead to fewer queues.

Scenarios that are easier to implement and have the potential to improve the system were combined in scenario 6. These include scenarios 2 and 4. According to Table 1, the average waiting time is 4.19 minutes.

DISCUSSION

All hypotheses were tested through scenario-based analysis and confirmed. H1: Resource-reallocation solutions were effective in solving queue problems. H2: The relationship between queues and student arrival rates was confirmed. Balancing the number of students arriving each lunch hour effectively solves queue problems. H3: In scenario 6, two resource-reallocation solutions were tested. A decrease in queues at the card machine area increased the number of students at the lunch distribution area, which reduced the effectiveness of the resource allocation solution in this area due to the system's flow.

Capacity reallocation scenarios impact average waiting times, and this effect is statistically significant. The results are consistent with findings from other simulation studies that focus on resource reallocation (Curin et al., 2005; Ghaleb et al., 2015; He & Hu, 2018; Kambli et al., 2020).

There is partial similarity with the literature regarding the results of changing students' arrival rates between lunch hours (Aslan & Özderir, 2021). Lillo et al. (2022) emphasized that altering the number of students arriving at a facility at different hours has minimal effect on capacity usage. In another study, where class scheduling was tested in a school cafeteria setting, scheduling was found to solve the queue problem (Nettles & Gregoire, 1997). The system being optimized in this case was an elementary school cafeteria, which may explain why class scheduling was so effective in addressing queue issues. However, in a study where class scheduling was applied to solve queue problems in a university cafeteria, the results were similar to those of Nettles & Gregoire (1997) (Ivan, 2021). Scenario 5 assumes that class scheduling and student arrival to the facility are related and seeks to investigate the outcomes if this relationship holds true. The optimal state for the facility can be achieved by balancing student arrivals, and numerous studies in the literature either support or challenge this hypothesis.

CONCLUSION

Many service facilities rely on managerial intuition rather than systematic analysis when addressing operational challenges. However, research in the field emphasizes the importance of data-driven, analytical approaches while often overlooking the role of intuitive decision-making. This study highlights the potential for integrating structured analytical methods with experiential judgment to develop more effective solutions. By bridging this gap, the proposed approach provides a practical framework for service operations, ensuring that decision-making balances empirical analysis with managerial expertise. These findings contribute to the ongoing discussion on optimizing service systems by leveraging both quantitative techniques and professional insight.

Effective resource management contributes to productivity and plays a key role in addressing queue challenges. The 'chair' resource is sufficient for the facility, and there is no queue related to the 'chair' resource in any of the scenarios.

The card reading process is automated, eliminating the need for workers in these areas. Similar systems are common in cities, and people are familiar with their use, further reducing the need for manual assistance. Having workers solely to ensure proper card use is unproductive for the facility. These workers should be reassigned to lunch distribution for better efficiency. This solution would not require hiring additional personnel and would significantly reduce queues at lunch distribution. Compared to the other scenarios, Scenario 4 is simpler for the facility to implement and is recommended as an effective solution for addressing queue problems.

Encouraging students to use card machines outside of lunch hours may help alleviate queues in the card machine area. This solution is recommended if the facility can implement it. If such behavioral change advocacy is not feasible or is too costly, the solution in Scenario 2 should be considered. The results of Scenario 2 are similar to those of Scenario 1, with no statistically significant difference. This solution involves relocating the least used card machine on campus to the available space near the other card machines at the entry. With five card machines, queue problems in the card machine area can be effectively addressed.

Although based on an assumption and difficult to implement, the solution in Scenario 5 should still be considered. The primary cause of queues in the facility is the large number of students arriving in a short time frame. Queue problems could be alleviated if an approximately equal number of students arrive at the facility throughout the lunch hours. If students arrive at the facility immediately after their classes, class schedules can be adjusted to match the facility's capacity.

The most strongly recommended solution is Scenario 6, which combines the solutions from Scenarios 2 and 4. In this scenario, two workers from the card reading machine areas should be reassigned to assist with lunch distribution, and one of the least used card machines on campus should be relocated to the facility. This approach can reduce the average waiting time by 71 percent.

Productive resource usage is essential for improving service quality and achieving cost efficiency. By considering different viewpoints, the facility can uncover new ways to meet productivity goals.

REFERENCES

Aslan, E., & Özdeiir, N. (2021). Bir Üniversite Öğrenci Yemekhanesinde Simülasyon Uygulaması. *Kahramanmaraş Sütçü İmam Üniversitesi Sosyal Bilimler Dergisi*, *18*(2), 965–978. https://doi.org/10.33437/ksusbd.629888

Curin, S. A., Vosko, J. S., Chan, E. W., & Tsimhoni, O. (2005). Reducing Service Time at a Busy Fast Food Restaurant on Campus. *Proceedings of the Winter Simulation Conference, 2005.*, 2628–2635. https://doi.org/10.1109/WSC.2005.1574562

Firmansyah, F., & Saputra, A. C. (2021). Effect Of The Implementation Of Queue System On Customer Satisfaction. *Bongaya Journal for Research in Management (BJRM)*, *4*(1), 1–7. https://doi.org/10.37888/bjrm.v4i1.245

Ghaleb, M. A., Suryahatmaja, U. S., & Alharkan, I. M. (2015). Modeling and simulation of Queuing Systems using arena software: A case study. *2015 International Conference on Industrial Engineering and Operations Management (IEOM)*, 1–7. https://doi.org/10.1109/IEOM.2015.7093945

Habibi, N. (2017). Higher education policies and overeducation in Turkey. *European Journal of Higher Education*, *7*(4), 440–449. https://doi.org/10.1080/21568235.2017.1308832

Harrison, H., King, H., Mchudleigh, Sawong, Gsavinkoff, JenchuiAusenco, & Pierre-Luc Paour. (2016). *Jaamsim: Release 2023-02* (Version v2023-02) [Computer software]. Zenodo. https://doi.org/10.5281/ZENODO.57118

He, H., & Hu, Z. (2018). Analysis of Fast Food Service Capability Based on Flexsim Modeling and Simulation. *IOP Conference Series: Materials Science and Engineering*, *394*, 052005. https://doi.org/10.1088/1757-899X/394/5/052005

Ivan, J. (2021). The Impact of the Constraints of Class Scheduling on Campus Dining: A Simulation-based Case Study. *Proceedings of the 33rd European Modeling & Simulation Symposium*, 266–271. https://doi.org/10.46354/i3m.2021.emss.037

Kambli, A., Sinha, A. A., & Srinivas, S. (2020). Improving campus dining operations using capacity and queue management: A simulation-based case study. *Journal of Hospitality and Tourism Management*, *43*, 62–70. https://doi.org/10.1016/j.jhtm.2020.02.008

King, D. H., & Harrison, H. S. (2013). Open-source simulation software "JaamSim"; *2013 Winter Simulations Conference (WSC)*, 2163–2171. https://doi.org/10.1109/WSC.2013.6721593

Lang, S., Reggelin, T., Müller, M., & Nahhas, A. (2021). Open-source discrete-event simulation software for applications in production and logistics: An alternative to commercial tools? *Procedia Computer Science*, *180*, 978–987. https://doi.org/10.1016/j.procs.2021.01.349

Lillo, F., Gonzalez, A., Severino-Gonzalez, P., Toro-Lagos, V., & Rojas-Sepulveda, I. (2022). Capacity in University Food Services: A Simulation Analysis Based on the case of Universidad Católica del Maule. *Review of Economics and Finance*, *20*, 805–815. https://doi.org/10.55365/1923.x2022.20.91

Nettles, M. F., & Gregoire, M. B. (1997). Use Of Computer Simulation In School Foodservice. *Foodservice Research International*, *9*(3), 143–156. https://doi.org/10.1111/j.1745-4506.1997.tb00316.x

Ning, J., Li, J., Li, Z., Tian, Y., & Li, S. (2023). Study on The Form of Reservation of Food Orders in Campus Canteens in The Post-epidemic Era. *International Journal of Education and Humanities*, *8*(2), 96–102. https://doi.org/10.54097/ijeh.v8i2.7754

Osuna, E. E. (1985). The Psychological Cost of Waiting. *Journal of Mathematical Psychology*, *29*(1), 82–105. https://doi.org/10.1016/0022-2496(85)90020-3

Pidd, M. (2004). *Computer Simulation in Management Science* (5. ed). Wiley.

Raczynski, S. (2022). Discrete Event Models. In S. Raczynski, *Models for Research and Understanding* (pp. 171–187). Springer International Publishing. https://doi.org/10.1007/978-3-031-11926-2_7

Sargent, R. G., & Balci, O. (2017). History of verification and validation of simulation models. *2017 Winter Simulation Conference (WSC)*, 292–307. https://doi.org/10.1109/WSC.2017.8247794

Smith, R. A., White-McNeil, A., & Ali, F. (2020). Students' perceptions and behavior toward on-campus foodservice operations. International Hospitality Review, 34(1), 13–28. https://doi.org/10.1108/IHR-06-2019-0010

Taha, H. A. (2018). *Operations Research: An Introduction* (10. ed). Pearson India.

Wooten, R., Lambert, L. G., & Joung, H.-W. (2018). Evaluation of students' satisfaction with three all-you-can-eat university dining facilities. *Journal of Foodservice Business Research*, *21*(5), 539–552. https://doi.org/10.1080/15378020.2018.1483691