

RESEARCH ARTICLE

A Discrete Event Simulation Approach for Efficient Student Enrolment Processes at Universiti Malaysia Pahang Al-Sultan Abdullah

Hui Jing Pang¹, Jack Kie Cheng^{1*}, Yao Liu²

¹Faculty of Industrial Management, Universiti Malaysia Pahang Al-Sultan Abdullah, Lebuhr Persiaran Tun Khalil Yaakob, 26300 Kuantan, Pahang, Malaysia

²Faculty of Management Engineering, Huaiyin Institute of Technology, Huai'an 223003, China

ABSTRACT - Rapid advances in technology and globalization have shaped our world, and the acquisition and application of knowledge have become critical to success. At Universiti Malaysia Pahang Al-Sultan Abdullah (UMPSA), the increasing number of students has led to inefficiencies in the student enrolment process, particularly concerning long waiting times and resource bottlenecks. These problems have caused delays and dissatisfaction, hence calling the urgent need to improve the student enrolment processes. The objectives of this study are to develop a simulation model to evaluate the inefficiencies in the student enrolment process and recommend new improvements using discrete event simulation (DES). The ARENA software simulation was employed to simulate the enrolment process while comparing the base case with the improved scenarios using the performance metrics of waiting times and queue lengths. The proposed improvements resulted in significant reductions in waiting times and queue lengths, particularly through increased staffing at hostel counters. The findings highlight the importance of strategic resource allocation in optimizing high-volume administrative processes. This study contributes to the body of knowledge regarding DES applications in the educational sector and serves as practical strategies for improving student enrolment processes at UMPSA and similar institutions.

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1. INTRODUCTION

Education is one of the important factors that advance an individual forward in their personal and professional life. It is a fundamental foundation for the development and growth of both individuals and societies. Rapid advances in technology and globalization have shaped the world, making the acquisition and application of knowledge critical for success. Education develops people's critical thinking, creativity, skills, and abilities while inculcating important values such as integrity and social responsibility (Elder, 2022). To date, the Malaysian higher education landscape comprises of 20 public universities, 36 polytechnics, 105 community colleges, and 434 private institutions. The public universities are fewer in number but provide quality education regulated by the Ministry of Higher Education (MOHE). Additionally, both public and private universities serve more than 590,000 and 517,000 students, respectively.

Among these institutions, Universiti Malaysia Pahang Al-Sultan Abdullah (UMPSA) is a public university that focuses on engineering within the technology-driven industry. Established in 2002, both the Gambang and Pekan campuses have served thousands of students, underscoring the significance of efficient enrolment processes. Between 2020 and 2021, UMPSA enrolment rose from 13,607 to 13,685 students, thereby indicating the necessity of efficient registration systems. Improving the effectiveness of the student enrolment process at UMPSA through a discrete event simulation (DES) approach will allow for enhanced efficiency of the processes involved. This method helps in capturing and evaluating the performance in order to identify possibilities for improvement through the prediction and modeling of real situations (Kambli et al., 2020). The simulation enables UMPSA to trial strategies and plan for improved student enrolment processes without incurring costs that would have arisen from the actual implementation. This is advantageous to students and administrators alike. This study is essential as it aims to improve the student enrolment process at UMPSA. Past literature supports that positive enrolment experiences enhance students' loyalty to the institution of learning and even its reputation (Masserini et al., 2019). Such assistance also adds to the existing knowledge on how DES can be used to improve registration processes in universities and offers practical ideas that can be implemented in similar institutions to enhance their effectiveness (Marsudi, 2020).

The objectives of this study are to develop a simulation model for the university registration process, evaluate its efficiency, and recommend areas for improvement. The significance of this study lies in its potential to enhance student satisfaction and operational efficiency at UMPSA by simplifying and optimizing the university registration process. Furthermore, the study contributes to the body of knowledge by demonstrating the application of discrete event simulation to analyze and improve service delivery in student enrolment processes, thereby enhancing efficiency and operational quality. The scope of this study focuses on the student enrolment processes at UMPSA, which is situated in the Gambang

campus, where challenges in registration have come to the fore owing to its rapid growth. Such a focus allows the study to design a DES specific to the campus' existing student enrolment problems and tackle the issues of efficiency in the processes.

The rising student population at UMPSA has created an inherent challenge to the student registration process during the enrolment day since it leads to strenuous queue times that cause operational delays. This essentially translates to inefficiency, student dissatisfaction, and poor experiences laced with inconveniences during registration. Registration prior to the COVID-19 pandemic was done using manual processes, which often caused delays and congestion due to the inability to register on time (Dennis, 2021). The onset of COVID-19 has shaped the way students are enrolled, thus encouraging online enrolment applications to practice social distancing (Akhmetova et al., 2021). However, this creates other problems due to poor infrastructure and technical problems, in addition to confusion and inefficiencies as it involves both offline and online methods. Also, the ineffective process designs, few service points, and scheduling issues lead to overcrowding and an increase in waiting times (Falolo et al., 2022). These bottlenecks must be eliminated to achieve better performance and satisfaction among students. Therefore, this study seeks to establish a DES model aimed at increasing the efficiency of enrolment processes in higher education institutions.

2. LITERATURE REVIEW

This section examines the student enrolment process in higher education institutions. It starts with a brief introduction of the student enrolment procedure within higher education institutions, followed by the workflow, current challenges, and the importance of optimizing student enrolment. Lastly, the study includes an analysis of different techniques, such as the queuing theory, the advances of technology, and DES, to tackle the issue of enrolment.

2.1 Workflow of Student Enrolment

Marsudi (2020) indicated that the enrolment process consists of several steps, which are implemented in a particular order to assimilate the students into the university. Such a process is illustrated in Figure 1.

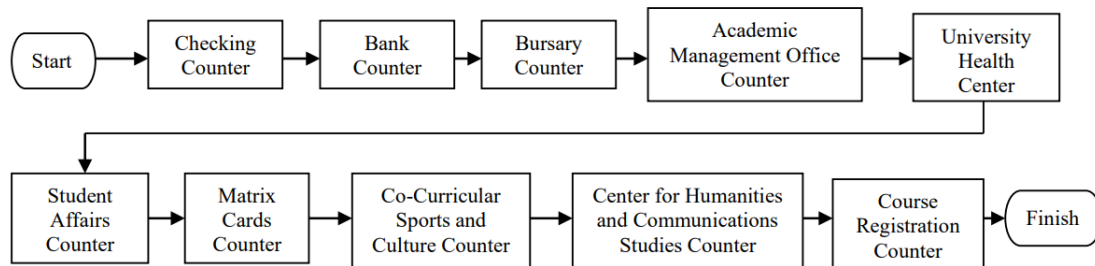


Figure 1. The flow diagram of the student enrolment process

The enrolment process begins at the Check Counter, where students must check and confirm whether their documents are complete. Next, they will proceed to the Bank and Bursary Counters to pay for their enrolment fees. The next step is account activation at the Academic Management Office, followed by the submission of their health report to the University Health Centre. Students will then collect items like t-shirts and dormitory allocations from the Students Affairs Counter and obtain their Student ID from the Matrix Cards Counter. The final step is going to the Co-Curricular, Sports, and Culture Counter, the Centre of Humanities and Communication Studies Counter, and the Course Registration Counter, before they can register for the dormitory. Marsudi (2020) highlights on the importance of clarity in each step to establish a smooth student enrolment process, which in turn will reduce waiting times, minimize cost, and optimize manpower.

2.2 Current Challenges in Student Enrolment

Though the enrolment procedure is set up by the higher institution's education bodies, most universities face challenges that diminish their efficiency and effectiveness. Aye et al. (2020) summarized several key challenges, such as student waiting in queues, complex scheduling in specialty units, and severe delays in processing their research. These issues not only extend students' waiting time but also cause congestion, which may lead to low satisfaction and frustration for all concerned parties (Aye et al., 2020). Overcoming these hurdles is vital and should be a priority in ensuring that the enrolment is efficient and smooth for the benefit of students in the university.

One of the prevalent issues in the current university student enrolment process is the long waiting time and extended queues during registration processes, resulting in delays and frustration among students. According to Ma et al. (2019), long waiting time in registration processes at universities can lead to inefficiencies and dissatisfaction among students. Similarly, Hendri et al. (2021) emphasize the long queue problem during the re-registration of new students, which can affect the system control and cause inconvenience to system efficiency. In order to get the greatest student experience after they enrol at the university, universities can set efficient processes for their registration.

Another issue associated with the current student registration systems is complexity. University registration processes are complex because of the numerous requirements and steps that must be completed (Marsudi, 2020). The process can be a harrowing experience, from handing over documents to running from counter to counter. Marsudi (2020) states that this arduous process lengthens the registration period and results in increased inconvenience for students. It can also cause delays and inefficiencies among students as they strive to complete the university registration process (Aye et al., 2020). This will lead to waiting times, with long queues and blockages at the counter.

In summary, the current challenges in the student enrolment process at universities include, but are not limited to, the length of time to process documents, waiting queues that lead to overcrowding, and the intricate nature of registration, which pose impediments to efficacy and efficiency. These obstacles only serve as fuel for dissatisfied students and staff, further deepening the inefficiencies within the registration process (Masserini et al., 2019).

2.3 Importance of Optimizing the Enrolment Process in Higher Education Institutions

In the higher education environment, the enrolment process is the primary gate to students' educational journey (Niranjan & Hegde, 2021). Thus, it is vital to optimize the enrolment process to ensure its efficiency. This paper will explore the need for optimizing the registration process in higher education institutions. The integration of procedures simplifies the majority of administrative activities and speeds registration while decreasing the number of opportunities for error by individuals (Sudana et al., 2023). Universities that have implemented efficient workflows through technology have reduced registration times to a minimum, allowing students to register for courses and the university's facilities with no problems. Time efficiency creates benefits for both students and university staff, who can work within a more conducive environment to get work done.

Moreover, optimization of the enrolment process leaves students with a positive experience (Masserini et al., 2019). It includes less waiting time, clear guidance, and procedures that are easy to conduct. As a result, students report higher levels of satisfaction when applying to the university. Masserini et al. (2019) found that a positive enrolment experience improves a student's sense of belonging and retention within the university. Furthermore, an efficient student enrolment process also allows universities to allocate resources properly, including staff, facilities, and technology (Gaftandzhieva et al., 2022). Therefore, by eliminating inefficiencies in the enrolment process, universities can proactively take charge of what remains the best way to use their resources. This primarily results in cost savings and the enhancement of the overall operational performance.

In conclusion, optimizing the student enrolment process in higher education institutions is an essential exercise for increased efficiency, a better student experience, and optimal resource utilization. Investments in optimization methods and utilities, such as technology, simulation capabilities, and data analytics systems, are necessary for universities to create an easier and more user-friendly registration process, improve students' satisfaction, and help them achieve their ideal strategic goals in the increasingly competitive world of education.

2.4 Techniques to Solve Student Enrolment Issues

To find the solution for challenges encountered in student enrolment processes, various techniques have been employed to enhance efficiency and optimize system performance. This section explores several of these techniques and their applications in overcoming enrolment hurdles.

2.4.1 Queuing Theory

The queuing theory concerns mathematical modeling and examination of queues or lines at various systems (Bansal, 2022). The theory posits that the time individuals wait or queue length is an essential quantity in the system and many analytic models have been developed to estimate it. According to Bansal (2022), the queuing theory examines factors like arrival rates, service times, and the number of servers involved in order to understand and optimize the behavior and efficiency of these systems. In the best-case scenario, the first person to arrive is always the first to be served; but real queues may not exhibit this. Thus, the most important thing to target is understanding the behavior and structure of queues to make informed strategic decisions.

The queuing theory can be applied to various practical problems, such as the student enrolment process in universities, and it is a valuable tool to solve problems like long queues at the registration counters. Especially amidst the challenges brought forth by the COVID-19 crisis, this queuing principle holds promise in simplifying tasks like completing application paperwork, thereby contributing to cutbacks in expenditures concerning time, costs, and energy (Sharma, 2021). Compounding queuing paradigms with digital simulation techniques, academic institutions have been adept at diminishing learner pileups across sectors, such as collegiate matters, whilst elevating the aggregate efficacy tied to signup activities (Aye et al., 2020). This improvement encompasses enhancements regarding duration depletion, deployment of assets effectively, expandability pluses, and span stretches alongside progress throughputs heightened. Besides, when coupled with envisaged illustrative mock-ups, even infirmaries gain from recognizing snags while perfecting how resources are assigned, consequently dialing down lingering periods plus boosting functional output within registry functions (Tyagi et al., 2023).

2.4.2 Other Technological Advancements

In the area of technological advancement, Laura et al. (2019) stated that a simulator system based on IT was created to minimize human involvement in the course registration process at the university. The system is a planned abetment to tutors, lecturers, and students in the registration process and is available through the faculty website for ease of use (Marsudi, 2020). Additionally, the creation of a mobile application with the Flutter framework and Firebase database linked to the academies for learners could help instructors and students with the registration deeds (Ali & Dauwed, 2022). An archetype of a mobile app has also been elaborated to ease the registration process for parents and students with better vehicle registration control and the reduction of transmission risks during the pandemic (Delgado et al., 2020).

2.4.3 Discrete Event Simulation (DES)

DES is a powerful modeling and analysis method for complex systems analysis, such as the university registration process. It enhances systems by mimicking their operations in different environments (Vázquez-Serrano et al., 2021). DES is concerned with events, a significant occurrence or change in the simulated system that causes a response or action. Queue is a basic concept in DES that denotes the formation of a line of entities that await service or processing (Anuruddhika et al., 2022). This is because all of them can be incorporated into DES and allow for the examination of various designs to ensure performance and interrogate the scope for improvement, hence enhancing the allocation of resources and the making of decisions (Zamani, 2023). Marsudi (2020) reported that the student registration process was improved with DES using ARENA software. This approach involved creating mathematical models of the registration process to analyze and optimize the system's performance. DES can be used to identify potential bottlenecks and inefficiencies and test alternative arrangements and scenarios to improve the overall process. Moreover, the utilization of DES in determining arrangements for healthcare and decisions regarding planning, especially within diverse department outpatient clinics, is evidenced by research like Vázquez-Serrano et al. (2021). Such investigations display the capacity of discrete event simulation to assess various designs and their influences on functional results, contributing to pinpointing weaknesses and enhancing clinical efficacy.

2.4.4 Advantages of Using Discrete Event Simulation

Advantages of DES in university registration system optimization include increased efficiency, reduced error occurrence, and better resource allocation. It enables universities to analyze operations and processes, thereby reducing wait times and improving service delivery through optimal staffing and resource use (Laura et al., 2019). This also reduces errors in the registration process, which minimizes chaos and wastage of resources while guaranteeing that the students are ready for their courses through a better tracking of progress (Laura et al., 2019). Furthermore, DES evaluates configurations, such as centralized versus decentralized systems, allowing the universities to make optimum decisions to improve the utilization of their staff and reduce operating costs. It eventually increases satisfaction for both the students and staff alike (Zamani, 2023). Nevertheless, the huge initial investment for model development and validation can be a barrier to the adoption of this technique by some institutions.

3. METHODOLOGY

This section shows the overall approach employed in the simulation to increase the efficiency of the student enrolment process. It begins by describing the data collection process, which is classified into two types: primary and secondary data collection. This is followed by outlining the components of discrete event simulation and discussing the simulation's stages as well as the software utilized for its construction. Finally, the validation and verification checks guarantee that the data is logical and authentic.

3.1 Data Collection Method

Primary data collection involves retrieving firsthand facts, which cannot be obtained by any other means (Mazhar, 2021). For this study, primary data collection was conducted using both interviews and observations. Several interview sessions were held with key stakeholders, such as Perwakilan Mahasiswa Residen Pelajar (PEKA), involved in student enrolment to gather primary data regarding the entire student enrolment process at UMPSA, such as the total number of student enrolment and the waiting time per section. Conversely, observation allows the researchers to directly witness the enrolment process to identify inefficiencies and areas that need optimization (Gaftandzhieva et al., 2022). The observation was conducted on 28 September 2024, the first day of new student enrolment at UMPSA, to capture a realistic picture of the challenges faced by both students and staff during peak enrolment periods. Such method is important to identify and understand any bottleneck situations or practical dimensions that exist during the actual student enrolment process.

On the other hand, secondary data was collected through a literature review of previous research and publications to elucidate insights and data relevant to the research objectives (Mazhar, 2021). Stringing together existing literature in the student enrolment process lays the groundwork for mainstreaming common practices and innovations in higher education. This review also enables the benchmarking of UMPSA student enrolment system with similar systems in other institutions of higher learning. Thus, the common mistakes in the study can be avoided through previous research and studies. The secondary data collection in this study utilized different sources, such as journal articles on student enrolment systems and processes of higher educational institutions as well as university and annual reports, which include student enrolment statistics.

3.2 Components of Discrete Event Simulation

DES is a highly useful tool for representing complicated systems and analyzing how they work in terms of distinct activities that can occur at any point during such operations (Vázquez-Serrano et al., 2021). Its essential elements are entities, attributes, resources used, and variables, which must be dealt with to accurately define the structure’s particular features. This study focuses on a UMPSA student who is moving from one stage of the registration process to another. Therefore, it is significant to comprehend and trace the entities of students in a DES model for simulating and optimizing the enrolment process. The resources of this study are the register staff, hostel staff, and PEKA Residen Pelajar 1 (RP1), Residen Pelajar 2 (RP2), and Residen Pelajar 3 (RP3) who handle registration tasks and assist students during enrolment day. The attributes of this study are personal information and enrolment status. Lastly, the variables of this study are arrival rates, service time, queue lengths, and resource availability. These factors optimize the process of enrolling, improve operational effectiveness, and enhance learners' overall experience of registration into educational programs.

3.3 Step in Discrete Event Simulation

Simulation typically contains several key stages aimed at ensuring that the model builder is guided systematically and appropriately in undertaking a valuable simulation exercise. Figure 2 illustrates the main steps involved in a simulation.

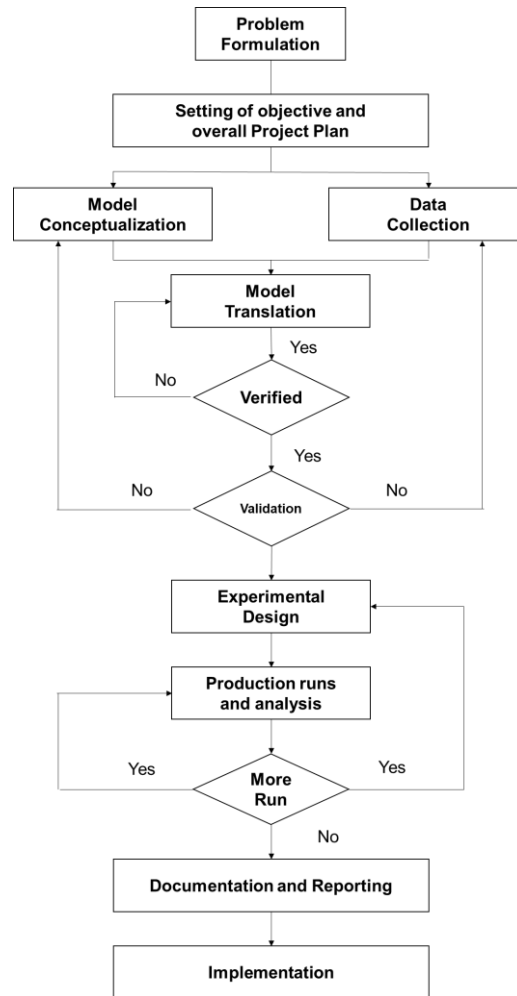


Figure 2. Steps in Discrete Event Simulation
 Source: (Obagbuwa et al., 2023)

Figure 2 shows a set of steps to guide a model builder through a sound simulation study. It starts with problem formulation in which some aspects of the problem are defined in collaboration with the stakeholders concerned. The objectives and overall project plan are later drawn to develop the aims and determine whether simulation is the best technique. This is preceded with the model conceptualization and data collection processes, where major aspects of the problem are simplified and embedded in a model. It starts with a simple model and the complexity increases with time, while learning necessary data. The next step is transforming the model into a format that can be processed by a computer by relying on programming or simulation software. After this stage, verification and validation procedures are completed to ensure that the model is implemented correctly and it operates as expected in comparison to the real system, hence making it iterative in nature. At the experimental design stage, appropriate scenarios are chosen, metrics for system performance are determined, and simulations are conducted to assess and improve the system designs. Documentation and reporting are necessary to know how to use the model and keep a record of the simulation. These steps are conducted by the execution where the analyst's engagement must be active to obtain favorable results.

3.4 Simulation Software

Simulation software is a powerful tool in the modeling and analysis of real-world systems to conduct scenario testing and process optimization without disturbing the real-world operations. The applications include industries, such as manufacturing, logistics, healthcare, and education simulations, that can help discover bottlenecks, distribute resources better, and increase effectiveness. In this study, Arena Software was used for DES. Arena has a strong reputation among simulation software packages due to its ease of use and graphical interface that allows users to develop models visually and experiment with different scenarios. The effectiveness of Arena software has been demonstrated in various studies (e.g., Marsudi, 2020) for optimizing student enrolment systems, reducing waiting times, and improving efficiency. In this study, Arena serves the purpose of simulating and improving the student enrolment process at UMPSA, with practical recommendations on streamlining operations and enabling better user experiences.

3.5 Verification and Validation

Verification ensures the model correctly works and is as it should be, starting from a comprehensive conceptual model review in which the correctness of flow charts representing the registration process is verified. The model must be error-free to work well in this process phase and any bugs or logical inconsistencies will be corrected (Alsolami, 2020). Moreover, data verification is important to ensure that the input data in the form of student arrival rates and service times are accurately represented in the model, hence capturing real-world conditions.

Validation, on the other hand, tests whether the model is an accurate representation of the real-world registration system being examined. The Mean Absolute Percentage Error (MAPE) is a significant statistical approach that helps to evaluate the actual results against the simulated ones effectively (Khairina et al., 2019). DES is performed using the same input parameters as in the actual process. It involves determining the degree of error in the numbers of students processed, such as between the simulation output and the actual observed data.

The formula to calculate MAPE is:

$$MAPE = \frac{1}{n} \sum_{i=1}^n \left| \frac{Actual_i - Forecasted_i}{Actual_i} \right| \times 100 \tag{1}$$

Source:(Khairina et al., 2019)

where:

n: Number of observations

Actual Value_{*i*}: Observed value from real-world data

Simulated Value_{*i*}: Predicted value from the simulation

This formula calculates the average absolute percentage difference between the actual and simulated data, providing a measure of accuracy for the DES model. Lower MAPE values indicate a better precision of the simulation model. In most cases of practical application, the ideal MAPE value would be less than 10%, while values between 10% to 20% can be accepted (see Table 1).

Table 1. Level of accuracy for MAPE

MAPE Value	Level of Accuracy
MAPE ≤ 10%	Very accurate
10% < MAPE ≤ 20%	Accurate
20% < MAPE ≤ 50%	Medium
50% ≤ MAPE	Less accurate

Source: (Khairina et al., 2019)

4. RESULTS

This section presents the results of designing and developing a discrete event simulation to optimize the student enrolment processes at UMPSA. The discussion revolves around the student enrolment process, animation, results, key performance indicators, and Scenario 1.

4.1 Student Enrolment Processes

Students arrive at the campus either by private or public transportation. They later proceed to the assigned hostels (see Figure 3). The registration of female students will be explained first, followed by male students. Female students reside in either RP1 or RP3.

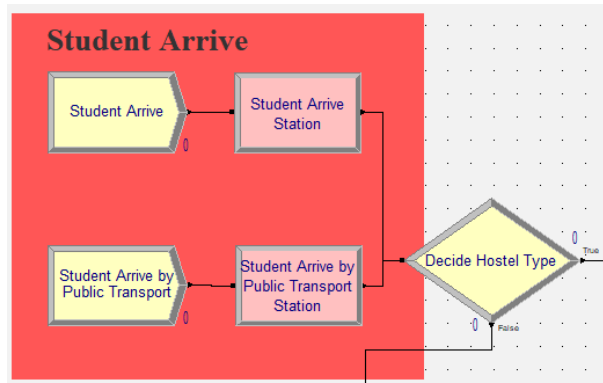


Figure 3. Student enrolment process at UMPSA - student arrival

As illustrated in Figure 4, female students have the option for drive-thru assistance upon arrival. Those who require help can drive through a designated area where the staff will assist with unloading belongings. If no assistance is required, they can proceed directly to the parking area and determine whether they are assigned to RP1 or RP3. Finally, they will proceed to the registration process at the assigned hostel.

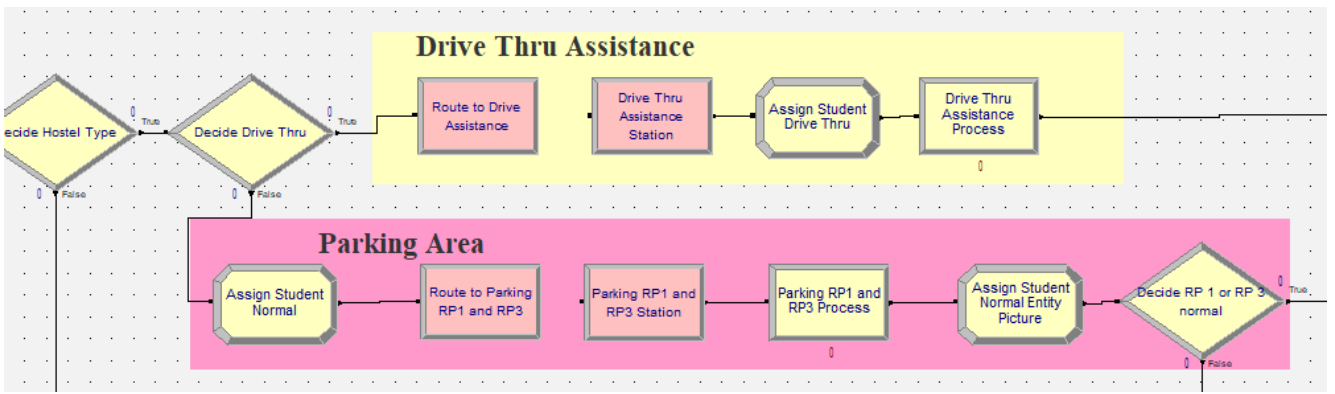


Figure 4. Student enrolment process at UMPSA - drive thru option

According to Figure 5, at the start of RP1, female students will first undergo the drop-off process. There are 3 parking spaces in the drop-off area where several staff will assist the students in alighting and getting their luggage. Later, the students will move to the registration and hostel registration processes to obtain their room keys. Each process has 2 counters. The students will then leave the RP1 office upon obtaining their room keys.

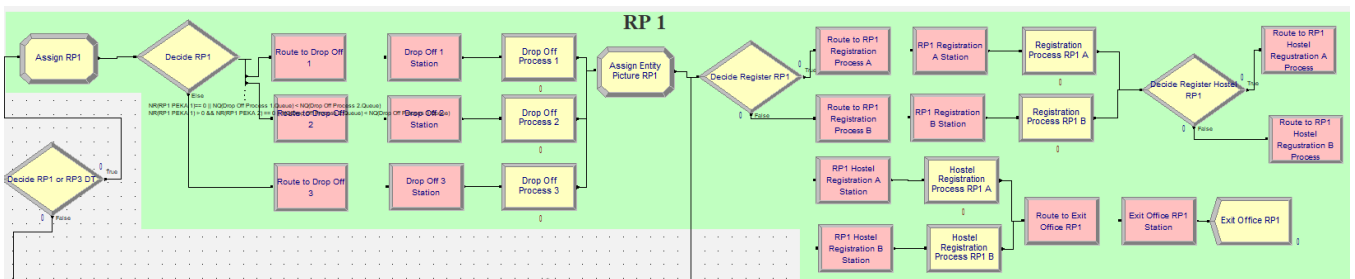


Figure 5. Student enrolment process at UMPSA - RP1

Female students assigned to RP3 will undergo similar processes as illustrated in Figure 6. They will go through the drop-off area, receive assistance with their luggage, and proceed with the registration process. Finally, they will continue with the hostel registration process, obtain their room keys, and exit the RP3 office.

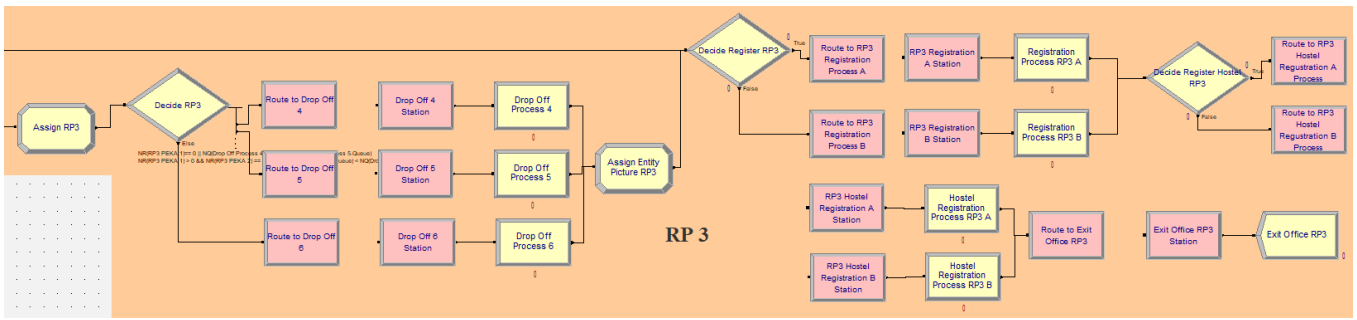


Figure 6. Student Enrolment Process at UMPSA - RP3

Figure 7 shows the registration processes undergone by male students. They will park their vehicles proceed in a straight line to the registration process. This is followed by the hostel registration process to collect their room keys, each with 2 counters. After completing these processes, the male students will exit the RP4 office.

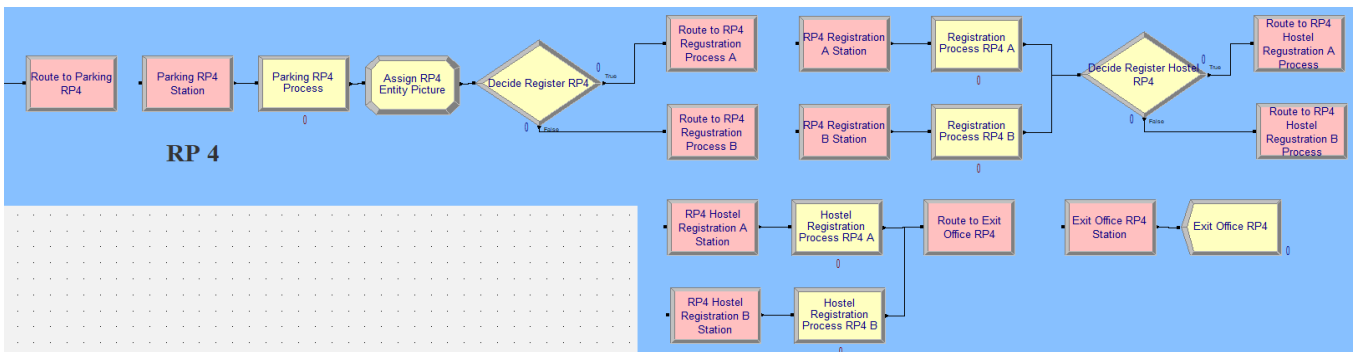


Figure 7. Student enrolment process at UMPSA - RP4

Figure 8 combines all steps of the student enrolment process in a single detailed figure. It incorporates the entire process, starting from the students' arrival until the last stages of hostel registration and room key collection.

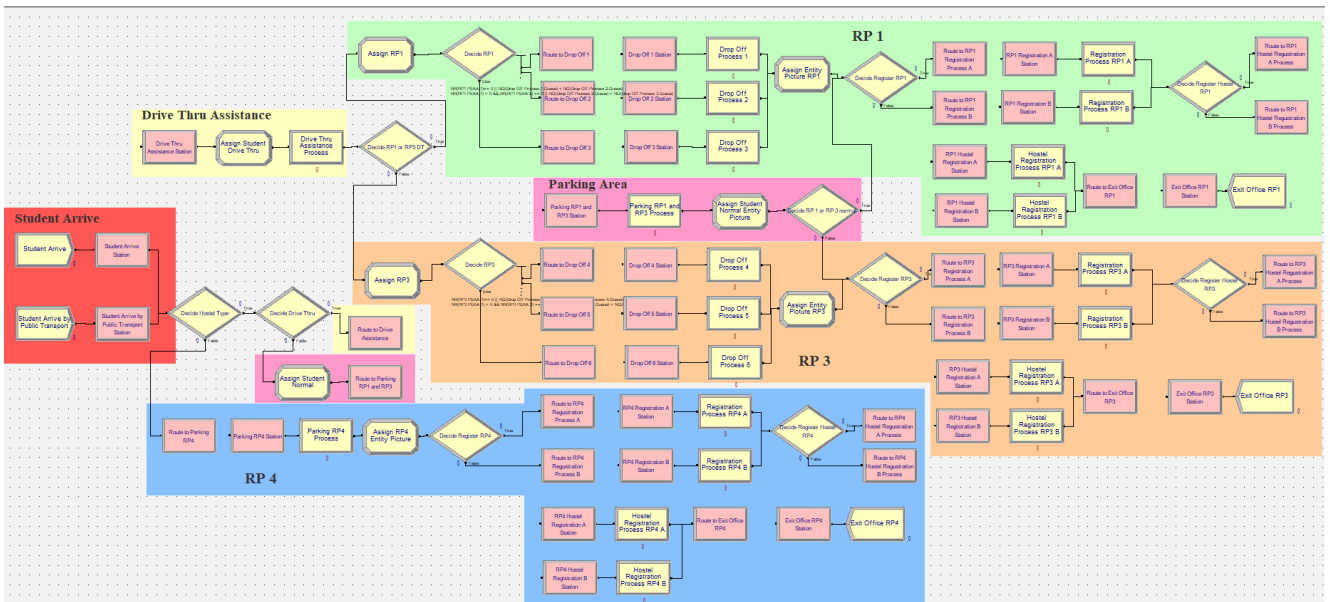


Figure 8. Model logic of student enrolment process at UMPSA

4.2 Animation of Student Enrolment Processes

Figure 9 presents the enrolment of students visually in an animated manner. It encompasses the whole process from the arrival of the students to the campus, which has clear pathways for both drive-thru assistance and parking. The animation also describes the drop-off process of female students assigned to RP1 or RP3 and the registration and hostel registration processes. It also shows the proportion of male students to RP4 who arrive at their hostels after the registration and hostel registration processes.

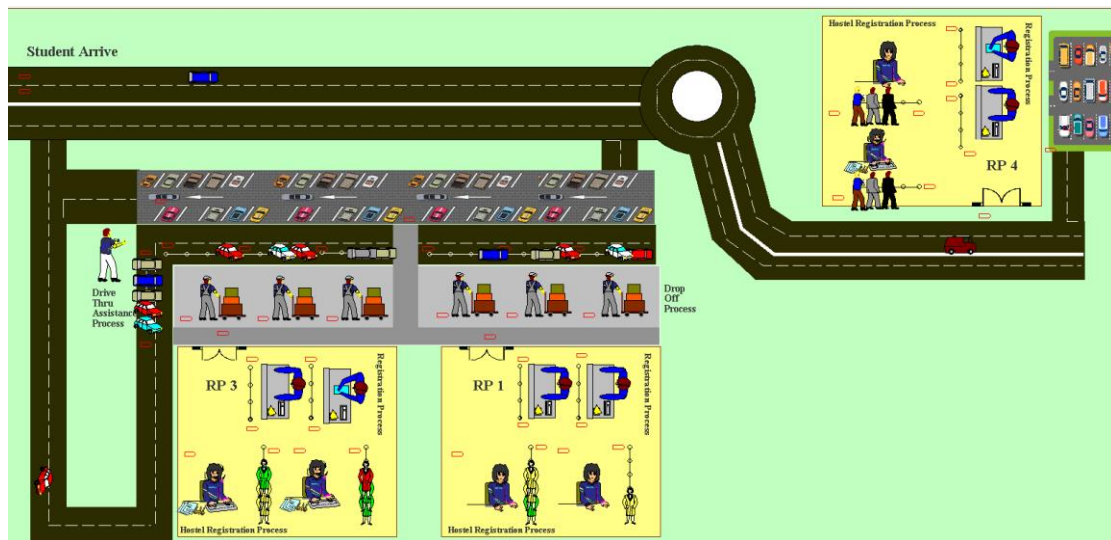


Figure 9. Animation of student enrolment process at UMPSA – base case

4.3 Base Case

4.3.1 Queue Waiting Time (Minutes)

This metric reflects the average time that a student spends waiting in line at each registration counter (see Table 2). In the base case, the queue waiting times for hostel registration are significantly high across all hostels. For Hostel Registration RP1, the waiting times are 18.623 minutes for Section A and 22.59 minutes for Section B. At RP3, the waiting times are 16.69 minutes for Section A and 22.11 minutes for Section B. For RP4, the waiting times are 18.02 minutes for Section A and 18.96 minutes for Section B.

4.3.2 Number of Students in the Queue

Table 1 represents the average number of students waiting in line at each counter. The base case shows a significant number of students waiting in queues. For Hostel Registration RP1, Section A has 5 students waiting, while Section B has 6 students. For RP3, the number of students waiting is 5 for Section A and 5 for Section B. Finally, RP4 has 6 students waiting in Section A and 6 students in Section B.

4.4 Verification and Validation

4.4.1 Verification - Face Validation

The verification process involved holding an interview with the Deputy President of PEKA 1 to elicit relevant evidence and experience with the current system. The verification results confirmed the model's fidelity to the enrolment process as it occurs in reality. She expressed insightful feedback on the flow charts and data for student arrival rates and service times, judging them as representative of the actual operations. The assumptions about peak times and resource allocation in the model were also validated, which guarantees the model's reliability for further analysis and decision-making.

4.4.2 Validation - Mean Absolute Percentage Error (MAPE)

The MAPE value for the base case was calculated at 11.9631, which indicates a moderate level of predictive accuracy in the simulation model. A MAPE value below 10% typically represents a highly accurate model, while values between 10% and 20% indicate reasonable accuracy. Thus, a MAPE value of 11.9631% suggests that the simulation has a satisfactory level of precision but could benefit from further refinements to enhance its reliability. To calculate the MAPE, the actual number of students, which is 978, is compared to the forecasted value of 861. For this case, the MAPE is calculated as:

$$MAPE = \frac{|978 - 861|}{978} \times 100 = 11.9631\%$$

This shows that the difference between the predicted and the real number of students is within 11.96%, which is acceptable.

4.5 Scenario 1

The base case output problem is associated with excessive queuing times and a high count of students waiting in queue. These indicate poor efficiency in the existing system, especially at the hostel registration counters where limited staff availability creates bottlenecks and delays, causing frustration for students.

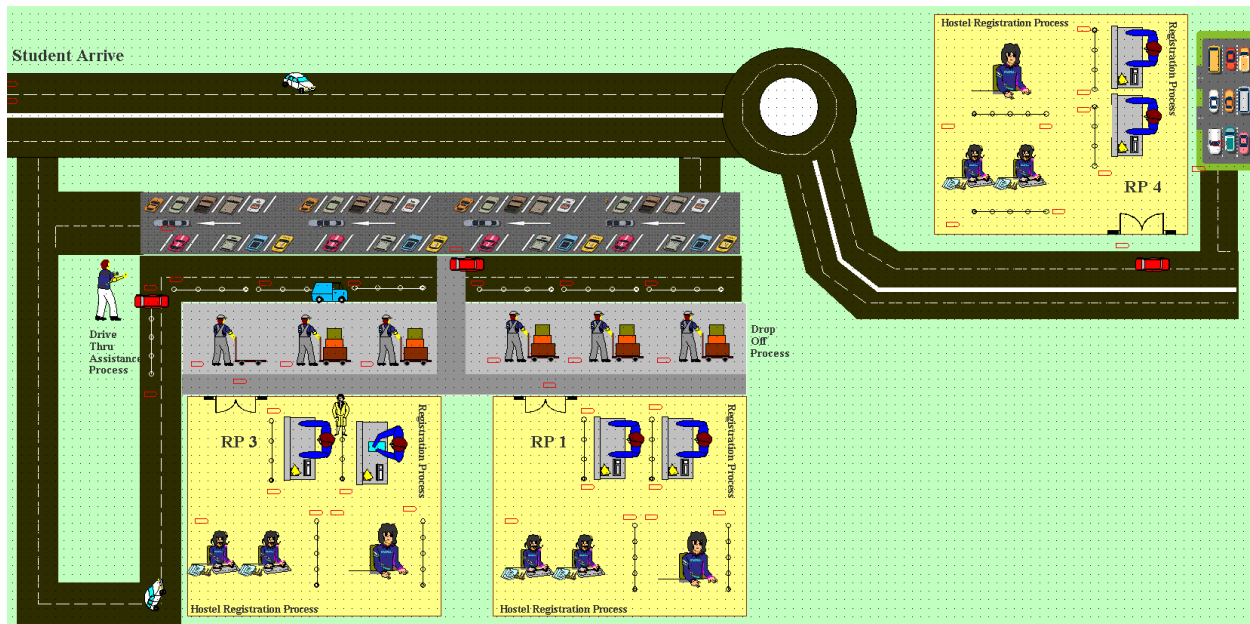


Figure 10. Animation scenario 1 of student enrolment process at UMPSA - additional one staff

To address this issue, Scenario 1 introduces one additional staff member at the hostel registration counters of RP1, RP3, and RP4. This strategic decision aims to enhance service efficiency and reduce waiting times for students (see Figure 10). It represents the enhanced flow of the student enrolment process under this new arrangement, showcasing how the addition of staff impacts the overall system.

4.5.1 Queue Waiting Time (Minutes)

Table 2 represents Scenario 1, which has significantly high reductions in queue waiting times. For Hostel Registration RP1, the waiting times decrease to 1.36 minutes for Section A and 0.94 minutes for Section B. Likewise, RP3 also depicts an improvement in waiting times with 1.77 minutes in Section A and 1.24 minutes in Section B. Similar improvement in waiting times is also exemplary in RP4 with 2.09 minutes in Section A and 0.96 minutes in Section B.

4.5.2 Number of Students in the Queue

In Table 2, a significant improvement can be observed in Scenario 1. For Hostel Registrations RP1 and RP4, the number of students waiting in both Sections A and B is 0, indicating no queues in these sections. RP3 also denotes a substantial improvement in the number of students waiting, with 0 in Section A and only 1 student in Section B. The metrics offer valuable insights into the performance of the student enrolment process, particularly focusing on queue waiting times and the number of students waiting at various hostel registration counters. Furthermore, Table 2 presents the key performance indicators for the student enrolment process by comparing the base case with Scenario 1. It focuses on three main metrics: number of students, queue waiting times, and the number of students in the queue at various hostel registration counters. These metrics reflect the effectiveness of the resource allocation and process improvement introduced in Scenario 1, which has led to the reduction of waiting times and student crowding at the counters.

Table 2. Key performance indicators

Metrics		Base Case	Scenario 1
Number of Students		861	929
Queue Waiting Time (Minute)	Hostel Registration RP1 A	18.623	1.359
	Hostel Registration RP1 B	22.586	0.940
	Hostel Registration RP3 A	16.685	1.768
	Hostel Registration RP3 B	22.105	1.235
	Hostel Registration RP4 A	18.023	2.087
	Hostel Registration RP4 B	18.959	0.957
Number of Students in the Queue	Hostel Registration RP1 A	5	0
	Hostel Registration RP1 B	6	0
	Hostel Registration RP3 A	5	0
	Hostel Registration RP3 B	5	1
	Hostel Registration RP4 A	6	0
	Hostel Registration RP4 B	6	0

4.6 Discussion

The increasing number of student enrolments over the years has imposed prominent challenges to the university, such as long queues at the main registration counter and uneven distribution of workload among staff. These inefficiencies contribute to delays and dissatisfaction among students while creating general pressure on the enrolment process. Therefore, this study aimed to improve the efficiency of enrolment processes through DES by using the ARENA software for modelling the analysis of the present processes and suggesting improvements. The comparison of the base case and Scenario 1 shows significant improvements in the efficiency of the enrolment process. Waiting times recorded significant reductions in the base case by up to 90%, evidently suggesting that the targeted allocation of resources leads to improved performance at individual counters and optimizes the process overall. Queue lengths also showed considerable improvement. In Scenario 1, however, the average queue size at RP1 and RP4 went down to zero students, thus putting an end to the evidence of overcrowding. Similar reductions in queue lengths were seen at RP3, which advocates the added staffing to address the bottlenecks.

These findings are consistent with earlier findings and further strengthen the argument that increased staffing reduces congestion and improves the flow of operations (Amelia et al., 2021). The enhancement in Scenario 1 emphasizes the importance of allocating resources for managing high-volume processes like student enrolment. As highlighted by Oluwatobi Arikawe et al. (2024), strategic resource allocation in such processes is crucial for overcoming bottlenecks and improving overall efficiency. Such findings confirm that all these bottlenecks at critical counters were some major areas where inefficiencies existed and they could be solved with minimal interventions. Through effective strategic deployment of extra staff, the service delivery at UMPSA was improved to reduce students' waiting times and queue lengths. These results substantiate the importance of tackling specific problems with petty yet strategic interventions. Potent areas, such as waiting times and queue lengths, are high-impact areas for UMPSA to enhance its service delivery in terms of a more effective, pleasant, and student-centered experience during enrolment. This study has successfully achieved all the objectives. The first objective of the study—to develop a simulation model of the university student enrolment process—was achieved by considering event-discrete simulations, including important parameters, such as queue waiting time and queue lengths. The second objective—the evaluation of the enrolment process—was achieved by identifying the areas of inefficiency, namely very long waiting times and some bottlenecks at critical counters. Finally, the last objective—recommendations for improvement—was achieved through Scenario 1, which demonstrated that additional staffing considerably reduced waiting times and queue lengths.

5. CONCLUSION

This investigation highlights the challenges related to inefficiencies in the admission process of prospective students at UMPSA and suggests that DES techniques can aid in overcoming these problems. Upon modeling and examining the processes, the study found some critical issues causing most of the delays, especially at the hostel registration counters, and offered a feasible solution by increasing the number of workers. As a result, wait times were almost eliminated as demonstrated in Scenario 1, and the total number of student pass-throughs was higher than in the previous circumstances. This demonstrates the importance of resource-oriented simulation modeling within the systems for the diagnosis of problems and alterations in the type and amount of resource allocation within operational systems. This study enhances UMPSA by providing DES-oriented strategies, which are implementable to improve student enrolment procedures. For example, the focus on the consumption of operational resources was improved by optimizing processes and the increase in staff can significantly reduce waiting times, thus creating a smoother queue during registration and improving student satisfaction. These findings serve to streamline operations and offer a better service to the increasingly heavy student load in UMPSA.

These findings have two implications. First, it practically provides a guide for UMPSA to follow in improving its enrolment-day registration processes. Second, this study contributes to the knowledge development of DES and how it can be used to enhance service processes in educational situations, thus impacting operational efficiency and student satisfaction. It also lays the groundwork for future research in even more intricate systems. Nevertheless, this study has several limitations. First, it is restricted to the UMPSA Gampang campus only and does not consider the Pekan campus. This may limit the generalizability of the findings to other campuses or institutions. The DES model also relies purely on static data rather than real-time data, which can potentially influence the accuracy of prediction in dynamic, rapidly changing environments. These limitations underscore the need for further studies to include aspects such as digital transformation and hybrid systems that employ human and automated resources together.

Finally, this study reveals additional paths for future research to build upon by examining the digital transformations of the student enrolment process or by integrating hybrid solutions that combine human resources with automation. It would also be beneficial to incorporate real-time data in DES models to allow certain adjustments in institutions depending on changes in the enrolment processes. Such developments shall improve the operational efficiency of the organization and enhance internal processes to provide students with a better experience, which is in line with institutional operations and the current trends in the higher education sector.

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AUTHORS' CONTRIBUTION

Each author was involved and contributed evenly to this manuscript. All authors read and approved the final manuscript.

AVAILABILITY OF DATA AND MATERIALS

The data supporting the study's findings are available on request from the corresponding author.

ETHICS STATEMENT

This study was conducted in accordance with ethical standards and all required approvals were obtained from relevant institutional review boards. Informed consent was obtained from all participants.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest regarding the publication of this manuscript.

GENERATIVE ARTIFICIAL INTELLIGENCE DECLARATIONS

The author(s) declare that no generative AI or AI-assisted technologies were used in the writing of this manuscript. All content, including text, figures, and tables, was created by the author(s).

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