Smart Parking Solutions: Enhancing Efficiency With Technology

AP Research

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Introduction

In urban high schools, the challenges associated with parking are emblematic of broader inefficiencies in institutional infrastructure. Teachers, who often commute from distant suburbs in personal vehicles, rely on large faculty and staff parking lots as essential facilities. These lots are designed to accommodate high volumes of vehicles, as existing street parking is insufficient. However, the complexity and vastness of these lots frequently create difficulties in navigation, leading to time lost as teachers search for available spots hidden among rows of parked cars. New faculty members or visitors are particularly vulnerable to these challenges, as they may be unfamiliar with the layout, further compounding the inefficiency. This issue, though seemingly minor, can have significant ripple effects, adding stress and consuming valuable time from teachers' already packed schedules.

Addressing this problem requires innovative solutions that integrate technology into everyday processes. A potential remedy lies in the implementation of an Internet of Things (IoT)-based parking management system connected to a user-friendly web application. Such a system would not only provide real-time information on parking spot availability but also offer an intuitive layout map of the parking area. According to Jabbar et al. (2021), IoT-based parking solutions have demonstrated effectiveness in optimizing parking availability and reducing user inconvenience in large institutions such as campuses. By applying this technology in high school settings, teachers, especially new or visiting ones, could save time and avoid unnecessary frustration, resulting in an overall enhancement of their workday experience.

Beyond mere convenience, the adoption of a smart parking solution in urban high schools has broader implications. Grodi, Rawat, and Rios-Gutierrez (2016) highlight the benefits of real-time data monitoring, which allows users to locate available parking spots quickly, reducing not only time wasted but also the environmental impact associated with idling vehicles. This aligns with the increasing emphasis on sustainability in urban design and education infrastructure. Additionally, as Tătulea et al. (2019) point out, integrating computer vision or sensor-based systems can reduce initial implementation and scaling costs, making these solutions more accessible for public institutions with budget constraints.

This study aims to explore the transformative potential of modern parking technologies within urban high school settings. By leveraging research on IoT and smart parking systems, it seeks to propose a scalable, cost-effective solution tailored to the specific needs of teachers and school visitors. Ultimately, such a system could alleviate stress, improve time management, and contribute to a more efficient educational environment.

Literature Review

Correlations of Parking Experience on Faculty Disposition

One of the most pressing reasons necessitating such a system is how its implementation may impact teachers' morale and mood throughout the day. It is reasonable to believe that if a teacher starts their day with an irritating commute and then has to face a bothersome parking experience, their mood may be negatively impacted throughout the day. This negative mood could potentially degrade their teaching quality, imparting their prior parking struggles into the quality of education they are able to offer. The cascading effects of such stress can include reduced engagement with students, strained interactions with colleagues, and an overall drop in workplace satisfaction.

Studies consistently show how much frustration drivers experience in situations where parking is limited or difficult. Research from the Journal of Transport and Land Use highlights this issue with pointed commentary: "According to angry survey respondents, parking on campus is a 'disgusting,' 'greedy,' 'nasty,' 'nightmare' of a 'scam' that is so 'insultingly,' 'insanely,' 'exorbitantly,' 'hideously,' 'outlandishly expensive,' it's 'criminal.'" (Wiers & Schneider, 2022). These feelings of frustration are compounded in professional settings like schools, where a calm and prepared demeanor is essential for teachers to perform effectively. Addressing this source of irritation could significantly enhance faculty satisfaction and improve their overall performance.

Efforts to Improve Parking Experience

There are a multitude of ways the parking experience for teachers may be enhanced more subtly without requiring direct input from users. Optimized parking lot design, for example, has been shown to improve user experiences by reducing bottlenecks and increasing efficiency. Research in an issue of E3S Web of Conferences lists several design considerations, including intuitive layouts, clear signage, adequate lighting, and the strategic placement of parking spaces closer to high-traffic entrances. These features minimize confusion and help users navigate the parking lot more efficiently. Another enhancement is the implementation of automated entry and exit systems. By streamlining these processes, schools can further reduce the time teachers spend navigating parking lots, freeing them to focus on their responsibilities. However, such approaches remain limited in their ability to provide real-time information about spot availability, which is where IoT systems can offer additional advantages.

Internet of Things

The Internet of Things (IoT), abbreviated as IoT, is a term coined by British technology innovator Kevin Ashton to describe how physical objects could be connected to the Internet via sensors and computers (Rose et al., 2015). These systems are useful in that they allow for the automation of menial or tedious tasks through the implementation of computers, sensors, motors, and other devices capable of carrying out tasks in the real world. This freedom opens enormous opportunities for applications that enhance the quality of life of users (Xia et al., 2012). IoT is already a part of most people's everyday life. For example, commonplace IoT devices include smartphones, smartwatches, tablets, and even appliances like smart refrigerators or thermostats (Sivanathan et al., 2019). These devices showcase IoT's capabilities and why such a system could improve user experiences in practically any field. Applying these principles to parking management offers the potential to revolutionize how high-demand facilities, like schools, approach this essential aspect of daily operations.

Relevant Techniques and Implementations of IoT

Several studies agree that real-time monitoring of parking spot availability can significantly enhance parking experiences by reducing congestion and improving the efficiency of parking systems. For example, Jabbar et al. (2021) demonstrate how an IoT-based system can efficiently track parking availability on a smart campus, leveraging GPS and mobile apps to guide users to available spots. This aligns with Al Mamari et al. (2019), who also found that IoT solutions could reduce congestion by providing real-time data. Both studies highlight the potential benefits of smart parking systems, particularly in high-demand environments like schools and universities, suggesting that a similar solution could help high school teachers find parking more easily. However, while these studies underscore the positive impact of real-time data, they largely focus on technical aspects, leaving gaps in understanding the user experience and how these technologies might be received by teachers in a school setting.

Another approach to enhancing the parking experience for teachers is through the use of advanced sensor systems. Grodi et al. (2016) describe a wireless sensor network (WSN) that detects parking occupancy, providing users with near-instantaneous updates on available spaces. This system emphasizes the flexibility of sensor placement and its ability to provide accurate, real-time information to drivers. Similarly, Amato et al. (2017) introduce a decentralized system using deep learning for parking detection, which performs better than traditional methods by avoiding central server dependence. Both systems rely on real-time data to alleviate the stress of parking in high-demand areas. However, Tătulea et al. (2019) propose an alternative method using image-based detection that offers a cost-effective and scalable solution, which could be particularly advantageous for schools with limited budgets. While all these studies support the idea that real-time detection can enhance the parking experience, they differ in the specific technologies used and the scalability of their systems, suggesting that further research is needed to determine which method would work best in a high school parking lot setting.

Although much of the existing research emphasizes the technological benefits of real-time parking systems, there is a clear gap in evaluating the user experience, particularly in educational settings. For instance, while Jabbar et al. (2021) and Al Mamari et al. (2019) focus on the technical implementation of smart parking systems, they do not delve deeply into how teachers, as end users, interact with these systems. Grodi et al. (2016) point out the importance of user interface design in ensuring that parking systems are accessible and user-friendly, which is crucial for ensuring that teachers can easily navigate such systems in their daily routines. Additionally, concerns about the scalability of these systems are often raised. While IoT systems may function well in controlled environments, the scalability of such technologies to larger, more complex school campuses remains uncertain. Further research is needed to address these concerns and explore how these systems can be tailored to fit the specific needs and constraints of a high school parking environment. My research seeks to address this gap by exploring the impact of a web application designed to monitor real-time parking spot availability at an urban high school. Through a series of surveys conducted during the 2024-2025 school year, the study will assess how this technology influences the parking experience for school faculty.

Method

Data Collection Approach

I employed a mixed-method survey for this study because it allowed me to gather user opinions efficiently while minimizing disruptions to participants. Compared to interviews, which could be time-consuming and intrusive for faculty members, the survey enabled participants to share their perspectives on the parking facility quickly and conveniently. My primary aim was to identify areas for improvement and enhance the parking experience for faculty without imposing on their daily schedules. By focusing on user feedback, I ensured that any adjustments to the parking facility would be data-driven and directly address user needs. The target population for this survey consisted of faculty members who regularly use the parking facility. I invited these individuals to participate in the study both before and after implementing the new parking facility design and web application. To reach participants, I used a voluntary response sample. I advertised the survey through advertisements of QR codes distributed to all faculty members in the institution by the administration, which made the survey easily accessible and emphasized its voluntary nature, respecting the time and preferences of participants.

To collect data efficiently, I chose a structured questionnaire as the primary data collection tool. This decision was inspired by the methodology in *User Satisfaction Level of Parking Space Facility: A Case of Faculty of Geography, Universitas Gadjah Mada, Indonesia* by S. R. Budiani et al., which demonstrated the value of structured questionnaires for gathering actionable feedback. My questionnaire captured both quantitative and qualitative data, enabling me to compare satisfaction levels before and after the changes to the parking facility. I designed the questions to focus on specific aspects of the parking experience, such as ease of navigation, flow clarity, convenience, cleanliness, and safety. This structured approach ensured that participants provided detailed feedback, which was essential for evaluating the impact of the implemented changes.

Table 1 displays the pre-test questionnaire used in the survey. It depicts the questions used in order of their being rendered to the survey taker. The two question type properties that were employed were primarily five-point likert scales, in addition to a single open response question, used to better grasp the personal feelings of the respondents.

Question	Туре	Required
1. How would you rate the simplicity of the parking facility?	Five-Point Likert Scale	Yes
2. How would you rate the clarity of the flow of the parking facility?(The clearness of the intended flow of cars to park)	Five-Point Likert Scale	Yes
3. How would you rate the convenience of the parking facility?	Five-Point Likert Scale	Yes
4. How would you rate cleanliness and neatness of the parking facility?	Five-Point Likert Scale	Yes
5. How would you rate the safety and security of the parking facility?	Five-Point Likert Scale	Yes

Table 1. Employed Pre-Test Questionnaire; Adapted from: "S R Budian, et al., 2018"

6. Brief, summarize	ed, assessment of parking facility	
experience		

Short Open No Response

The survey questions targeted specific components of the parking experience, allowing me to identify the strengths and weaknesses of the facility's design. For instance, questions about flow clarity assessed whether users found the facility intuitive to navigate, while questions about safety gauged their sense of security. Additionally, I included an optional open-ended question to allow participants to share unique perspectives or elaborate on their experiences. This qualitative input complemented the quantitative data and provided deeper insights into user satisfaction.

The goal of my survey questions was to gather detailed feedback to inform actionable recommendations for improving the parking facility. By evaluating specific elements of the parking experience, I ensured that proposed changes were directly aligned with faculty needs and preferences. This targeted approach also facilitated a data-driven analysis, allowing me to compare satisfaction levels before and after the new technologies and design elements were introduced. This feedback loop was crucial for ensuring continuous improvement and fostering a user-friendly parking experience.

Similarly, Table 2 depicts the post-test questionnaire used to gauge the respondents affinity towards the web application and parking lot redesign.

Question	Туре	Required
1. The app is easy to use and navigate.	Five-Point Likert Scale	Yes
2. I was able to quickly and easily check into a parking spot using the app.	Five-Point Likert Scale	Yes
3. The instructions for using the app and QR codes were clear and easy to follow.	Five-Point Likert Scale	Yes
4. The design and layout of the app made it easy to find the necessary features. (Live map, etc.)	Five-Point Likert Scale	Yes
5. The app assisted in saving me time when finding a parking spot.	Five-Point Likert Scale	Yes
6. I preferred using this app over manually searching for a parking spot.	Five-Point Likert Scale	Yes

Table 2. Employed Post-Test Questionnaire

7. The app provided real-time updates that helped me make better parking decisions.	Five-Point Likert Scale	Yes
8. I feel that the concept of this application would be a good addition to new parking lots.	Five-Point Likert Scale	Yes
9. What did you like or appreciate most about the app?	Short Open Response	No
10. What did you dislike or find frustrating about the app?	Short Open Response	No
11. Additional comments or concerns related to the application or parking lot in general.	Short Open Response	No

Ethical considerations were taken under great scrutiny in my research design and execution, ensuring that participants rights, autonomy, and privacy were respected throughout the process. I obtained informed consent from all participants before they joined the study. The consent form provided detailed information about the study's purpose, procedures, potential risks, and benefits, enabling participants to make an informed decision about their involvement. I emphasized that participation was voluntary, with no obligation to complete the survey and no penalties for withdrawing at any time. This transparency fostered trust and ensured that all contributions were made willingly.

To protect participant privacy, I implemented strict confidentiality measures. I did not collect any personally identifiable information, and all responses were anonymized to prevent any connection between participants and their feedback. The data was stored securely and used only for the purposes outlined in the consent form. Participants were informed that their anonymized data might be included in published research or presented at conferences, but their identities would remain protected. These ethical safeguards allowed participants to share their opinions candidly without fear of reprisal or misuse of their responses. By adhering to these principles, I upheld the integrity and transparency of my research while prioritizing participant well-being.

Application Implementation

I. Parking Facility Redesign

I redesigned the parking facilities using industry-standard tools to ensure optimal functionality and user satisfaction. TestFit was used, known for its rapid prototyping and parking layout optimization, to evaluate and reconfigure the existing parking infrastructure. Additionally, I utilized Google Earth for high-resolution aerial imagery and precise geospatial data, allowing me to consider contextual factors such as traffic patterns, space constraints, and accessibility requirements. These tools enabled me to analyze various scenarios and simulate the impact of proposed changes on traffic flow and space utilization. This process, which took into account both technical and practical considerations, helped achieve a balanced design that optimized both space and usability.

Key adjustments included optimizing the alignment and spacing of parking spots to maximize capacity, improving entry and exit points to reduce congestion, and adding clear directional signage to enhance navigability. I prioritized creating an intuitive flow of traffic within the facility to help users easily locate and access parking spaces. This systematic redesign addressed common pain points, such as overcrowding and confusion, while adhering to safety standards and urban planning guidelines. The result was a modernized parking layout focused on efficiency, accessibility, and user convenience.

II. Integration of IoT and Mobile Web Application

Figure 1.a. Picture of QR code implementation for center row



In addition to the physical redesign, I developed and implemented an IoT-enabled mobile web application to expedite the parking experience. Each parking space was equipped with a unique QR code, strategically placed for visibility and ease of use. The QR codes were affixed to the appropriate spots using one of three methods, depending on the location. For spots facing solid walls, duct tape was used to secure the codes. For spots facing fences, zip ties were employed. In the central areas, where vehicles would face each other, temporary fiberglass reflective poles were installed in the ground, holding QR codes on both sides. Faculty members would scan the QR code at their chosen parking spot using their smartphones, marking the space as occupied in real time as demonstrated in Figure 1.a.

The web application offered several benefits. It provided a live feed of available parking spaces, reducing the time and frustration associated with searching for an open spot, especially during peak times. The system also facilitated enhanced monitoring and data collection, enabling me to track usage patterns, identify high-demand areas, and plan future improvements.



Figure 1.b. *Screenshot of web application to be implemented*

I designed the application with user experience in mind, as seen in Figure 1.b, featuring an intuitive and minimalist interface that required minimal technical knowledge to operate. The web app was developed and hosted entirely free of charge. I utilized SvelteKit, a JavaScript framework, along with minimal styling to deliver a fast and seamless user experience. For the backend, I leveraged Cloudflare Pages, a free hosting service that offered more than enough bandwidth

to support the project's needs. The scanning process was quick and straightforward, ensuring a seamless interaction for faculty members. This integration of IoT technology and QR codes bridged the gap between physical infrastructure and digital convenience, creating a modern, efficient, and scalable parking solution.

<u>Results</u>

Pre-Test

The survey yielded results from over 30 self-proclaimed regular users of the parking facility. The survey was almost entirely responded to on a singular day, that being the day that it was initially distributed by email at the beginning of a school week. Figure 2.a depicts a bar chart of the responses of faculty, asking to rate the simplicity of the parking facility.

Figure 2.a. Chart of Question No. 1 Responses



How would you rate the simplicity of the parking facility? 33 responses

Only a small fraction of the respondents rated the simplicity of the parking facility highly, with a majority of users rating the simplicity at or below a 3. Responses to the clarity of flow of the parking facility were varied, with ratings spread between 1 and 5. Some respondents noted the absence of designated lanes for parking. Others mentioned that spray-painted lines were needed. Regarding convenience, the majority of users rated the parking facility between 3 and 5. Several comments referenced the availability of spaces, with some users mentioning that they had to arrive early to secure a spot. Cleanliness and neatness of the parking facility received ratings mostly at 4 or 5. Similarly, safety and security ratings varied, with some ratings as low as 1.

Open-ended responses included concerns about organization in the parking lot. Several respondents mentioned issues with individuals occupying multiple spaces or blocking other vehicles. One respondent stated, "People are selfish and take up two parking spots or block others in," while another noted, "Parking wouldn't be awful if people could park, or park without being selfish and blocking others or taking up more than one spot." Some comments suggested that additional markings or structured parking lanes were needed, with one individual recommending, "Spray lines so that others properly park." Another respondent stated, "We need lines to help people park better."

Other responses referenced parking availability and navigation during peak times. One user stated, "The limited number of spots makes it a bit inconvenient—you have to get here very early to get a spot," while another shared, "Are no spots available when I get to school so I have only twice used the parking lot." Additionally, some respondents mentioned challenges related to the layout, with one stating, "Our parking lot is very difficult to navigate when there are many vehicles moving at the same time. It also doesn't help that many drivers do not consider others

when parking and will take up more room than necessary to park. The front lot needs a little more organization to maximize the number of spaces there too."

Post-Test

The post survey yielded results from 26 self-proclaimed users of the parking facility during the time frame that the system was implemented. The survey was almost entirely responded to on a singular day, that being the day that it was initially distributed by email. Figure 2.b depicts responses of faculty asking to rate the ease of use for features pertaining to the application.





I was able to quickly and easily check into a parking spot using the app. ²⁶ responses

Figure 2.c. Chart of Question No. 7 Response

The app provided real-time updates that helped me make better parking decisions. ²⁶ responses



The post-test survey results indicate that a large portion of faculty users were highly satisfied with various features of the new IoT-enabled parking system, highly satisfied being a four or a five rating. Notably, 80% of users rated the ease of use highly, and 70% were pleased with the quick check-in process. The clarity of instructions received high marks from 85% of users, suggesting that the app's guidance was clear and easy to follow as shown in Figure 2.c. A majority, 75%, rated the design and layout positively, indicating that the app's interface was well-received. In terms of time-saving however, 50% of users rated the feature highly, while 60% preferred the app over manually searching for a parking spot and appreciated the real-time updates. Finally, the app concept was rated highly by 90% of users.

Discussion

The most important factor to address, from the very beginning, was identifying the various challenges faced by regular users of the parking lot. These challenges needed to be clearly understood in order to find effective solutions to them. The difficulties were made especially evident in the pre-test phase, where there was a widespread sense of frustration and dissatisfaction with the existing parking lot situation. Respondents expressed strong discontent with the current layout, highlighting issues such as the inefficiency and inconvenience caused by the design.

One of the key complaints that emerged from the data was the tendency for cars to double park and block other drivers, leading to further chaos and inefficiency. As one respondent put it, "Parking wouldn't be awful if people could park, or park without being selfish and blocking others or taking up more than one spot." This statement encapsulated the frustrations of many, showing how the original parking lot design was not only problematic but in dire need of a complete overhaul and redesign to address these serious issues.

Understandings

The initial understanding of this study was rooted in the potential of IoT to enhance user satisfaction in parking management. Prior research and emerging technologies suggested that real-time data collection and automated systems could alleviate common parking frustrations. By leveraging IoT, the goal was to create a more seamless and efficient experience for users, addressing key issues such as space availability and navigation. The study aimed to determine whether integrating IoT into parking management would lead to measurable improvements in user satisfaction, ultimately validating the technology's promise in this field.

The findings of this study confirmed that integrating a smart parking system with IoT into existing infrastructure can enhance overall user satisfaction. User responses demonstrated that real-time monitoring and improved organization led to a more seamless parking experience, reducing common frustrations such as uncertainty in spot availability and inefficient traffic flow. This new understanding reinforces the viability of IoT-driven solutions in optimizing parking management, showing that technological enhancements can effectively address long-standing issues and improve daily convenience for users.

Limitations

One of the key limitations of this study was the reliance on questionnaires as the primary data collection tool. While surveys are a common method for gathering user feedback, they can sometimes lack nuance, making it difficult to capture the full complexity of participants' experiences. Additionally, respondents may misinterpret questions, leading to potential inconsistencies in the data. The inclusion of open-ended responses, while valuable for gaining deeper insights, also introduces challenges in replicability. Since individual responses vary

widely in detail and interpretation, future researchers may find it difficult to draw direct comparisons or reproduce the exact conditions of this study. Furthermore the limited respondent pool was a hindering factor. A larger pool of participants and parking lots for this system to be implemented possibly across multiple schools could help solve for this issue.

Beyond survey limitations, issues existed with a large portion of users who were checking in parking spots but forgetting to check out which did lead to issues of reliability in the system. This was partially remedied through the use of automatic resets during the evening which assumed nobody would be staying overnight. Further improvements to fix this issue could be taken through the use of notifications and flyers to users who forgot.

Practical constraints such as time and environmental factors also played a role in shaping the study's outcomes. The experiment was conducted under less-than-ideal conditions, with weather potentially impacting parking behavior and system performance with users finding difficulty scanning in harsher weather such as rain. Weather scanning concerns could be addressed by allowing users to manually input codes through the app from their car eliminating some inconvenience in having to stand in the rain attempting to scan the codes.

Additionally, coordinating with school facilities to implement the smart parking system proved challenging, as logistical hurdles delayed execution and limited the time available for observation and data collection. These constraints highlight the need for more extensive, long-term studies that can account for seasonal variations, larger participant pools, and improved coordination to ensure more comprehensive results.

Implications

The implications of this study extend beyond high school parking lots, offering valuable insights for other venues with large, complex, and often disorganized parking structures, such as arenas and concert venues. These locations typically struggle with managing large volumes of vehicles, leading to frustration and inefficiency for attendees. By implementing an IoT-based smart parking solution, these venues could offer real-time parking spot availability, reduce congestion, and enhance the overall experience for visitors. This technology could streamline parking management, improving both user satisfaction and operational efficiency, especially during high-demand events where parking tends to be chaotic and time-consuming.

Another important implication of this study is the potential for IoT-driven parking systems to contribute to broader urban planning and sustainability goals. As cities grow and parking becomes increasingly scarce, optimizing parking resources through smart technology can alleviate pressure on urban infrastructure. By reducing the time drivers spend searching for parking, IoT solutions can help lower carbon emissions and minimize traffic congestion, contributing to more sustainable urban environments. This study lays the groundwork for future

applications in smart city initiatives, where technology can be leveraged to improve the quality of life for residents while also promoting environmental benefits.

Future Research

Future research should focus on expanding the implementation of the smart parking system across multiple lots in different areas and environments. By testing the system in diverse locations, such as urban, suburban, and high-traffic commercial areas, researchers can assess its adaptability and effectiveness under varying conditions. This would provide a more comprehensive understanding of how different infrastructure layouts, traffic patterns, and user behaviors impact the system's overall success. Additionally, studying a broader range of users, including students, visitors, and staff, could offer further insights into how different demographics interact with and benefit from the technology.

Another crucial area for future research is extending the observation period to collect long-term data on user satisfaction and system performance. A longer study duration would allow researchers to analyze trends over time, including seasonal variations in parking habits, system reliability, and potential areas for improvement. Continuous feedback from users over an extended period would also help refine the technology, ensuring that it remains effective and user-friendly. By implementing these recommendations, future studies can build upon this research to further optimize smart parking solutions and enhance their practical applications.

Conclusion

Schools, institutions, and possibly independent companies or venues with parking lots should strongly consider upgrading their infrastructure with modern smart technology to improve convenience and efficiency for users. By integrating real-time monitoring systems, automated guidance, and IoT-enabled sensors, organizations can reduce the frustration associated with parking, ensuring a smoother experience for employees, visitors, and customers. Smart parking systems optimize space usage, minimize congestion, and provide valuable data insights that help refine long-term parking management strategies. Additionally, these solutions are adaptable and scalable, making them viable for a range of environments, from corporate campuses to schools and commercial areas. Investing in modern parking technology not only enhances user satisfaction but also future-proofs infrastructure, ensuring that parking facilities remain efficient and capable of meeting evolving demands.

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<u>Appendix</u>

Pre-test survey

Section 1 of 2

High School Faculty Parking Lot Satisfaction Survey

BIUGX

Form description

Informed Consent

Study Title: Impact of Technology on Parking Experience

Purpose of the Study: You are invited to participate in a research study exploring the satisfaction of users within a dense, urban parking lot setting.

Procedures: If you choose to participate, you will answer a few questions to summarize your experience using the parking lot complex. The study is expected to take approximately 1-5 minutes.

Potential Risks and Benefits: Participation in this study is unlikely to result in any risks or discomforts beyond those typically encountered in daily life. By participating, you will provide valuable insights into the parking facility on which this study is being employed. Benefits of your involvement include the opportunity to contribute to the enhancement of urban parking facilities and the potential to influence positive changes in the technology and services provided.

Confidentiality: The data collected in this study are completely anonymous. No personally identifiable information will be collected, and the information you choose to provide in this study cannot be connected back to you. Results from this study may be published or presented at research conferences, and the anonymous data may be shared with other researchers through an online data repository.

Voluntary Participation: Your participation in this study is voluntary, and you may choose not to participate or may withdraw from the study at any time without penalty.

Questions or Concerns: For any questions or concerns pertaining to the conduction of this survey or study please contact the following emails:

I have read, and fully understand the information provided in this consent form. I certify that I am 18 years of age or older, and a regular user* of the parking complex where this survey is being conducted. By clicking the "Next" button to begin the survey, I voluntarily agree to participate in this study.

*For the purposes of this study, a "regular user" is defined as a faculty member who commutes to the institution in their personal vehicle and primarily uses the onsite parking lots provided by the institution for their daily commute.

:

How would you rate the simplicity of the parking facility? *													
	1	2	3	4	5								
Very Simple	0	0	\bigcirc	0	0	Very Complicated							
How would you rate (The clearness of the	How would you rate the clarity of the flow of the parking facility? * (The clearness of the intended flow of cars to park)												
	1	2	3	4	5								
Very Unclear	0	0	\bigcirc	0	\bigcirc	Very Straightforward							
How would you rate	How would you rate the convenience of the parking facility? *												
	1	2	3	4	5								
Very Inconvenient	0	0	0	0	0	Very Convenient							
How would you rate	cleanliness	and neatne	ss of the pa	rking facili	ty? *								
	1	2	3	4	5								
Very Bad	0	\bigcirc	\bigcirc	0	0	Very Good							
How would you rate	the safety a	and security	of the park	ng facility?	*								
	1	2	3	4	5								
Very Bad	0	0	0	0	0	Very Good							
Brief, summarized, assessment of parking facility experience (Optional) Long answer text													

Post-test survey

High School Faculty Parking Lot Application Implementation Satisfaction Survey

BIUGX

Form description

Informed Consent

Study Title: Impact of Technology on Parking Experience

Purpose of the Study: You are invited to participate in a research study exploring the satisfaction of users within a dense, urban parking lot setting.

Procedures: If you choose to participate, you will answer a few questions to summarize your experience using the parking lot complex. The study is expected to take approximately 1-5 minutes.

Potential Risks and Benefits: Participation in this study is unlikely to result in any risks or discomforts beyond those typically encountered in daily life. By participating, you will provide valuable insights into the parking facility on which this study is being employed. Benefits of your involvement include the opportunity to contribute to the enhancement of urban parking facilities and the potential to influence positive changes in the technology and services provided.

Confidentiality: The data collected in this study are completely anonymous. No personally identifiable information will be collected, and the information you choose to provide in this study cannot be connected back to you. Results from this study may be published or presented at research conferences, and the anonymous data may be shared with other researchers through an online data repository.

Voluntary Participation: Your participation in this study is voluntary, and you may choose not to participate or may withdraw from the study at any time without penalty.

Questions or Concerns: For any questions or concerns pertaining to the conduction of this survey or study please contact the following emails:

I have read, and fully understand the information provided in this consent form. I certify that I am 18 years of age or older, and a regular user* of the parking complex where this

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Section 2 of 2 App Survey X : Please gauge your responses based on your experience over the past week using the implemented web app. The app is easy to use and navigate. * 2 3 4 5 1 0 0 0 0 0 Strongly Disagree Strongly Agree I was able to quickly and easily check into a parking spot using the app. 1 2 3 4 5 Strongly Disagree 0 0 0 0 0 Strongly Agree The instructions for using the app and QR codes were clear and easy to follow. 2 3 4 1 5 0 0 0 0 0 Strongly Disagree Strongly Agree The design and layout of the app made it easy to find the necessary features. (Live map, etc.) 1 2 3 4 5 0 0 0 0 0 Strongly Disagree Strongly Agree

be ann assisted in asving me time when finding a perking enet

I preferred using this app over manually searching for a parking spot. 1 2 3 4 5 0 0 0 0 0 Strongly Agree Strongly Disagree * The app provided real-time updates that helped me make better parking decisions. 1 2 3 4 5 O O O Strongly Agree Strongly Disagree I feel that the concept of this application would be a good addition to new parking * lots. 1 2 3 4 5 O O O Strongly Agree Strongly Disagree What did you like or appreciate most about the app? Long answer text What did you dislike or find frustrating about the app? Long answer text Additional comments or concerns related to the application or parking lot in general. Long answer text

Pre-test raw data

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·	How would you	а	n		t	
limestam	rate the simplicity	r	V]	е	Brief, summarized, assessment of parking facility
р	of the parking	İ	е	n	t	experience (Optional)
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		s t p a r k)				
1/10/2025 13:45:11	1	3	4	5	4	
1/10/2025 14:13:10	3	3	5	4	1	
1/13/2025 9:11:45	1	3	5	3	4	I have a reserved parking spot so my experience may be different than others.
1/13/2025 13:28:36	2	1	5	3	4	No lanes for individuals to park into. People park into random spots
1/13/2025 14:15:01	1	3	5	5	3	We need lines to help people park better.
1/13/2025 14:15:22	1	5	4	5	5	Parking a car is very easy, people that have difficulty using a car are usually the problem where they either take up 2 spots or block people in.
1/13/2025 14:15:48	4	2	3	5	3	Parking wouldn't be awful if people could park, or park without being selfish and blocking others or taking up more than one spot
1/13/2025 14:15:59	3	3	4	5	5	Spray lines so that others properly park
1/13/2025 14:16:27	5	4	3	5	4	People are selfish and take up 2 parking spots or block others in.
1/13/2025 14:16:42	4	4	3	1	3	
1/13/2025 14:20:47	1	5	5	5	5	Very good except a certain car did not find a spot in morning and decided to block 4 cars one was mine and I had appointment to keep.
1/13/2025 14:26:59	2	3	4	5	5	
1/13/2025 14:27:18	3	5	4	4	4	
1/13/2025 14:27:57	1	5	4	5	3	
1/13/2025	1	4	4	3	5	

14:28:32						
1/13/2025 14:28:42	2	2	4	4	3	
1/13/2025 14:29:07	3	3	4	3	4	
1/13/2025 14:29:09	1	4	4	4	3	
1/13/2025 14:30:37	2	3	2	4	4	I do not often use the school parking, answers based on the few times I have
1/13/2025 14:31:26	3	4	3	3	3	
1/13/2025 15:21:50	4	2	3	2	5	
1/13/2025 15:21:51	3	3	3	3	3	
1/13/2025 15:22:17	2	4	3	5	3	
1/13/2025 15:22:23	5	3	1	3	4	
1/13/2025 15:22:48	4	4	3	3	3	
1/13/2025 15:22:50	3	4	1	4	3	
1/13/2025 15:22:59	3	2	2	4	4	Not enough parking
1/13/2025 15:23:39	1	3	5	5	5	
1/13/2025 15:23:53	3	3	4	4	4	
1/13/2025 15:25:02	4	3	4	4	4	The limited number of spots makes it a bit inconvenientyou have to get here very early to get a spot.
1/13/2025 15:26:19	1	5	5	5	5	
1/13/2025 15:34:08	3	1	3	2	4	Our parking lot is very difficult to navigate when there are many vehicles moving at the same time. It also doesn't help that many drivers do not consuder others when parking and will take up more room than necessary to park. The front lot needs a little more organization to maximize the number of spaces there

						too.
1/13/2025 16:41:39	3	2	1	5	5	Are no spots available when I get to school so I have only twice used the parking lot

Post-test raw data

Ti m st a p	The app is easy to use and navi gate.	l was able to quickl y and easily check into a parkin g spot using the app.	The instru ctions for using the app and QR codes were clear and easy to follow	The desig n and layout of the app made it easy to find the neces sary featur es. (Live map, etc.)	The app assist ed in saving me time when findin g a parkin g spot.	l prefer red using this app over manu ally searc hing for a parkin g spot.	The app provid ed real-ti me updat es that helpe d me make better parkin g decisi ons.	I feel that the conce pt of this applic ation would be a good additi on to new parkin g lots.	What did you like or appre ciate most about the app?	What did you dislike or find frustr ating about the app?	Additi onal comm ents or conce rns relate d to the applic ation or parkin g lot in gener al.
3 / 2 4 / 2 0 2 5 1 1: 4 3: 5 2	5	4	5	4	2	1	2	3	The live map was great - but not updat ed, so not alway s useful	Havin g to check out before checki ng in.	
3 / 2 4 /	5	5	5	5	4	3	3	5	It was simpl e and easy to	N/A	Being able to see the availa

2 0 2 5 1 2: 1 5: 1 3									use.	bility map before enteri ng the lot and not only after alread y parkin g and scann ing in.
3 / 2 4 / 2 0 2 5 1 2: 2 0: 0 3	3	3	3	3	3	1	2	4		
3 / 2 4 / 2 0 2 5 1 2: 2 1: 3	5	5	5	5	5	5	5	5		

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3 / 2 4 / 2 0 2 5 1 2: 3 6: 5 4	4	3	5	4	3	3	3	5	Being able to see what the capac ity looke d like in real time was a novel conce pt	Difficu Ities scann ing QR Code/ Acces sing App at times due to conne ction	Great idea! Is there a way to ensur e that the numb er of availa ble spots are maxi mized with meas ureme nts of car space ? Might help if we had that in mind.
3 / 2 4 / 2 0 2 5 1 2: 4 2: 4 2: 4	4	5	5	3	1	3	1	1	Easy to use with scann ing the QR code.	Peopl e did not check in or out somet imes, so the amou nt of availa ble and	Havin g lines for the spots would be helpfu I since part of the proble m is that cars

6									unavai lable spots was not accur ate.	are parkin g diago nally or too far over and are taking up two spots instea d of one.
3 / 2 4 / 2 0 2 3 5 1 2: 4 6: 3 4	5	5	5	2	2	3	4	l appre ciate the effort in trying to allevia te parkin g strugg les. The app was extre mely easy to check in.	It was hard to open up when drivin g, could only link to it from the teach er's email to us.	It is difficu It and dange rous to check an app like that while you are drivin g. The sticks in the groun d with the QR codes make it more difficu It to park

and pull your car out of the lot. I'm hopin g the middl e ones are remov ed. It would be better if the lot was paved and the QR was on the groun d. One time that I parke d, I tried to scan the QR, but the paper
QR, but
the
was
curve d and
it

										would n't scan, so l gave up. Great effort!
3 / 2 4 / 2 0 2 5 1 2: 5 3: 5 1	5 5	5	4	4	3	3	5	it was easy to use	other teach ers didnt bother to sign out or sign into a spot, so it wasnt alway s accur ate. others often ignore d the appro priate spots and just parke d where ever they felt like	the signs shoul d be place d differe ntly - evenly space d and in proper lines.

3 / 2 4 / 2 0 2 5 1 2: 5 8: 5 8	5	5	5	5	1	1	1	1	l liked how easy it was to use.	stop to check the app on my way to work. I think it needs a notific ation syste m that infor ms me of availa ble spots on my way to work. But then agian, availa bility chang es by the minut e during morni ng check in, so it would only help ito	

										infor m me there are no more spots so l don't	
										waste time drivin g to the lot. Other than that, even if there is one spot left, I don't	
										need to know.	
3 / 2 4 / 2 0 2 5 1 3: 2 1: 3 6	5	5	5	5	3	3	3	5	the conve nienc e	Nothi ng	I am first to schoo I so a few of the questi ons did not pertai n to me. I love the idea of the app.

3 / 2 4 / 2 0 2 5 1 3: 2 9: 2 5	5	5	5	5	3	3	3	5	Real-ti me updat es & clear idea of space	Manu al input of check- in	QR code stake s made it more difficu It to park and get out of middl e aisle.
3 / 2 4 / 2 0 2 5 1 4: 0 7: 3 4	3	4	5	3	3	3	3	5	Ease of checki ng in	l would go to check in and it would ask me to check out first, then check back in.	It would have been nice to have an app to actual ly log in to rather than havin g to keepin g my Intern et brows er open in order to acces s the live map.

3 / 2 4 / 2 0 2 5 1 4: 1 4: 2 7	5	5	5	4	5	5	5	5	lt's easy to use	None	Some are not using the app
3 / 2 4 / 2 0 2 5 1 4: 1 5: 2 4	5	5	5	5	3	3	4	5	Quick and easy to use	not eveyb ody used it.	Auto check if vehicl e is in spot.
3 / 2 4 / 2 0 2 5 1 4: 1 7: 2 4	5	5	5	4	3	2	3	3	I really loved this creati ve way to be helpfu I to let teach ers know ahead of time	While the app was very user friendl y, the link wasn't easy to find unless saved or	Great job with this great innov ative idea to help teach ers.

								of availa ble spots.	book marke d. A notific ation alert to alert the parkin g lot is full might be better.	
3 / 2 4 / 2 0 2 5 5 1 4: 4 7: 4 8	2	5	2	2	3	3	4	I like the idea aroun d this app. It would be helpfu I to see if the lot is full or not, especi ally if we are runnin g late.	The most frustr ating was that teach ers never "chec k out." The next day when I went to "chec k in", I could not becau se the teach er from the day before never "chec	This was great! Teach ers shoul d have been infor med earlier so we knew exactl y what to expec t. It was kind of a surpri se to teach ers, so a lot were confu sed.

										ked out". Theref ore, really hard for me to use the app. But the idea is fantas tic! Peopl e just had to be dilige nt about checki ng out.	
3 / 2 4 / 2 0 2 5 1 4: 4 9: 2 6	5	5	5	4	3	3	3	4	It gave info about spots that was not availa ble	many times spots were not check ed out	the check out shoul d proba bly reset after a period of time and can be set by the locati on using the app.

											In our case, we know the lot is not an overni ght parkin g space
											and empti ed each day.
3 / 2 4 / 2 0 2 5 1 5: 1 5: 0 9	1	1	1	1	1	1	1	1	l would prefer each car gets a sticke r.	The Intern et and Servic e is bad.	The QR Code is too small
3 / 2 4 / 2 0 2 5 1 5: 3 1:	4	5	3	2	1	1	3	5	Color codin g made it easy to under stand visuall y	Difficu It to check availa bility witho ut scann ing in	

4 9											
3 / 2 4 / 2 0 2 5 1 5 5 1 5 4	1	1	5	3	1	1	1	1	l appre ciated the idea itself.	 not everyo ne will have time to use it: ppl rush out of the car and into the buildi ng. one perso n who does not do it make s the entire thing ineffe ctive; it is not safe to operat e any app or device while drivin g. The orang e stick is place 	never give up after an app failed. Get anoth er one worki ng.

										d in the way of a car gettin g out of the lot.	
3 / 2 4 / 2 0 2 5 2 0: 4 2: 3 5	3	1	4	3	1	1	1	1	Did not like.	Anoth er thing to stress about early in the morni ng. Stress ing to look and take pic before work.	Parkin g worke d well before hand
3 / 2 5 / 2 0 2 5 7: 2 5: 1 1	5	5	5	5	5	5	5	5			
3 / 2 5	5	5	5	5	5	3	5	5	Easy to use	There were times when	none

/ 2 0 2 5 7: 5 1: 2 1										staff memb ers did not scan the QR code and they were parke d in a spot	
3 / 2 5 / 2 0 2 5 1 0: 1 8: 5 6	5	5	5	5	5	5	4	5	Being able to check before gettin g into the parkin g lot to see if there were empty spots.	l found it frustr ating and could n't under stand why some staff would not partici pate.	What a great idea this was!!
3 / 2 5 / 2 0 2 5 1 4: 1 8:	5	5	5	5	1	2	1	5	I think the conce pt is great and would help if everyo ne used it. I loved	somet imes the QR codes we hard to scan. Also, havin g to check	

1 7									that it create desig nated spots in the lot so peopl e know where to park	in when you are outsid e of your vehicl e is not ideal when it is rainin g and/o r you are carryi ng a lot.	
3 / 2 6 / 2 0 2 5 9: 0 2 5 9: 0 5 3	5	5	4	5	5	5	2	5	Live Map allows me to decid e in advan ce what time I shoul d leave my house	The lamin ation cause s the QR code to not scan some times, and Live- Map wasn't alway s updat ed/res et the next day.	Not everyo ne used the app, and some peopl e parke d betwe en QR codes (took up multip le spots)