Parking Characteristics, Policies and Management: An Empirical Evaluation on Kumasi Technical University Campus

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Abstract

Kumasi Technical University has well-designed parking areas though demand exceeds capacity. If unchecked, the high vehicle population growth will worsen the problem. Most university parking facilities are evaluated from an operational perspective without considering policies and user perceptions that are equally important for efficient use and management. This study sought to improve Kumasi Technical University (KsTU) parking to meet user expectations through these questions: 1) What policies and plans guide parking provision and management on KsTU campus? 2) What are the perceptions of staff and students about the existing parking facility? 3) What is the pattern of parking on KsTU campus and to what extent does the parking facility meet the current demand? 4) What are the possible improvement strategies for parking facility on KsTU campus? Structured questionnaires, in-depth interviews and parking studies were employed to meet the study objectives. It was discovered that parking is managed by the Security Department without a comprehensive Parking Policy. Most respondents (57%) reported lateness to class while 39% reported parking outside due to parking space shortage. Interestingly, few parkers were satisfied with the parking spaces provided. Parking patterns varied by time of the day and day of the week. On typical weekdays, parking demand exceeded supply by 20-50% during peak periods. Improvement strategies recommended by respondents include banning storage parking, introducing parking permits, and coupling parking supply and course scheduling. This study may influence KsTU parking policies and management while helping university officials identify areas that need upgrade to improve the parking facility and meet user needs.

Keywords: *Parking; Demand and Supply; Accumulation; Turnover, Policy, and Management*

1.0 Introduction

1.1 Background

Parking remains an important component of every road transportation system in that each vehicular trip end requires an act of parking. This notwithstanding, this important phenomenon appears not to receive the needed attention during transportation planning and engineering design. As argued by Bates (2014), "there is a sense in which parking is taken for granted, and only managed or regulated when problems are apparent. In fact, as we shall see, the average car spends most of its life stationary (i.e., parked), while the concentration of transport analysts is on

the movement of cars". Universities rely on facility planners to build adequate parking capacity to support recruitment and staffing policies (Bridgelall, 2014). Tertiary educational institutions including universities are major trip generators that attract a wide range of visitors across different times of the day and year. As a major trip generator, universities within urban centres with space constraint coupled with limited on-campus housing (Riggs, 2014) and increasing vehicle ownership among the student and staff population overtime usually face parking challenges (Brown-West, 1996) including lack of available parking spaces to meet the demand, parking price, parking fines or quality provision (Ison & Mulley, 2014). Parking availability enables the daily interactions among students, faculty, and staff, but generates high fiscal and environmental costs (Riggs, 2014). A key objective for employers is to maximize their accessibility to employees but inefficiencies in parking at workplaces makes it difficult for the objective to be achieved.

Parking is a sensitive area that impacts on commuters, employers, and local authority decision makers who must manage this resource in an efficient and effective manner. Not only are inefficiencies in parking provided by institutions the consequence of lack of space but also the lack of a comprehensive and up-to-date parking policies, and management plans (Boob & Biswas, 2018; Dehghanmongabadi & Hoşkara2018; Wang and Zhou, 2010; Brown-West, 1996). It is therefore critical for educational institutions to develop parking operational management plans to enable them to manage parking effectively and efficiently on their campuses. Developing an effective parking plan requires knowledge and understanding of the existing performance of the facility to inform the decisions of university transport planners and managers in adopting and/or amending parking management strategies to utilize their existing parking infrastructure efficiently, or to accommodate expansions and increasing student enrolments (Department of Transport, 2017). Universities and corporate campuses therefore need to evaluate the operation and utilization patterns of the provided parking infrastructure as well as review the current approach to managing parking and supply. In most cases, parking facilities on university campuses are evaluated from only an operational perspective with a neglect of the user perceptions and guiding policies, which are equally important with regard to efficient use and effective management of the facility (Wiers & Schneider, 2022; Innes & Booher, 2004). As mentioned by dell'Olio et al. (2011), the formulation of transport policies, including new infrastructure, must consider users' expectations and perceptions that influence their travel decisions. Perceptions of users and policymakers vary significantly (Guzman et al., 2022; Chowdhury et al., 2018). As such, failure to consider the target population's needs and perceptions during decision making towards policy development, design and operational management can lead to poor cost-effective projects that do not meet demand expectations (Louw et al., 2013). At this point, it is evident that the evaluation of user perceptions allows designing policies that meet their specific expectations by identifying the factors that define the willingness to comply with planning outcomes (Beirão & Cabral, 2007).

The main goal of this study was to evaluate the parking provision on KsTU campus and identify areas for improvement by combining insights from objective measurement of the parking characteristics, and facility planners', managers', and users' perspectives. Specifically, this study sought to address the following questions: 1) What policies and plans guide the provision and management of parking on KsTU campus? 2) What are the perceptions of staff and students about the existing parking facility? 3) What is the pattern of parking on KsTU campus and to what extent does the parking facility meet the current demand? 4) What are the possible improvement strategies to improve parking facility on KsTU campus?

This study could be a useful source of information for future researchers who have interest in undertaking new case studies for improving the operations and management of parking facilities on other university campuses. Further, the study could provide a framework of strategies that could guide researchers as well as the decisions of university authorities and administrators towards developing local context parking policies and management plans to meet the users' needs.

1.2 Parking Policy and Management

Parking is a land-use which competes with other land-uses on university campuses as population grows (Zhang & Boamah, 2021). It however resides at the heart of an integrated land-use and transport strategy since it glues together the land-use and transport system (Marsden, 2014). As the number of vehicle ownership and demand of parking space increases on university campuses, it is important to put in place policies to effectively operate the facilities to meet the needs and expectations of users. Parking policies are operational documents which link parking supply with appropriate parking management strategies that focus on the approach of regulating parking and managing demand for the institution. Parking policy is used as part of the congestion and air pollution in cities (Marsden, 2014) and as argued by McCahill and Garrick (2014) it can be effective as a means of reducing overall demand for travel by car when applied in a consistent manner over the long term. The development of parking policy plans requires educational institutions to review their parking supply and utilisation, estimate future parking demands while incorporating the needs of all users.

The management of parking is a complex issue both in terms of its supply and demand. Provision of spaces to accommodate the potential demand for parking is both a financial and environmental cost to the employers (Riggs, 2014; Marsden, 2014). The parking demand at workplaces can be managed by on-site parking (which could either be free parking or paid and managed parking) and off-site parking. For these broad categories of parking, specific strategies as described by the report, *Parking Guidelines for Tertiary Educational Institutions*, 2017 could be deployed. These include but not limited to parking controls (e.g., time limit by location and parking pricing), communication of space allocation and other parking-related information to users, monitoring to understand whether utilization occurs as expected and lastly, enforcement of the defined parking controls and their associated penalties for non-compliance.

1.3 Parking Demand and Supply

A comprehensive transport policy that seeks to provide sustainable transport systems should encompass the provision and regulation of parking. There is therefore the need for an in-depth knowledge of the demand of parking. *Parking demand* represents the number of vehicles that desire to be served by the parking facility. The demand for parking in an area is influenced by several factors including but not limited to the rate of arrival, length of stay (Bates, 2014), time of the day, the type of parking facility, parking price and land-use. *Parking supply* on the other hand refers to the availability of a parking space at a particular time. An optimal parking supply (i.e., number of parking spaces required to meet the demand) is usually desired by planners. According to McCahill & Garrick (2014), most studies of parking supply and demand (e.g., Marshall and Garrick, 2006) reveal that existing supply is considerably underutilized. It is however worth mentioning that free or under-priced parking increases parking demand and total parking costs (Young et al., 2014; Litman, 2006) as operators have little incentive to efficiently manage the

parking facility. If the supply fails to meet the demand, vehicles may overspill the parking facility creating delays, congestion, and inconveniences.

On university campuses, however, parking demand most often exceeds parking supply as the population continues to grow with the provision of additional parking spaces competing with other land uses. With space and financial constraints in expanding parking facilities, some universities have explored other restrictive strategies and transport demand management strategies to reduce the parking demand or redistribute parking demand over time and space (Aoun et al., 2013; Yan et al., 2019; Stasko et al., 2013). These demand management strategies include bus/shuttle subsidizations, non-motorized infrastructure improvements, parking pricing, parking permitting, ridesharing, and carpooling programs, promoting cycling and walking (Aoun et al., 2013; Caicedo, 2010). One other interesting approach which has not been well exploited by universities but studied by Zhang and Boamah (2021) and Moradkhany et al. (2015) is integrating the information of course schedules in the planning of campus parking systems.

1.4 Parking Characteristics

Well-designed and managed parking facilities are marked to prevent parking at undesignated places and to allow for easy access and manoeuvring of vehicles in and out of the facility (Rathi & Patel, 2013). Within each type of parking facility, differences may be observed in terms of the parking orientation in relation to the flow of traffic or carriageway: parallel parking, perpendicular parking, drive-in angled parking, back-in angled parking. The angles could be 30-degree parking, 45-degree parking and 60-degree parking. Various factors including land size, terrain, vehicular width, and length are considered before setting up the parking orientation.

It is important to monitor the operations of parking facilities to determine their utilization level and possible strategies to improve operations. Several performance measures are necessary to be estimated and understood during the monitoring studies:

Parking accumulation: shows numbers of parked vehicles at specific times of the day and the distribution determines the peak accumulation and time of occurrence.

Parking volume: represents number of vehicles parked at a given time in the survey period.

Parking load: the total area under the accumulation curve at a time or the measure of total number of space hours used during a given time.

Parking duration: length of time individual vehicles park at a given time. When measured as an average, it gives an indication of how often a parking space becomes available. Parking charges are usually informed by length of stay of vehicle and can be broadly categorized into short-stay parking and long-stay parking (Hamer, 2012). In general, it is assumed that short-stay parking facilities (for shopping, medical visits, drop off someone) must be located close to final destinations while long-stay parking facilities (for work, recreation, travel among others) can be located at a distance (Van der Waerden et al., 2017).

$$\textit{Parking duration} = \frac{\boldsymbol{parking\ load}}{\boldsymbol{parking\ volume}} \quad (1)$$

Parking turnover: average number of times a parking space is used by different vehicles at a time or simply the number of vehicles per parking space per time. Parking turnover

relates to inflow and outflow of vehicles entering or leaving a parking space over a period (Shang et al., 2007). High turnover, as occurs in short-stay parking, increases the number of drivers parking over a set period, but simultaneously increases the volume of traffic entering/exiting a facility and may lead to congestion in the wider network locality.

$$Parking\ turnover = \frac{\boldsymbol{parking\ load}}{\boldsymbol{no.of\ bays\ available}} \quad (2)$$

Parking index: or parking occupancy is a measure of efficiency of the parking facility and is defined as the ratio of total number of vehicles parked at a time to parking facility capacity. It gives an indication of how effectively the parking space is utilized.

2.0 Methods and Materials

This study employed a mixed method approach by collecting both quantitative and qualitative data in July and August 2022 to help address the research questions. The qualitative data was collected through a questionnaire survey and an in-depth interview. The questionnaire had three main sections. The first part solicited for the socio-demographic information of the respondents. The second section of the questionnaire sought to collect information about the respondent's perceptions, experiences, challenges and level of satisfaction about the performance of the parking facility. The last section solicited for possible strategies for improving the parking conditions on KsTU campus. While the first and second sections contained closed ended questions, the last section contained both opened and closed ended questions. Typical examples of questions under the section perceptions, experiences and level of satisfaction are as follows:

1. *How often are you blocked when you want to move from your parking lot?*
2. *How difficult is it to find a parking space on campus?*

The semi-structured interview was structured under three main themes: parking policies/ regulation and management strategies, safety and security, and parking performance and areas of improvement. Typical examples of questions under the theme parking policies/ regulation and management strategies are as follows:

1. *What are the specific policies and procedures governing parking on KsTU campus?*
2. *What constitutes parking violation? What is the penalty for parking in an illegal space on campus?*

The questionnaire was developed and administered face-to-face to highlight the perceptions, satisfactions, and expectations of users (i.e., staff and students). Using the Macorr (2009) sample size method, the sample size for university population of 26,841 was estimated to be 370 at 95% confidence level; a margin of error of 5%, and an assumed population proportion of 50%. Thus the 469 participants who responded to the survey are adequate for KsTU's population of about 12,000. Secondly, the in-depth interview was conducted with the head of the Estate Unit of the Works and Physical Development Directorate and the head of Security to obtain information about the existing parking policies and management strategies on campus. The interviews were recorded with an audio recorder and later transcribed verbatim for further analysis.

Moreover, the quantitative data was obtained by conducting observation surveys, inventories, and parking surveys. The inventory was first conducted on Google Earth to identify the number and physical characteristics of the existing parking lots within KsTU campus. Findings from Google Earth were later confirmed on the field. To understand the parking pattern on campus, the parking surveys (i.e., license plate method and in-and-out surveys) were conducted for two weekdays (i.e., Monday and Wednesday) and a weekend (i.e., Saturday). Each day's survey covered a 12-hour period (6:00am. to 6:00pm.). During the license plate survey, enumerators recorded the number plates of vehicles parked in each parking area at one-hour intervals. Surveyors recorded the number the existing cars parked on the study area before 6:00am. Vehicles parked at both designated and undesignated lots were recorded. Furthermore, vehicles were counted at intervals of 15 minutes as they entered and exited the university through the three main gates.

3.0 Results

3.1 Inventory and observations

Figure 1 is a layout of KsTU showing three main parking areas on campus: A (Blue), B (Red), and C (Yellow) named for purpose of this study as, BTech/Mechanical/Electrical Parking Area, Block C Parking Area and Administration/MP Block/Liberty Parking Area, respectively.

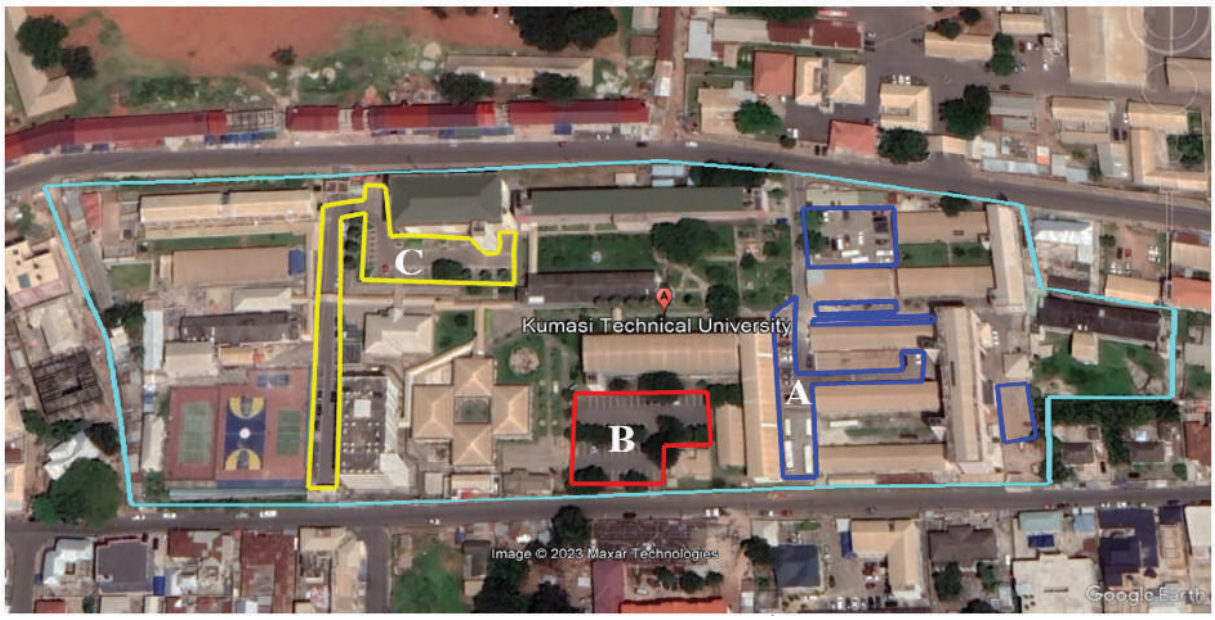

Figure 1 Layout of the study area showing main parking areas (A, B, C) (Source: Google earth)

As shown in Table 1, there are 199 designated parking spaces with varying orientations: parallel, angled (30 degrees) and perpendicular. The inventory shows that the BTech/ Mechanical/Electrical Parking Area (A) has the highest number of parking spaces (82), followed by Administration/MP Block/Liberty Parking Area (64) and Block C Parking Area (53). The lack of direct connectivity remains a challenge among the three parking areas, thus an individual parker who fails to find a parking space has no alternative

than to move the vehicle outside the campus. For example, one must travel about 0.76 km and 0.64 km from parking area A to B, and B to C respectively. Another operational problem observed was vehicles parking in undesignated places during peak periods and even blocking movement of other vehicles. This could be attributed partly to the parking demand exceeding the available parking spaces and poor management of the parking facility. Figure 2a shows the lane beside the designated parking spaces clearly marked "No Parking" but occupied by vehicles at peak periods as in Figure 2b.

Table 1: Parking pattern on KsTU campus

Parking area	Location	Parking spaces	Parking orientation
A	Electrical Parking Segment	32	90 degrees parking
	BTECH Block	6	90 degrees parking
	BTECH Extension	14	Parallel and 30 degrees parking
	D-Block	14	90 degrees parking
	Mechanical Workshop	16	90 degrees and parallel parking
B	C-Block	53	90 degrees parking
C	Administration Parking Area	30	90 degrees parking
	MP Block	32	Parallel parking and 90 degrees parking
	Medical – Lab	2	90 degrees parking
	Total	199	

Figure 2a: Vehicles parked at designated spaces only

Figure 2b: Vehicles parked at "No Parking" designated areas during peak periods.

3.2 Parking characteristics

The parking index charts in Figure 3 (A, B, C and D) show that weekdays generally have the highest parking demand. Specifically, Mondays have the highest demand while Saturdays exhibit the lowest parking demand. The lowest parking index on Saturdays are as expected since the population of staff and students associated with the weekend classes is low. Comparing the parking areas, the results show that the BTech/Mechanical/Electrical Parking area has the highest parking index. This means that parking area attracts most of the parking demand within campus relative to the supply. It is important to note from Figure 3 (A, B, C and D) that the parking facility operates over-capacity for at least 6 hours (8:00am to 3:00pm) in the weekdays. This is a very critical information to highlight the extent to which the parking demand exceeds supply. The challenge is so critical that for all three parking areas, the total parking demand exceeds supply by more than 50% and 20% on Mondays and Wednesdays respectively between 11:00am and 12:00pm. This is an indication that users who arrive on campus after 8:00am are more likely to face some difficulties in search of parking spaces on campus. Furthermore, it is a confirmation of why some vehicles are usually parked at undesignated spaces which consequently block other users who may want to move out of the parking lot.

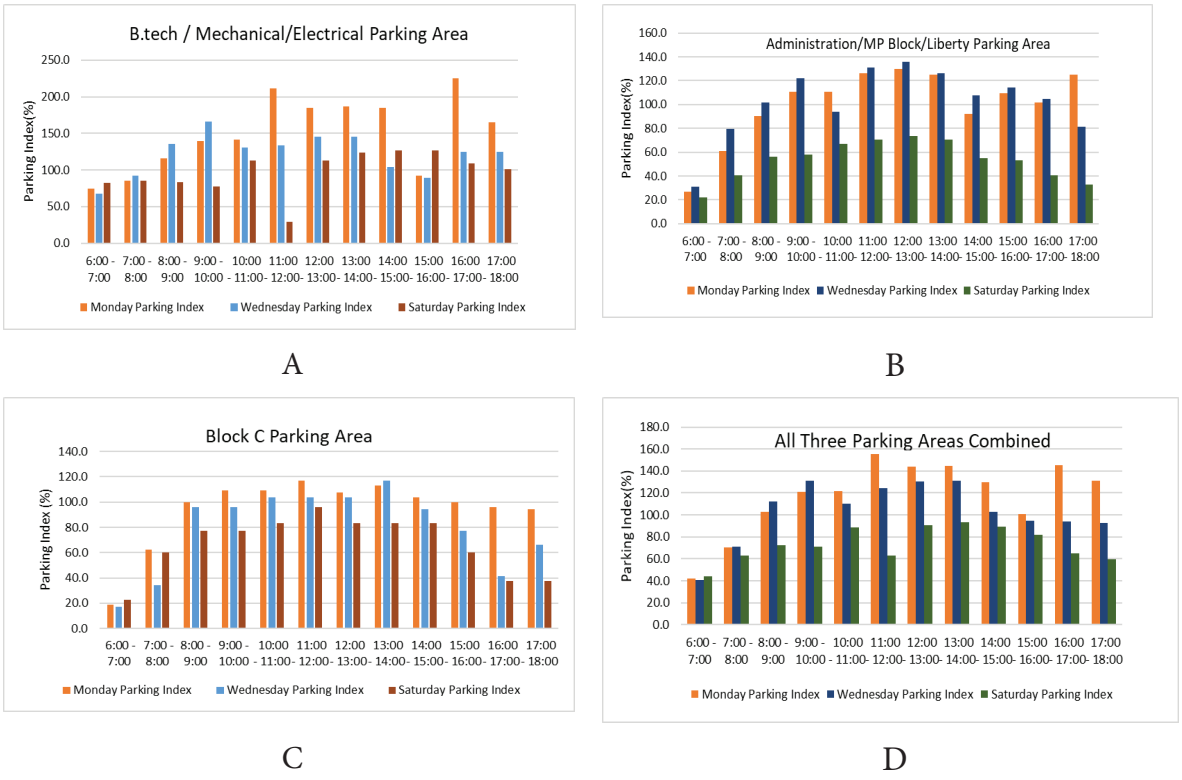

Figure 3: Parking Index by time of day and day of week

Table 2 confirms that the BTech parking area with the highest parking volumes and parking loads attracts most of the parking demand for all the days. Aside having the highest parking volumes and loads, its patrons are observed to park for relatively longer periods (at least 6 hours) compared to those who patronize the other areas. It is not surprising that the BTech parking area has the lowest parking turnovers (0.25, 0.38 and 0.25 for Mondays, Wednesdays and Saturdays respectively) and consequently the worst parking conditions

with the highest parking indexes as mentioned previously. It is important to mention that Wednesdays have the highest parking turnovers and consequently the lowest parking duration to a large extent. Moreover, Figure 4 shows the temporary characteristics of the parking, that is, the proportion of vehicles and how long they stay in the parking lot for the various days. It can be observed from the chart that the majority of the users of the parking facility park only 1-3 hours during weekdays. On Wednesdays, about 60% of users of the facility park for only 1-3 hours while only 22% park for more than 6 hours. Mondays have the highest proportion (40%) of vehicles parking more than 6 hours followed by Saturdays.

Table 2: Parking statistics of all parking areas and the respective days

Day of Week	Parking Areas	Parking volume	Parking Load	Parking Duration	Parking Turnover
Monday	All Combined	569	2604	4.6	0.26
	BTech	200	1230	6.2	0.25
	Block C	177	600	3.4	0.28
	Admin.	192	774	4.0	0.25
Wednesday	All Combined	576	2285	4.0	0.62
	BTech	230	994	4.3	0.38
	Block C	140	504	3.6	1.17
	Admin.	206	787	3.8	1.01
Saturday	All Combined	359	1631	4.5	0.40
	BTech	140	797	5.7	0.25
	Block C	123	425	3.5	1.14
	Admin.	96	409	4.3	0.40

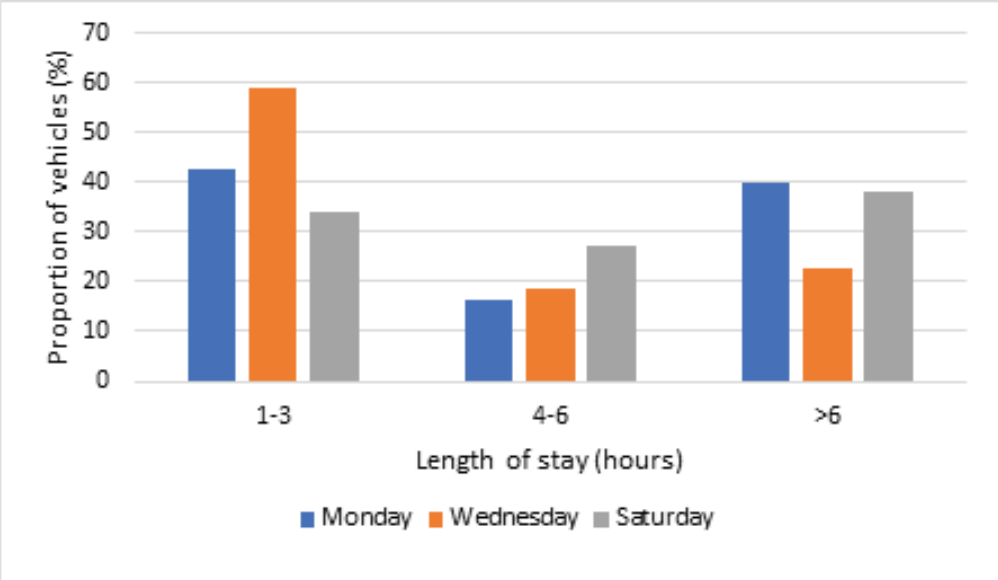

Figure 4.0: Parking length of stay and proportion of vehicles

3.3 Existing parking policies and management strategies

Interviews were conducted to identify the policies and plans that govern the provision and management of parking on KsTU campus and how effective they are implemented. Two KsTU officials were interviewed: Head of Security Unit and Head of Estate Unit. The outcome of the interviews conducted are highlighted below.

Interview with KsTU Heads of Security and Estate Units

The interviews revealed that the development office manages and controls the land use in the university. There is a housing policy document with a section of it dedicated to the management of parking space on campus. The estate and the security units have the mandate to collaboratively manage the parking on campus. Specifically, the estate unit is responsible for marking the parking spaces and ensuring that they are well maintained. The security office, however, is responsible for the day-to-day operations of the facility while enforcing all the parking regulations and ensuring parking safety. The university is not liable financially to damages to or theft from parked vehicles although the security unit oversees it. The Estate Officer, therefore, advises anybody who parks to be security conscious. All staff and students who own vehicles are supposed to secure the university's staff and student stickers to identify all vehicles and ensure true ownership. Overstayed vehicles (i.e., vehicles parked beyond 24 hours) are prohibited and those parked over 48 hours shall be towed by the Kumasi Metropolitan Assembly (KMA) and the cost borne by the owner. Some of the parking spaces have been reserved for key officers of the university by clearly marking the officers' titles on the pavement. There are no reserved spaces for visitors. There are spaces designated for parking of the university's vehicles.

The head of security and estate suggest that there is the need for the implementation of the staff and student stickers policy at the entry. The security must improve upon their patrols and ensure that drivers leave their contact numbers behind after parking. There is the need to have closed circuit television (CCTV) cameras around to enhance safety and security. Both officers suggest the need for more parking spaces but due to limited space. The estate officer suggests that the university considers sending some of the departments to the other campuses of the university to reduce the parking demand on the main campus. The two streets adjacent the university can be acquired, and the lane used as an off-site parking facility for the university staff and monitored by the security. Illumination should be improved at the parking areas to improve security. According to the head of security, there is the need to connect all three parking areas to improve accessibility and security at all gates.

3.4 Profile of Respondents

This section of the research study outlines the demographic characteristics of the respondents who were actively engaged in the field survey. Understanding the diverse demographic profiles of the individuals interviewed during the survey is paramount to gaining a holistic perspective on the parking situation at KsTU. By collecting data from a wide range of staff and students with varying backgrounds, including gender and category (role) within the university community, we aimed to capture a comprehensive representation of the campus population.

Gender of respondents

A total of 469 people were interviewed during the field survey through questionnaires. Out of this number of people, 305 of the which represents 65% of the total were males and the remaining 35% which is 164 people were females.

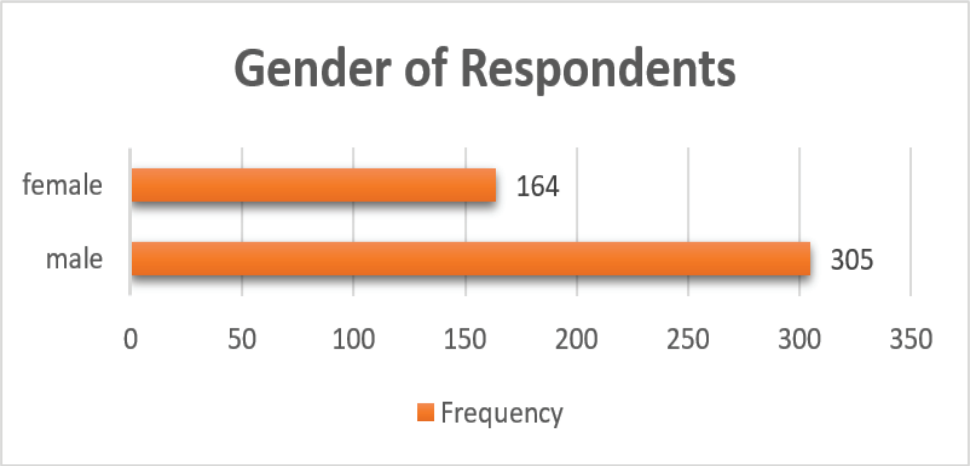

Figure 5: Gender of respondents

Categories of respondents

The individuals who were interviewed during the field survey were categorized into four distinct groups, namely, administration staff (78 respondents, accounting for 16.6% of the total), lecturers (218 respondents, accounting for 46.5% of the total), students (114 respondents, accounting for 24.3% of the total), and technicians (59 respondents, accounting for 12.6% of the total). Based on the survey data, it is evident that a greater percentage of lecturers choose to park their vehicles on campus in comparison to the remaining three categories. Moreover, a significant portion of the individuals surveyed comprised students who made use of the parking facilities on campus, contributing to a considerable proportion of the total sample. In contrast, the data collected from technicians indicated the lowest proportion of participants who choose to park on campus and make use of the designated parking facility.

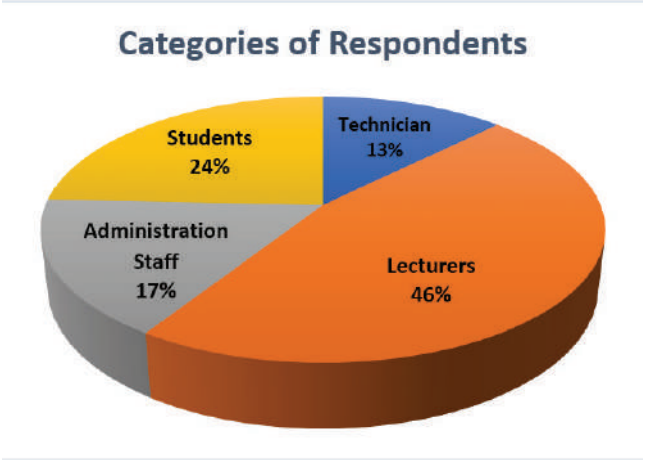

Figure 6: Categories of respondents

3.5 *Parking Challenges Faced by Respondents*

Respondents were made to indicate the challenges they face with parking on campus. They were asked to respond to how often they are blocked when they want to move from their parking slots and how difficult it is for them to find a parking space on campus.

From Figure 7, most users (45%) of the facility have often or very often been blocked at the parking lot while only 16.4% reported to have never been blocked at the parking lot. The rest have rarely experienced any form of blockage at the parking lots. The field observations revealed that the cause of blockages emanates from the vehicles that park at undesignated spaces (i.e., travel lanes at various parking areas). Thus, the suggestion by the Estate Officer that the security must ensure parkers leave their contact numbers behind is tenable.

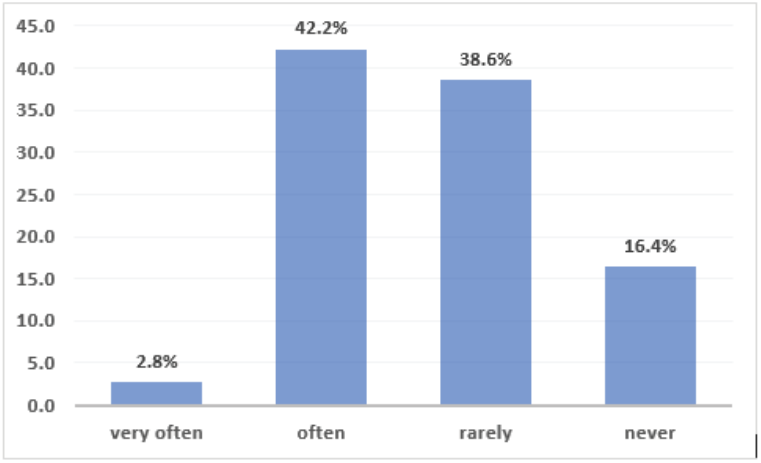

Figure 7: How often respondents have been blocked when moving out of the parking lot

Further, respondents were asked the question; "How hard is it to find parking space on campus?" According to Figure 8, most of the respondents (282, 60.1%)) said it was hard or very hard to find parking space on campus. The remaining 187 (39.9%) said it was very easy or easy to find parking space on campus. The lecturers were the largest cohort who reported that they found it hard or very hard to find a parking space. Interestingly, most of the respondents who reported that it is easy or very easy to find a parking space on campus were students. This could be due to the weekend students who do not experience the high parking demand during the weekdays. But the challenge of having to search for a parking space consequently results in delays to staff and students in carrying out their academic activities. About 57% of the respondents reported that they have ever been late to class due to the inability to find a parking space. As a coping strategy, about 39% of the respondents indicated to have often or very often parked outside the campus. This may be against the minimum distance most respondents are willing to park and walk to their destination – the majority of the respondents (56.9%) indicated to prefer to walk a distance of 50 meters or less to their final destination and 38.4% preferred to walk a distance beyond 50 meters but less than a 100 meters after parking.

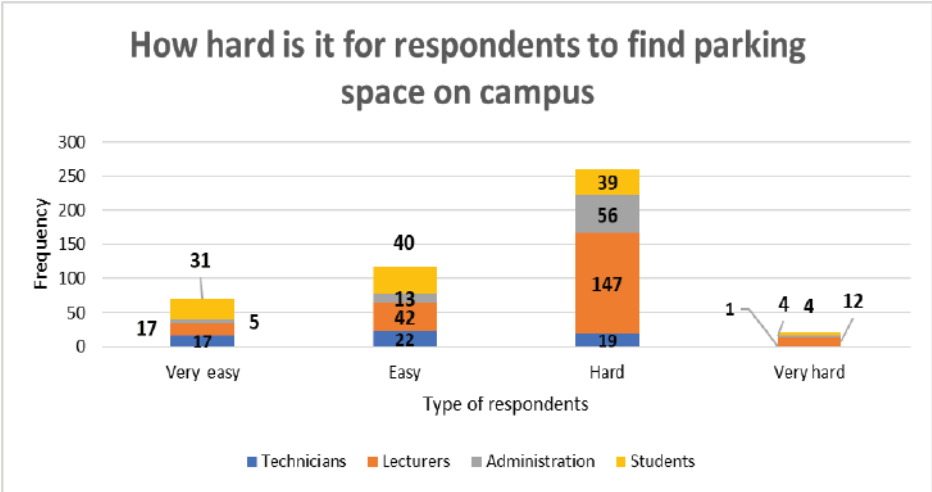

Figure 8: How hard is for respondents to find parking space on campus

3.6 Level of Parking Satisfaction/Dissatisfaction with parking space and security

Satisfaction with number of available parking space

During the field interview, respondents were asked to choose their satisfaction level regarding number of available parking spaces. The results (Figure 9) reveal that about 34% of respondents were either satisfied or very satisfied with the available parking space; however, some 19% of the respondents were either dissatisfied or very dissatisfied.

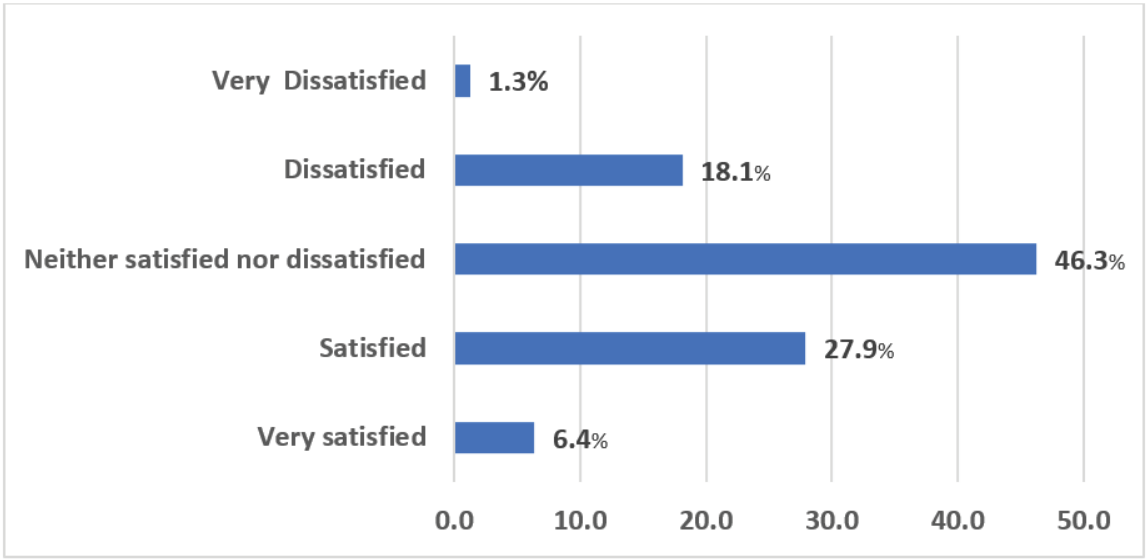

Figure 9: Respondents' level of satisfaction/dissatisfaction with number of available parking spaces

Respondents level of satisfaction with parking security

From Figure 10, 42.9% of respondents were satisfied with the parking security while 9.4% were very satisfied. Moreover, about 19% were either dissatisfied or very dissatisfied with

the parking security on campus, yet 28.6% of respondents were neutral with the parking security on campus.

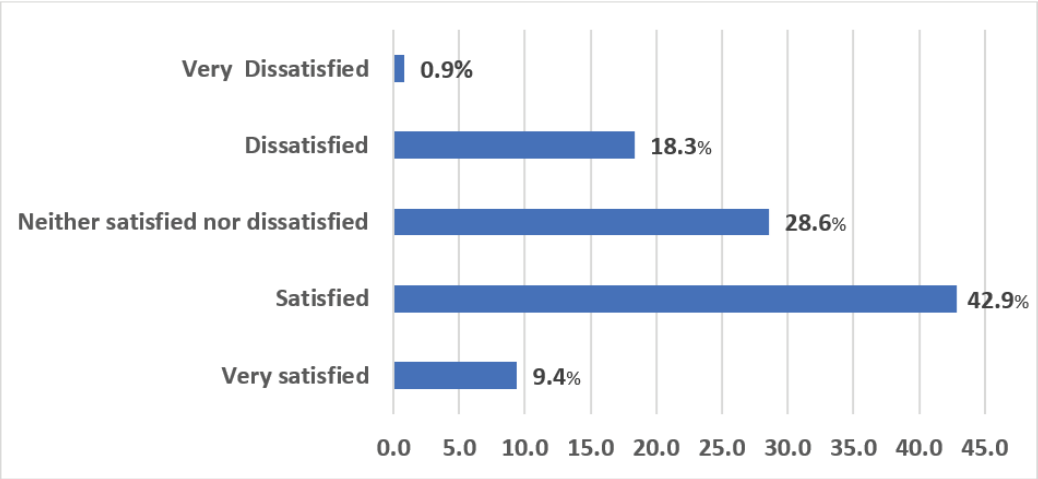

Figure 10: Respondents' level of satisfaction/dissatisfaction with parking security

3.7 Improvement Strategies

Table 3 shows results of multiple response questions which sought to identify the management strategies respondents think would improve parking on KsTU campus when implemented. The results show that prohibiting storage parking (i.e., preventing parking of vehicles on campus for more than 48 hours), parking permit and coupling parking supply and course scheduling are top three strategies selected by respondents to improve parking on KsTU campus. About 46%, 44% and 41% of respondents selected prohibiting storage parking, implementation of parking permit and coupling parking supply and course scheduling respectively. About 22% of the respondents selected park and pay as a parking management strategy.

Table 3: Recommended strategies to be implemented on KsTU campus to improve parking

Management strategies	Responses		Percent of Cases
	Number	Percent	
Coupling parking supply and course scheduling	194	20.2	41.4
Stack parking	96	10.0	20.5
Discouraging students from bringing a vehicle to campus	73	7.6	15.6
Prohibiting storage parking (preventing parking of vehicles on campus for more than 48 hours)	216	22.5	46.1
Parking permit	204	21.3	43.5
Formal sharing of assigned parking spaces	72	7.5	15.4
Park and pay	105	10.9	22.4
Total	960	100.0	204.7

Through the questionnaire administration an open-ended question was posed to the respondents, that is, "*With the rise in the population of KsTU, what suggestions do you have for improving parking*" Notable suggestions made by respondents to the parking supply and demand management strategies in order of importance were increasing parking lots on campus, implementation of parking restrictions, and provision of off-site parking facility. The restrictions include prohibiting students and visitors from parking in spaces designated to staff. Other suggested strategies include improving parking policies and management strategies, preventing storage parking, implementation of parking permits and vanpooling.

Figure 11: Improvement strategies suggested by respondents

5.0 Conclusions and recommendations

The provision of parking and its management on university campuses continues to be a critical and challenging issue. With a goal of improving parking on KsTU campus to meet users' expectation, this study sought to gain more insight into the existing parking policies and management strategies employed on campus. The study also assessed the performance of the KsTU parking facility from both operational and users' perspective and identify the specific improvement strategies that would address the parking challenges on campus. The observational study and inventory revealed three main parking areas with 199 designated parking spaces which fail to meet the increasing parking demand and forcing other vehicles to park at undesignated places. The findings of the operational analysis show that the parking capacity varies from day to day and time to time. However, there is a general capacity deficit during peak periods with the total parking demand exceeding the available number of parking spaces by more than 50% and 20% on Mondays and Wednesdays respectively between 11:00am and 12:00pm. One other important information needed to manage the parking facility is to have knowledge of its temporary characteristics. Comparatively, Mondays appear to be most critical as they are characterized by highest parking loads coupled with the least parking turnover and most users (i.e., 40% of the parking demand) parking for more than 6 hours.

Further, the available parking policies and management plans are not comprehensive enough. Aside from poor management strategies, enforcement of the existing parking policies appears to be weak. All these contribute to the operational parking challenges including blocking of users who may want to move from the parking lot, indiscriminate parking (i.e., parking at undesignated places), storage parking and overstayed vehicles, and poor connectivity among the parking areas leading to difficulties in finding parking

spaces. Although a substantial proportion (52.3%) of users are either satisfied or very satisfied with the parking security, about 34.3% are either satisfied or very satisfied with the parking supply.

The results of this study provide significant insights into the potential areas that require improvement. As indicated by the users of the parking facility, there is the need to increase the parking supply to adequately meet the current and future parking demand. With space constraint on campus, it is recommended that an off-site parking facility is provided to reduce the parking demand. The off-site facility would have to be closer to the university to ensure that the egress time of those who patronize the off-site parking would be short when walking to campus since most of the respondents (95.3%) indicated to be willing to park and walk a maximum of 100m to their final destinations. The university could negotiate with city authorities to convert one lane of the street adjacent the campus into an off-site parking facility which would be managed by the university security unit as free parking scheme for staff and paid parking scheme (Adams et al., 2008) for others. Expanding the supply of parking alone may not be a long-term solution but also a means to reap the full benefits would be realized when combined with effective implementation and enforcement of the existing parking policies and regulations including provision of staff and student vehicular stickers, parking permits, prohibiting parking at undesignated places, prohibiting storage parking, and overstayed vehicles. Further, there is also the need to ensure that the three parking areas are easily connected and accessible. This would reduce the travel distance and delays from one parking area to another in search of parking space on campus.

Further, the relocation of vehicles parked in areas not designated for parking, storage parking, and those that exceed the allotted parking time, which contribute to the scarcity of parking spaces, could be transferred to the Adako Jachie Campus of the University to facilitate the provision of additional parking spaces. Moreover, the establishment of a parking facility with multiple storage options could be erected within the premises of the university to mitigate the existing parking predicament.

Moreover, a relatively low-cost but effective approach to parking improvement is parking demand management scheme which could be achieved by coupling parking supply and course scheduling. The university can take advantage of its recent policy direction of online teaching and learning to manage the parking demand on campus. This requires a careful scheduling of the courses to ensure that, for certain days, some lecturers and students will have all their classes away from the campus through an online means. This could help reduce the parking demand significantly and consequently improve parking on campus. Paid parking is another strategy that has been successful in reducing parking demand on other campuses. However, findings in Table 3 indicate that implementing this strategy may not meet the preferences and expectations of most users.

The findings and recommendations of this study provide a basis to inform the decisions and policies of the university authorities, estate planners and the security towards the provision and management of parking on Kumasi Technical University campus. Although the findings of this study apply to the KsTU campus context, the approach (i.e., combination of both quantitative and qualitative) we used could be applied to other universities as the authorities seek to develop parking

policies and management plans to ensure a more sustainable parking systems. The findings of the quantitative analysis of this study are limited to an aggregated data. The perceptions and attitudes of different cohorts of users may however vary significantly. Future studies may investigate how demographic characteristics of the users (e.g., gender and type of user) may influence their perceptions and attitudes towards the existing parking conditions and improvement strategies.

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Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

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