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Smart parking strategies: Enhancing student experience at Universiti Utara Malaysia

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ABSTRACT

Parking is an important aspect of campus transportation, particularly at Universiti Utara Malaysia (UUM), where an increasing number of students choose to commute by car. The increased demand for parking spaces has compelled the institution to gradually tighten restrictions on on-campus student parking. In response to this challenge, this study conducted a comprehensive analysis of UUM's parking facilities. The study examined the saturation levels of key parking lots across campus, strategically placed near academic buildings, offices, and other essential facilities. Demand and supply calculations on parking spaces in UUM were conducted. In addition, 317 students were asked on their perception of the parking service and system. Finally, a decision matrix solution was proposed to provide a potential alternative solution on the parking problem. Beyond a mere assessment, the study aimed to produce actionable insights that can be used to inform the development of policies and strategic plans, fostering improved resource allocation, leveraging technology for increased efficiency, and facilitating infrastructure development to relieve the strain on the university's parking facilities.

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1.0 INTRODUCTION

Planning for campus parking has long been seen as a significant land use issue. Finding a parking spot in locations with high traffic for academic, administrative, residential, and recreational activities is a challenge that is understood by anybody who drives a car. The lack of parking places close to activity centres has worsened as more people on campus own and register cars (Brown-West, 1996). The issue of parking is an everyday concern experienced by individuals living in urban geographical areas. However, because it is the hub and the main campus, UUM in rural locations also has parking issues. During the peak hours, finding a parking space is an exceedingly challenging task.

Universiti Utara Malaysia (UUM) is a public management university located in Sintok, Kedah. Recently, in 2023, UUM received 3,879 new students, comprising local and international students, who attended 48 bachelor's degree programmes for the 2023/2024 session. This has increased the number of students from the usual capacity. The total number of UUM students until March 2023 was 26,924. Meanwhile, until October 2023, it was 30,803. The university provides full accommodation to students including postgraduate students. The name of the student residence is Inapan Siswa (Inasis). But, starting in 2023, the number of student admissions is increasing, causing the capacity of student accommodation in Inasis to decrease. As an initiative and facility for students who do not have accommodation in Inasis, the Student Accommodation Centre (SAC) has provided an off-campus area as a new community.

There are three types of off-campus areas, namely, Sisiran Sintok, Taman Universiti, and Sisiran Naib Canselor. This new community is known as Perumahan Universiti. Therefore, students who do not get to stay in Inasis can apply to settle in Perumahan Universiti. With this initiative, it helps solve the students' problem finding rental houses and so on. However, all services provided to students in Inasis are also available to off-campus students, including shuttle bus services. Because the bus service is still at a slow pace, the tendency for off-campus students to self-drive in the campus area is high. This is one of the causes that leads to the problem of this study. Student and staff parking areas are the two types of parking services that UUM offers. There is an open space where students can park. This has made it possible for staff members and guests to use the parking lots in addition to the students. This has led to a problem where most students believe that UUM's parking lots are insufficient. More challenging when there are no available parking spaces before rush hour. If the parking spaces are crowded, some students occasionally just park their cars close to the edges, especially in the early morning and afternoon as long as they are not blocking anyone's car.

Fig.1. Crowded parking

Fig.2. Green-coloured signs show the "Zone B Student"

Sintok Campus is a major campus and has a large population. As a result, the campus has several lecture halls, with seven primary lecture hall collections: DKG1, DKG2, DKG3, DKG4, DKG5, DKG6, and DKG7. Lecture Hall 1 (DKG1) is located between Faculty of Accountancy and Social and Human Development buildings. Next to Faculty of Accountancy is DKG2. Additionally, DKG3 is close to the Kafe Hijau Kuning area, while DKG4 is situated next to Faculties of Information Management and Technology. DKG5 is located close to Faculty of Public Management and Law, Finance and Banking, and Architecture, and it is newer than other lecture halls. SQS, STML, SMMTC, and foundation students are covered in DKG 6. Last but not least is DKG7, which is off-campus and mostly consists of SOIS and STHEM students.

The staff members have parking areas that are exclusive to them and difficult for outsiders or students to access. More specifically, there is a parking barrier that requires the card to pass through the area. This ensures that the staff will not interfere with the student parking area. However, some staff areas are unbarred and share the same open space as the student area. For example, in the parking lot of DKG3, the staff-only parking spaces are unbarred and simply labelled with the sign "Zone A Staff." This provides opportunities for students to use the parking there, especially when there is no available parking, leading them to get to class late. Consequently, this may lead to a risk of an accident due to driving from the opposite direction. Furthermore, some parking spots are situated a good distance away from the lecture hall. For instance, if there is no place left in the closest parking area, a DKG1 student will have to park at the lot of another school. Students dislike this because it forces them to park in distant parking lots, which is time-consuming and inconvenient. Avoiding campus parking congestion requires adequate parking spaces in designated lecture halls.

This study aims to assess the student's parking space management at UUM. The demand and supply of student parking lots in UUM were determined. Next is to identify students' perceptions on the serious level of certain parking areas on the UUM campus through questionnaire surveys, as well as to investigate potential alternative solutions based on the decision matrix method of reducing parking problems in UUM campus.

2.0 LITERATURE REVIEW

The issue of parking management on university campuses is a complex one, influenced by a range of factors. To tackle this problem, it is necessary to consider parking lot assignments, regarding intercampus users' needs. These users have different ages, physical characteristics, expectations, and administrative

positions that should be considered before any parking assignment. For this reason, parking needs to be properly controlled in all colleges. Diaz et al. (2020), Errousso et al. (2022), Tembhurkar and Khobragade (2015), Yang et al. (2024) and Parmar et al. (2020) highlight the increasing number of private vehicles and the challenges of finding adequate parking spaces. Nadimi et al. (2021) and Zhang and Frimpong (2021) proposed solutions, with the former introducing an optimisation model for campus parking and the latter emphasising the need to consider unique campus policies and planning parameters. These studies collectively underscore the need for a comprehensive approach to addressing the parking problem, one that takes into account the specific needs and characteristics of each campus.

A number of studies have explored mathematical models for optimising parking on university campuses. Liu et al. (2021) introduced an institution-based model to maximise land use, while Filipovitch and Boamah (2016) developed an economic model to minimise parking supply surpluses and shortages. Tembhurkar and Khobragade (2015) focused on forecasting parking demand, particularly in Indian institutional campuses. Adewumi (2014) proposed the use of heuristic algorithms for parking space allocation, with the particle swarm pattern search algorithm showing the most promise. The NI-ND algorithm solutions in a case study of Beijing, China by Zhao et al. (2021) are extremely close to the optimal objective, suggesting that the dual bin-packing principle-based shared parking allocation method is a practical means of addressing the realistic supply-demand relationship of parking resources under time-window constraints. Two linear integer programming models are put forth by Errousso et al. (2022) to maximise parking occupancy while allocating parking spots to all users of the road, including carriers and private automobiles. To analyse where these systems have developed, Diaz et al. (2020) looked into the different kinds of smart parking systems (SPS) that are available as well as the kinds of vehicle detection techniques (VDT) they had and the algorithms or other methods they employed, while Todorović et al. (2022) formulated the Methodology to Reframe Organisations into Smart Organisations (MORSO) approach. Elomiya et al. (2023) optimised parking recommendations on the Pardubice University campus. The model uses fuzzy logic to handle vague concepts, which allows for adaptability. These models collectively offer valuable insights for campus planners and administrators seeking to improve parking efficiency.

To simulate users' responses to policies like the introduction of new transport options or the imposition of fees for on-campus parking, Dell'Olio et al. (2019), conducted a study at University of Cantabria, Spain campus and suggested a methodology based on a revealed and stated preferences survey. The methodology's goal is to estimate the importance of various variables on users' mobility choices, and a mixed logit model was used for this estimation to account for potential user preference heterogeneity. They were also able to determine the ideal parking fee that should be paid to minimise the number of open spaces on campus or to maximise the amount of money collected by incorporating these results into an optimisation model.

In addition, the studies explored the challenges and potential solutions for parking management on university campuses. Aalsalem (2017) and Barde et al. (2022) both emphasised the need for improved parking systems, with Aalsalem proposing a smart monitoring and management system and Barde focusing on restructuring and surveying parking arrangements. Litman (2020), as well as Kirschner and Lanzendorf (2020) highlighted the importance of integrated parking management policies and the need for improved planning and management strategies. Parking management helps universities make better use of their existing parking capacity by adopting more organised and sophisticated strategies. This approach has been proven to have positive impacts, such as reducing demand for parking spaces, social equity, improving service efficiency and quality, and saving costs (Aoun et al., 2013). Kök et al. (2022) reviewed the matter of environmentally friendly campus transport and assessed Middle East Technical University's policies. The same topic on environmental and personal health was also covered in a study conducted by Ruiz (2021) at University of Texas, El Paso.

Dell'Olio et al. (2014) suggested promoting sustainable mobility through policies, such as managing parking spaces, implementing a bike-sharing system, and providing shuttle buses. Similar to UUM, some nearby colleges offer shuttle bus services on their campuses. When students use the buses that are offered, the demand for car parking spaces is decreased, and they can also save money because they will not have to pay for petrol. Because of this, the administration must upgrade the shuttle buses in light of the growing number of students enrolled on campus. On the other hand, independent learners who live off campus tend to drive themselves rather than use the bus. Shoup (2016) suggested balancing parking supply and demand by implementing performance-based pricing. All of these studies demonstrate how critical it is to tackle the parking issue on college campuses from a variety of angles.

A study conducted by Dehghanmongabadi and Hoşkara (2018) looked at previous research and data from a real case study to come up with a way to get college students to use active transport to get to and from classes. Physical infrastructure and services that are easy to use, comfortable, and well-designed can help motivate people (Ramli & Zain, 2018; Nwuke & Nwanguma, 2024). Moore et al. (2020) discovered that lowering bus travel times and increasing parking permit costs were useful in lowering the number of commuters who drive single-occupancy vehicles. Considering how the infrastructure and services affect transport is a good start, but it is not enough. An authoritative transportation management structure to define appropriate strategies based on existing conditions and user demands is necessary to plan and provide higher quality, more coordinated, more sustainable, and better-utilised campus transportation services. Moreover, implementing strategies to limit the use of private automobiles and to support existing users of active modes of transportation will encourage more commuters to shift to active modes of transportation. Furthermore, employing transportation-education strategies through workshops and seminars expands awareness and knowledge of the advantages of commuting by active modes of transportation. Menini et al. (2021) stated that a sustainable transportation system requires an investigation into the use of nonmotorised modes of transportation, particularly walking and cycling.

Nowadays, sustainable mobility is a main challenge addressed by policy-makers, public managers, and scholars worldwide. A set of guidelines and solutions to support the design of a more sustainable mobility plan have been implemented for Qatar University (Azzali & Sabour, 2018). The concept of sustainability, which has become increasingly important in every aspect of life, has become a topic that is often emphasised for university campuses, which can be considered a small urban model. Many universities in Turkey and abroad are working on sustainable campuses. They set many environmental, social, and economic targets, such as reducing the carbon footprint, using green technologies, designing by human and environment-oriented principles, using green transportation systems, reducing costs, and eliminating social injustice (Kalayci et al., 2021). At University of Cantabria in Spain's Las Llamas Campus, a set of mobility policies has been implemented to encourage the use of more environmentally friendly alternatives to private vehicles on campus and in the surrounding area (Dell'Olio et al., 2014).

This problem can be fixed by adding parking management to the smart campus. The goal is to help match drivers with available parking spots, which will save time, make better use of parking spaces, lower management costs, and ease traffic. Majeed and Ali (2018) conducted ground-breaking research that used Internet of Things (IoT) technology to establish the groundwork for the creation of a university smart campus. IoT Raspberry Pi-based parking management system (IoT-PiPMS) uses real-time vision and GPS data to make it easy for staff and students to find open parking spots through a smartphone app. The use of multiple sensors to identify the presence of vehicles has made the system more reliable, according to Jabbar et al. (2021). Alam et al. (2018), Nagowah et al. (2019), and Hossain et al. (2019) also explored the topic through extensive research efforts on IoT-based smart parking systems. Marouane et al. (2022) implemented an IoT system to ensure uninterrupted traffic flow within the university. Additionally, a hybrid Vehicle Routing Problem (VRand Multi-depot Vehicle Routing Problem (MDVRP) solution respects priorities and distributes parking lots fairly amongst visitors.

The parking issues can be rather complex. Efficient parking management is a crucial component of campus planning given the limited number of spaces available, the effects on campus traffic flow, and the environmental impact. The research under review shows that there is a rising recognition of the need for creative solutions, from technology-driven strategies to sustainable design concepts. Prioritising a comprehensive and flexible strategy for parking management is essential for creating a more effective, sustainable, and user-friendly campus environment as institutions grow and change.

3.0 METHODOLOGY

Three objectives are stated for this parking management system. It is necessary to create a solid approach to accomplish all those goals. There are three hypotheses related to this, which are:

H_1: The demand and supply of parking spaces are sufficient.

H_2: Students believe that the campus parking management needs to be improved.

H_3: Decision Matrix Solutions offer strategies to lessen the parking issue.

3.1 Demand and Supply for Parking Spaces

Determining the total quantity of parking spots available on campus (demand):

Demand can be assessed by acquiring an accurate count of parking spaces by consulting the campus plan drawing. Subsequently, it is possible to proceed to the selected area and systematically tally each encountered parking box. P_DKG is used to label the parking lot located near the lecture halls. In this study, there were seven identified parking spaces. Each parking lot was labelled as follows:

P_DKG 1: The parking spaces are located near Pusat Bahasa (CAS) and TISSA.

P_DKG 2: The parking spaces are close to UUMIT and SBM (COB).

P_DKG 3: The parking spaces are located between Kafe Hijau Kuning and SAPSP.

P_DKG 4: The location is at SOC.

P_DKG 5: The parking spaces are located at COLGIS.

P_DKG 6: The parking spaces are close to Pusat Pengajian Asasi.

P_DKG 7: The location at SOIS and STHEM lecture halls

The quantity of parking spots was then determined by the number of automobiles and motorcycles.

Determining the overall count of campus car users (supply):

Students and staff represent the majority of denizens at UUM. For the calculation, it is necessary to have the following information:

- The overall number of students
- The number of students in the current semester
- The number of students who have registered their vehicles
- The number of staff's registered vehicles

Next, the total number of vehicle users for the current semester was obtained. For example:

x = number of students on the campus for the current semester

y = number of overall students

The percentage of students in the campus (%) = (x/y) × 100;

The number of students who own the vehicles for the current semester = (x/y) × 100 × number of students who registered their vehicles

The total number of parking spots and the number of users were compared to see if there are enough places for every car user. If there are fewer users, it indicates that there are enough parking places at UUM, matching supply with demand.

3.2 Students' Perception

The questionnaire aims to gather students' perceptions and opinions on the parking issue. Students obtained the survey via Facebook, Telegram, and WhatsApp applications. The purpose of this survey is to collect data, mostly from students. A statistical calculator using a 90% confidence level and a 5% margin of error suggests that the total number of 268 respondents is an adequate sample size. Based on Bakhtiar & Darul (2015), there are 11 basic questions, including two on demographics that comprise the survey, leading to our study title. Note that it was adopted from Bakhtiar & Darul (2015).

3.3 Decision Matrix Solutions

There is a list of all potential fixes for the parking issue. To demonstrate a solution's efficacy, all designs and computations are provided. The next step is to compile these mentioned solutions into a decision matrix. The choice matrix is meant to verify if the solutions are appropriate. Six factors are typically considered: price, time needed, difficulty of implementation, ease of maintenance, length of solution, and human acceptability. As a result, the scoring system is based on the following ranking:

Factor	Ranking
Cost	Lowest (5) to highest (1)
Time required	Shortest time (5) to longest time (1)
Implementation difficulty	Easy to implement (5) to hard to implement (1)
Ease of maintenance	Easy to maintain (5) to hard to maintain (1)
Duration of solution	Used for long term (5) to use for short term (1)
Acceptance by people	More (5) to less (1)

4.0 RESULTS AND ANALYSIS

4.1 Demand and Supply for Parking Spaces

Table 1 shows the number of parking spaces in a certain area for cars and motorcycles. A majority of the space is open to the public, while several portions are off-limits to students. The UUM Development and Maintenance Department is where this data is collected.

Table 1. Number of parking spaces for cars and motorcycles

Parking Area	Type of Vehicles		Description
	Car	Motorcycle	
P_DKG 1	0	12	Student, Staff & Visitor
P_DKG 2	103	292	Student, Staff & Visitor
P_DKG 3	77	0	Student, Staff & Visitor
P_DKG 4	77	25	Student, Staff & Visitor
P_DKG 5	103	14	Student, Staff & Visitor
P_DKG 6	161	135	Student, Staff & Visitor
P_DKG 7	67	59	Student, Staff & Visitor

Total number of car parking spaces for students = 588 spaces
Total number of motorcycle spaces for students = 537 spaces

The UUM students fall into three categories: foundation, undergraduate, and postgraduate. Table 2 lists all the enrolled students at this university, including those on semester breaks and those enrolled in internships. It also shows the total number of students (excluding those in the internship programme) registered for the current semester's session A231. This data was supplied by the Department of Academic Affairs. Please note that the information is current as of October 2023.

Table 2. The total number of students and the number of students in the current semester

	Groups	The number of students	Total students(100%)
The total number of students	Foundation	210	32,190 students
	Undergraduate	26,558	
	Postgraduate	5,422	
The number of students in the current semester		22,831	22,831 students

The data is taken from the Development and Maintenance Department. Table 3 shows two categories of parking spaces: the number of overall parking spaces, and the number of student parking spaces.

Table 3. The number of parking spaces

	The number of parking spaces		Total spaces (100%)
	Cars	Motorcycles	
The number of overall parking spaces	1,993	1,033	3,026 spaces
The number of student parking spaces	588	537	1,125 spaces

The data is taken from U-Assist. Table 4 shows the number of students who own vehicles in the current semester by using the ratio method.

Table 4. The number of students who own vehicles in the current semester

	Types of vehicles	
	Cars	Motorcycles
The number of student's registered vehicles	2,043 units	808 units
Percentage of students on campus	(22,831/32,190)×100 = 71%	
The number of students who own vehicles in the current semester	(71%)×2043 = 1,450 students	(71%)×808 = 573 students

The Security Department is the source of the information. Using the ratio method, Table 5 displays the number of staff members on campus for the current semester.

Table 5. The number of staff on campus for the current semester

	Types of vehicles	
	Cars	Motorcycles
The number of staff's registered vehicles	3,912 units	879 units
	Each staff member owns either 2 cars or 1 motorcycle (2:1)	
The number of staff on campus for the current semester	3,912/2 = 1,956 staffs	879/1 = 879 staffs

To determine whether the parking spaces are sufficient or not, it is then calculated through the total vehicles used in the current semester as shown in Table 6. The used equations are as follows:

The total vehicles used in the current semester = The number of students who own vehicles in the current semester + The number of staff on campus for the current semester.

Table 6. Total vehicles used in the current semester

	Types of vehicles	
	Cars	Motorcycles
Total vehicles used in the current semester	1,450 + 1,956 = 3,406 unit (Maximum number of parking spaces is 1993)	573 + 879 = 1,452 units (Maximum number of parking spaces is 1,033)

The data indicate that there is a greater demand for parking spaces than there are available spaces for both vehicles and motorcycles. It can be said that 71% of the number of inadequate cars and 41% of the number of inadequate motorcycles from the number of parking spaces provided. However, from this study, it was aware that not all staff use all parking areas. This is because the staff have their own department, in which each department has a special parking space for them. For example, there are a lot of places to use for the staff who are working in the UUM Convention Centre and Counselling Building areas. Also, most of the staff only use the parking areas at these places. Therefore, those on duty in those areas do not suffer from parking inadequacy.

Additionally, the area is located away from the lecture hall areas, resulting in fewer students using the parking lots there, unless they have a significant business. But it still does not cause any problems. Thus, parking problems only occur in some places especially at the areas near the lecture halls. However, it remains an issue with the inadequacy of parking if it relates to the vehicle stickers for the staff. For example, by estimating the staff in the areas, this only comprises 20% of the overall number of staff's stickers. It still raises issues of inadequacy in parking.

Mathematically, it is logical why there are problems with the inadequacy of parking on campus. But are all parking spaces not enough? The parking spaces such as those at P_DKG 2 have many parking spaces, especially parking for motorcycles with a total of 292 spaces. Compared with P_DKG 1, only 12 parking spaces are available for motorcycles and no parking space for cars is provided to students, except a barrier parking system for the staff only. For this reason, there is a strong demand for parking in the area from users of vehicles and it is deemed necessary to be aware of.

4.2 Students' Perceptions

a. Questionnaire Output

This section discusses and presents the survey findings that were obtained to find out what the students thought about current parking management at UUM. The total number of respondents in this study was determined by considering the 22,831 students enrolled in the current semester. As mentioned in Chapter 3, 268 respondents are recommended as a sample size. However, 317 individuals responded to this survey, which was more than sufficient. Using this method enables us to make hypotheses and findings that apply to a wider group of people.

This section outlines the key demographic variables, semester, and college. According to a subgroup study based on semester groupings, respondents who are in semesters 7 and above are most in favour of this parking management issue, with 33.8% of them expressing this opinion. This is followed by 24.3% of the students in semesters 3 and 4, 22.7% of the students in semesters 5 and 6, and 19.2% of the students in semesters 1 and 2.

Our study's findings, which comprised respondents from all three colleges, demonstrate the strong support that this parking management issue has in general. This facilitates our understanding of the diverse perspectives maintained by these colleges. 33.8 % of the respondents came from COB, 25.2% were from COLGIS, and the remaining 41% were from CAS. For questions 1 until 8, the findings can be referred to in Table 7:

Table 7. Results of the questionnaire for Questions 1 to 8

No.	Question	Total (%)		
		Yes	No	Maybe
1	Do you bring your vehicle to campus?	126 (39.7%)	191 (60.3%)	0
2	Do you think UUM has a good parking management system?	96 (30.3%)	98 (30.9%)	123 (38.8%)
3	Do you think UUM provides a sufficient number of parking spaces on campus?	73 (23%)	159 (50.2%)	85 (26.8%)
4	A barrier parking system is a common system used to prevent other people from entering the parking area. Do you think it should be implemented more on campus?	166 (52.4%)	70 (22.1%)	81 (25.6%)
5	There are seven parking areas (DKG1, DKG2, DKG3, DKG4, DKG5, DKG6 & DKG7) provided on campus. Do you think UUM should build a new one?	180 (56.8%)	59 (18.6%)	78 (24.6%)
6	Do you agree if UUM makes an exception for students who stay outside of campus to use the staff's parking areas?	141 (44.5%)	107 (33.8%)	69 (21.8%)
7	In your opinion, is it necessary to reduce the number of vehicle users among the students on campus?	100 (31.5%)	144 (45.4%)	73 (23%)
8	Do you think UUM should encourage their students to cycle instead of using motorcars or motorcycles?	133 (42%)	95 (30%)	89 (28.1%)

Question 9: Which parking area on campus can be considered critical?

To answer this question, the respondents were free to choose as many critical parking options as possible. As a result, DKG 6 was ranked as one of the most important parking places by 195 out of 317 respondents that completed this questionnaire survey, as shown in Fig. 3. Furthermore, the DKG 1 parking area, with a 54.6% overall proportion, is considered essential. The respondents selected DKG 2, DKG 3, and DKG 5 as crucial parking areas, giving them respective scores of 38.2%, 36.6%, and 32.5%. Furthermore, DKG 4, which has just 180 parking spots accessible for cars because of its small size, was deemed a vital parking place by 30.6% of all respondents, followed by DKG 7 (28.7%) and other parking places (28.1%).

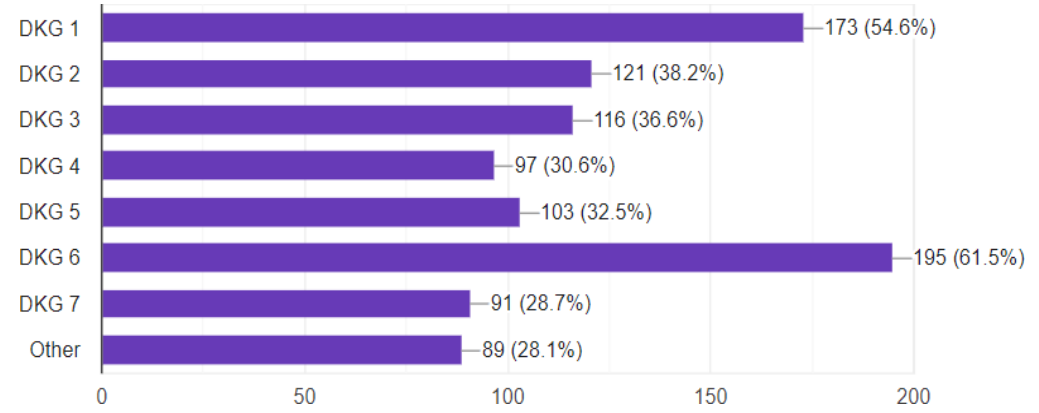

Fig. 3. Critical parking area on the UUM Campus

Question 10: In your opinion, why do some students tend to park their vehicles at illegal places?

Fig. 4. Illegal parking at P_DKG 6

The reasons stated by the respondents for why some students frequently park their cars at prohibited locations are listed in Table 8 along with some additional information.

Table 8. Respondents' opinions

Issues / Themes	Details
Insufficient parking lots	"No parking spaces are available", "they have no areas to park anymore", "lack of parking place", "there is no sufficient parking area", "students got less parking place", "because UUM provided more parking for staff even staff are not really", "Insufficient car park, but the parking for the staff is always vacant, too sufficient".
	According to them, apart from the barrier system areas used by the staff, there are also other areas available for the staff. The security guards (Security Department) have the authority to clamp the students' vehicles or sue them when they use the staff parking spaces. Students may have to park their cars at the staff parking lots or the yellow line areas when the designated student parking space is full.
Shorter distance to destination	"Rushing to class", "time-saving", "for their ease", "they are in a hurry", "because it is close to their destination", "shorter distance from parking to DKG", "sometimes the illegal places are nearby the class".
	Some classes are located far away from the lecture hall venue. It can take 5 to 10 minutes for students to walk from the parking spot to the class. So to shorten the time, students prefer to park their vehicles at illegal areas. They assume that as long as they do not obstruct and block other vehicles, they are safe. Staff parking nearer to the lecture hall also became a factor in driving them to do so. Save time, enjoy parking, and use lots of empty parking spaces.
Inadequate signage or vague regulation	"Not sure which parking space is for students", "to avoid car accidents and summon", "all the vacant parking spots are only for staff, which actually can be considered for the students to use, but we cannot and will be fined or clamped", "for their convenience. (selfish reason)".
	Some parking areas have been put up signs to distinguish between student parking and staff parking. There arealso unmarked areas, such as at DKG3 and DKG 4. This has confused students and staff. Nevertheless, they are either students or staff not taking this seriously as long as the opportunity they have used to park their vehicles. However, this will cause problems with the risk of accidents and road congestion.
Perceived emergencies	"Because they are in emergency".
	Emergency matters also prompt students to park at legal areas. Submitting assignments to lecturers and meeting with supervisors are among the typical reasons given by students. They are lucky not to be caught by the security. But it has broken the rule. Other reasons students use: security authorities are not always on guard in the area, and students should not worry about being summoned. The fact is, for them, it may be that their action will not be charged by the security guard, but it provides an accident risk to other users in the area.

b. Parking Area Observation

The observations were conducted on a significant number of working days. Even so, observations were conducted over the weekends, but the anticipated critical level was not met by the outcomes. Fewer students use parking on weekends unless there is an event on campus. The only observation was at P_DKG 6, where the parking area was considered the most critical. Table 9 shows the total of student parking spaces at P_DKG 6.

Table 9. The total of student's parking spaces at P_DKG6

Types of vehicles	Total of student parking spaces	Total spaces
Cars	161	296
Motorcycles	135	

P_DKG 6 was chosen for observation because it is one of the most critical parking areas, according to the survey respondents. There is a total of 296 parking spaces, including 161 for cars and 135 for motorcycles. This parking lot is near the STML building and Pusat Pengajian Asasi. It is also close to the SQS and SMMTC buildings. It is therefore possible that this parking area will become a critical area during peak hours.

This observation took place between 8 a.m. and 4 p.m. when students went to classes. Note that the normal class at UUM starts at 8.30 a.m. and ends at 5.30 p.m. Two observations were made for this parking lot in order to compare the critical parking level on weekdays and weekends. Weekend and weekday observational results are shown in Tables 10 and 11, respectively.

Four elements were taken for the observation which are in, out, net, and cumulative. For in and out, it is when the vehicle enters DKG 6 and moves out from DKG 6. Thus, the net is the vehicle that still stays in the same parking the next time observed. By subtracting the number of in and out, the net is calculated. Meanwhile,cumulative is the total of the net.

Table 10. The observation during the weekends

Time	Cars				Motorcycles			
	In	Out	Net	Cumulative	In	Out	Net	Cumulative
< 8:00 am	0	0	0	0	0	0	0	0
8:01 - 9:00 am	2	0	2	2	0	0	0	0
9:01 - 10:00 am	1	0	1	3	1	0	0	1
10:01 - 11:00 am	5	0	0	8	3	1	2	3
11:01 - 12:00 pm	0	0	0	8	0	1	-1	2
12:01 - 1:00 pm	2	3	-1	7	0	2	-2	0
1:01 - 2:00 pm	0	4	-4	3	0	0	0	0
2:01 - 3:00 pm	8	2	6	9	4	0	4	4
3:01 - 4:00 pm	0	9	-9	0	1	5	-4	0

Note: *Cumulative = Net before + Net after*

From P_DKG6, the parking lot associated with DKG6 becomes critical at certain times, particularly on weekdays; for example, from 10 a.m. to 1 p.m., and again from 2 p.m. until 3 p.m. This is because many students arrange their class schedules at DKG6 at that time. This could happen because many students choose to take a time break at that period and attend class after lunch and Zohor prayer. The most critical time for the car parking lot is at 2 p.m. when there are 214 cars parked but only 161 available parking spaces, as well as motorcycle parking places, which have only 135 spaces available but 144 motorcycles parked. This demonstrates that many vehicles park at prohibited areas, which may obstruct traffic and cause additional problems for others.

On weekends, this parking lot does not have any problems, either with cars or motorcycles. This is because students do not have any classes on weekends, except for special programmes that may take place during that time.

Table 11. The observation during weekdays

Time	Cars				Motorcycles			
	In	Out	Net	Cumulative	In	Out	Net	Cumulative
< 8:00 am	0	0	0	18	0	0	0	5
8:01 - 9:00 am	57	0	57	75	64	2	62	67
9:01 - 10:00 am	69	18	51	126	36	15	21	88
10:01 - 11:00 am	82	20	62	**188**	60	7	53	**141**
11:01 - 12:00 pm	118	141	-23	**165**	98	102	-4	**137**
12:01 - 1:00 pm	113	96	17	**182**	42	77	-35	102
1:01 - 2:00 pm	101	135	-34	148	33	62	-29	73
2:01 - 3:00 pm	195	129	66	**214**	112	41	71	**144**
3:01 - 4:00 pm	21	150	-129	85	17	86	-69	75

According to the observations, if the staff barrier system fails, many students choose to park their vehicles at the staff parking space because the student parking space is already full. It is also because the staff parking space has many available spots. In conclusion, this parking issue only occurs at specific times. Effective management can prevent this issue from recurring in the coming year.

4.3 Decision Matrix Solutions

A lot of potential alternative solutions are available from this study. Each of them has its ability to solve the parking problem. Here are six types of potential solutions that were suggested by the respondents and also adopted from Bakhtiar & Darul (2015). Among them are:

- Multi-storey parking system
- Bicycle facilities
- Shuttle buses
- Carpooling
- Restriction on the sticker requirement

Table 12 illustrates the use of a decision matrix for a solution to five potential alternative solution options with six factors considered.

Restriction on the sticker application requirement has been identified as the most relevant option with a score of 22 out of 30. Imposing it does not cost anything or need any maintenance. A majority of students agree that students who truly fulfil the prerequisites and criteria for off-campus students should be given precedence. Providing shuttle bus is the second-best alternative. A majority of students would rather take the shuttle bus due to its lesser cost than the bicycle facility. Consequently, UUM needs to enhance the bus shuttle service by augmenting the number of current shuttle buses and guaranteeing that the shuttle bus amenity is regularly utilised.

Based on the scores, carpooling may be regarded as an average option. It is incredibly economical, efficient with time, and has the potential to cut down on the number of cars on campus. Besides, with just 17 points out of a possible 30, the bicycle facility received the second lowest grade. UUM needs to supply additional bicycles to encourage students to ride their bikes on campus. Moreover, by offering a more

convenient and safe riding path, safety rates will rise. Lastly, the alternative solution of a multi-story parking system has become one of the respondents' choices even though the score is very low. This option is more suitable for long-term purposes due to its high cost, time required, implementation, and maintenance.

Table 12. Decision matrix for solutions

Solution	Multi-storey system	Bicycle facilities	Shuttle buses	Carpooling	Restriction on sticker application requirement
Cost	1	4	3	2	5
Time required	1	2	3	4	5
Implementation of difficulty	1	2	3	4	5
Ease of maintenance	1	2	3	4	5
Duration of solution	5	3	4	2	1
Acceptance by people	3	4	5	2	1
Total score (30)	12	17	21	18	22

5.0 CONCLUSION

Determining the campus's parking supply and demand is the project's primary goal. The parking supply is, mathematically speaking, greater than the demand based on the outcome. To be sure, there are still critical parking areas because there are not enough parking spaces in some locations. There may be a lot of parking spaces in certain places, but not enough in others. Parking locations with or without high demand could be determined by conducting a survey.

To achieve the second goal, a questionnaire survey was designed to find out what the respondents perceived about the parking issue on the UUM campus. Based on the basic evaluation, most respondents believed this campus's parking management needs improvement. In addition to addressing the present parking issue, effective parking management is essential for the future. Students claimed that they are forced to park illegally since they are unable to obtain parking spots, particularly during peak hours.

Furthermore, this survey allowed the participants to offer recommendations for developing a successful parking management system. Two parking lots were noticed, and they are in bad condition. For instance, the DKG 6 parking space is used for all, including students and visitors. The parking lot is full because there are thirty lecture halls where lectures are typically held simultaneously, excluding students from SCIMPA, SMMTC, SQS, and STML. Due to its location on the primary bus shuttle route, the parking lot presents an issue. Thus, drivers hurry to park to avoid disrupting the route of the bus. This is a critical issue that cannot be disregarded since improper management could deteriorate the parking lot over time. While the parking lots at DKG 1 may not be particularly important in terms of availability, many students frequently park at Alumni Junction since there is no space for students there due to limited space.

To decrease the quantity of unauthorised parking among them, this project ought to offer several remedies. The final goal is to offer strategies or solutions to lessen the parking issue. Five potential fixes are outlined in this section and could be applied on campus. All designs and computations are based on specified standards. In addition, a Decision Matrix table is created to assess the appropriateness of each stated solution. With a score of 22 out of 30, the Decision Matrix scoring system has determined that imposing restrictions on the sticker application requirement is the most pertinent choice. It does not require

any maintenance or cost anything to be brought in. Most students believe that priority should be given to those who meet the requirements and standards, especially off-campus students.

Only two of seven parking spaces are seen in this project. There are two causes for this which are human limitations and shortage of time. There may be extra parking spaces on campus if there is more time allowed. Additional parking areas that meet this criteria are all around the lecture hall, including a parking lot for staff. The data could yield more accurate results if more observations were made. In addition, it takes a lot of time to travel to the observation sites and gather data. In other locations, a camera is used to speed up the observation process. Installing cameras at each parking space allows them to simultaneously record every car movement. They only need to collect information from the captured videos. This method is far more practical because it saves time and allows for the observation of multiple locations. Even though there are enough parking spaces, better management and clearer information are needed to solve the student parking issues.

6.0 CONTRIBUTION OF AUTHORS

Nur Ainaa Maisarah and Siti Nabila carried out the research and wrote and revised the article. Masnita and Hasimah conceptualised the central research idea and provided the theoretical framework. Nur Ainaa Maisarah, Siti Nabila, and Zahayu designed the research, and supervised the research progress; Zahayu and Hasimah anchored the review, and revisions and approved the article submission.

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8.0 CONFLICT OF INTEREST STATEMENT

The authors agree that this research was conducted in the absence of any self-benefits, commercial, or financial conflicts and declare the absence of conflicting interests with the funders.

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