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Research on the Traveling Characteristics and Comparison of Bike Sharing in College Campus–A Case Study in Hangzhou

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Abstract: Bike sharing emerging from college campus in Mainland China has become a major part in the daily traveling of Chinese urban residents. It changes the traveling behavior of urban residents, and simultaneously, raises higher requirements on urban transportation facility construction and management. However, the return of bike sharing to college campus causes more troubles to schools. The fundamental cause is the closed peculiarity of campus traveling comparing with city traveling, and also the discrepancy between college campuses of different types. This paper investigates the traveling characteristics of bike sharing in college campus in three different locations in Hangzhou City, Zhejiang Province of China in the questionnaire, and compares the discrepancy with urban bike sharing traveling characteristics and the discrepancy in bike sharing use between college campuses of different types. From the perspective of parking, maintenance and operation, and hardware design, the paper eventually raises suggestions to optimize independent college campus bike sharing service facility and management consistent with urban system. The research may also offer beneficial reference to the release of bike sharing facilities consistent with urban system in all sorts of independent parks, especially college campus.

Keywords: Bike Sharing; university campus; travel characteristics; Hangzhou

1 Introduction

Public bike service originated from an experiment in Amsterdam in the 1960s. Throughout the development for decades, together with the maturity of third-generation service station system technology and application in international cities led by Paris, public bike service obtains rapid development across the world [1–2]. As of the introduction of third-generation public bike service (service station system, in 2008), China becomes the country with fastest-growing public bike service. By September 2016, altogether 400 third-generation public bike service systems and 1.2 million public bikes[1] had been officially put into use in Chinese mainland. For a time, China became the world-largest public bike market [3]. At the same time, OFO began the earliest experiment on small-scale public bike without service stations in the college campus of Beijing, China, which was later known as the embryo of "bike sharing". In April 2016, Mobike incorporated network positioning and electronic lock technology into bike, and ushered in a street fashion for Internet sharing bikes without service stations. Afterwards, OFO also developed and upgraded corresponding technologies, and began to offer urban bike sharing service outside college campus.

[1] According to the statistical data and launched information of each city, not including 7 systems in Hong Kong and Taiwan area, also not including the bike sharing systems (without service station) such as Mobike and OFO.

In 2016–2017, bike sharing massively marched to nearly all main cities on Mainland China. The development of bike sharing experienced a short-term high-tide period. Considerable companies and capital swarmed into the bike sharing market. According to research statistics by June 2017 [4–6], the user scale of bike sharing on Mainland China grossed 106 million in blowout growth momentum. However, the market cooling in late 2017–2018 witnessed the successive withdrawal of numerous bike sharing service companies. Even so, according to the incomplete statistics of the Ministry of Transport [7], there were still approximately 70 Internet bike renting operation companies on Mainland China, and accumulative released bikes totaled 16 million.

After undergoing explosive growth and market reshuffle, bike sharing successfully made public bike a major part in Chinese urban residents' traveling and changed Chinese urban residents' traveling behavior.

However, bike sharing gave rise to a series of problems after its return to college campus, the place where it was born from. At the very beginning, the concept of bike sharing was designed to solve college students' high bike acquisition expenses, loss and stolen risks, difficulty in maintenance and repairing, and "zombie bike" phenomenon after graduation [8]. Moreover, for fear of the outflow of campus bike sharing, earliest college bike sharing experimental system just targeted at students on campus. However, with the success and blowout growth of bike sharing mode in the society as of 2017, lots of bikes entered college campus in Mainland China and disorderly parking issue immediately turned increasingly prominent, which posed a huge challenge to teaching management and campus order. Some schools even prohibited or selectively prohibited the entry of bike sharing [9–10]. From 2018, Hangzhou West Lake District Urban Management Bureau began the trial operation of bike sharing in community and building, marking the re-entry of bike sharing backed by electronic fence and grid management technology to college campus [11].

Then why does such mature bike sharing mode in city cause so much trouble to college campus? The main reason should be different traveling behaviors between bike sharing in most independent and closed college campuses in Mainland China and common urban bike sharing in every location of the city. It is the result of unsound bike sharing facilities and management measures. By comparing the traveling characteristics of bike sharing on campus and in the city, the paper proposes suggestions for the operation, management and facility construction of bike sharing in college campus based on the case of Hangzhou, and simultaneously discovers the discrepancy in bike sharing use characteristics between college campuses of different type.

At the same time, the paper proposes suggestions for the operation, management and facility construction of bike sharing consistent with urban system in independent college campus, and simultaneously offers beneficial reference to the release of bike sharing facilities consistent with urban system in all sorts of independent parks, especially college campus.

2 Structure

At present, lots of scholars have analyzed the traveling behaviors and characteristics of bike sharing. Ran et al. establish a binomial Logit model for bike sharing traveling, concluding that gender, age and education leave significant impact on bike sharing traveling [12]. Based on Mobike development statistics, Lv et al. analyze bike sharing traveling characteristics in Shanghai City, and propose a set of development strategies, including clarifying riding development orientation, improving riding space environment, executing intelligent management measures [13]. Others observe bike sharing traveling characteristics in Guangzhou Tianhe CBD, and advocate to further monitor the dynamics of bike distribution, mobility and user traveling with intelligent feedback system, therefore formulating a more scientific and rational deployment and placement scheme [14].

Moreover, some scholars also conduct related studies on campus bike sharing traveling changes and use conditions. Jiang et al. observe the bike sharing traveling changes of college students, and raise measures to improve campus bike sharing operation [15]. Combining with survey and analysis results about bike sharing on campus, He et al. [16] put forward some measures to promote the sustainable

development of bike sharing in colleges, like controlling quantity, setting up parking lot, etc.

In a word, existing studies mostly investigate urban bike sharing traveling behaviors in Mainland China, but pay less attention to bike sharing traveling characteristics in college campus. No study has raised any suggestion to guide the orderly return of campus bike sharing to college campus from the perspective of traveling characteristics. As a consequence, this paper will expound campus bike sharing traveling characteristics in Hangzhou based on existing studies, compare it with general urban residents' bike sharing traveling characteristics, and summarize campus bike sharing use characteristics and peculiarity so as to offer strategic support to bike sharing construction, management and operation on campus and propel sustainability of campus bike sharing.

3 Research Methodology

In order to effectively learn about the use condition of campus bike sharing, the paper takes students in Zhejiang University Zijingang Campus, Zhejiang University of Technology Chaohui Campus and Zhejiang Sci-Tech University Xiasha Campus (three different types) as the research subject in Hangzhou, Zhejiang Province of China, and surveys their bike sharing use condition in the morning and afternoon on June 20th 2018–June 22nd 2018.

As shown in the Fig. 1, the three campuses chosen by the research represent three different types. In particular, Zhejiang University Zijingang Campus adjacent to central urban district (traffic restricted district) in the western end is the urban fringe type 8 km away from the downtown. It has largest campus coverage, totaling approximately 2.13 km^2. The in-campus commuting distance inside the campus lasts for around 2.5 km. The commuting distance for students is fairly long. The distance between the campus and nearest subway station is 500 m.

Zhejiang University of Technology Chaohui Campus in central urban district is the traditional city center type, 2.5 km away from the downtown. Surrounded by mature peripheral facilities, the campus is connected to many bus routes. The campus has a small coverage, approximately totaling 355,000 m^2. The in-campus commuting distance for students is about 1 km.

Zhejiang Sci-Tech University Xiasha Campus in city higher education district is the urban separately periphery type, 19 km away from the downtown. However, it is close to a subway station. With a full coverage of around 647,000 m^2, the in-campus commuting distance for students is around 1.5 km.

The questionnaire consists of four parts, namely bike sharing traveling characteristics, use condition, traveling will, and respondent personal attribute. Altogether 500 questionnaires have been recollected, including 422 valid questionnaires and 80 invalid questionnaires.

As to the distribution of respondent campus, the number of data collected from three campuses is very close. Therefore, the research precisely reflects the bike sharing use characteristics in different campuses. In particular, it collects 147 pieces of data from Zhejiang Sci-Tech University Xiasha Campus with a proportion of 34.8%, 132 pieces of data from Zhejiang University Zijingang Campus with a proportion of 31.3%, and 143 pieces of data from Zhejiang University Chaohui Campus with a proportion of 33.9%.

As to the gender of respondent, there are more male respondents but fewer female respondents. The gender ratio is 1:08.

As to the age distribution of respondent, respondents are mostly aged below 25. Among them, 123 respondents are aged below 20, 270 respondents are aged in 21-25, 22 respondents are aged in 26-30 and only 7 respondents are aged above 30.

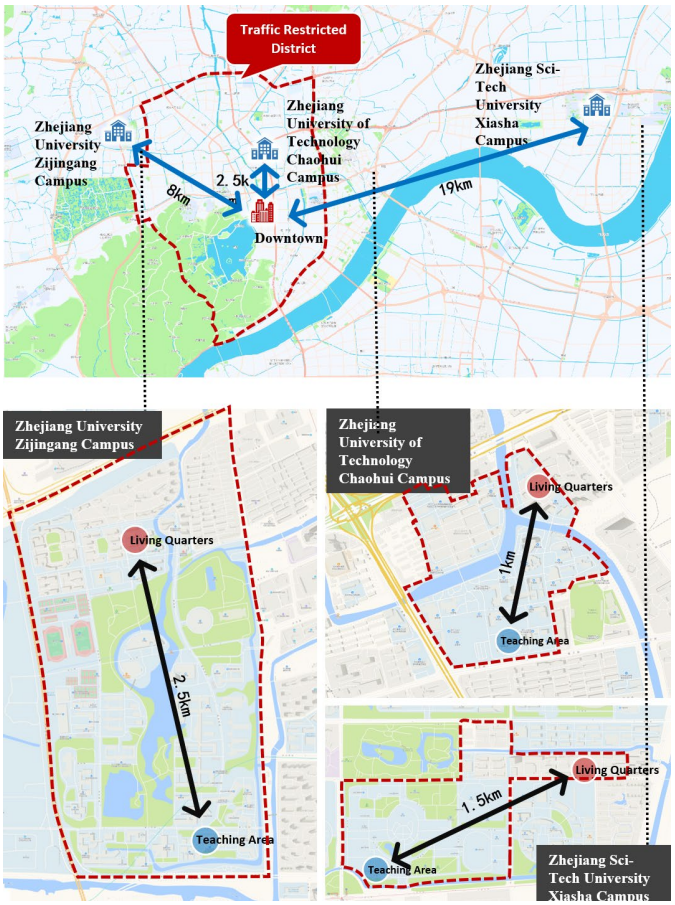

Figure 1: Location and overview of three campuses in Hangzhou

4 Campus Bike Sharing Use Characteristics and Comparison with Urban System

4.1 Campus Commuting is the Main Purpose of Bike Sharing Traveling with High Concentration

Due to the closed slow traffic space and short traveling distance in college campus, bike sharing well caters to the traveling demands of college students. As indicated by the survey results, college students mainly choose bike sharing to satisfy their commuting demands. Among all respondents, 66% of them ride a bike to go to class, go to school or return to dormitory. The main purpose of 22.6% respondents is to attend class or go to work. Comparing with Hangzhou residents' traveling data [17], it can be found that the average commuting ratio of urban residents in Hangzhou in 2015 was 56.9% and campus bike sharing traveling had a higher ratio. Similarly, comparing with 50%-55% [18–19] commuting ratio in an urban public bike traveling survey, campus bike sharing traveling still has a higher ratio. Besides, as the accommodation district is separate from the teaching district, and respective space is rather concentrated in college campus, the commuting time is consistent with class schedule. It is also the reason why college campus has high traveling concentration, and encounters more difficulties in use and parking than other urban areas.

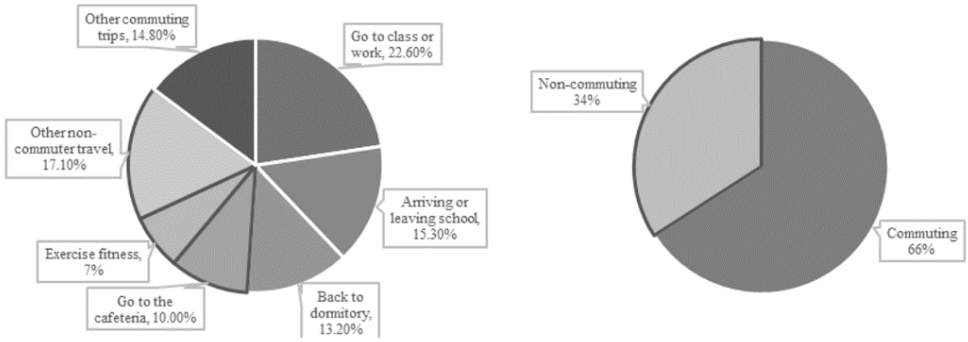

Figure 2: Travel purpose for campus shared bicycle

4.2 High Traveling Rate and High Bike Sharing Daily Use Rate

Traveling frequency can generally show students' traveling demand intensity in all activities. As suggested by the survey, students travel for around 8.4 times per day. Throughout the crosswise comparison with average traveling frequency in other cities, it implies that residents in most cities travel for around 3 times per day on average. Therefore, the traveling frequency of students nearly doubles that of urban average level, and students have higher traveling frequency and demands. According to the comparison about the distribution of traveling frequency in Hangzhou, merely 10.9% students travel for less than 4 times per day in college campus, and urban residents mainly travel for less than 4 times per day with a ratio as high as 84.4%.

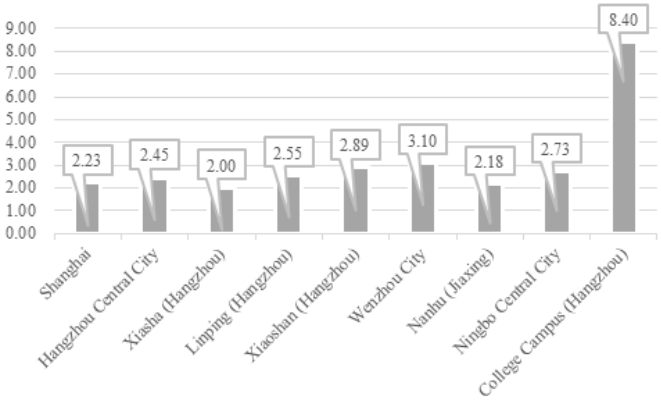

Figure 3: Comparison of daily travel times in different cities

Analysis on the use efficiency data of students' bike sharing in college campus proves that around 56% respondents (daily users) would use public bike every day. If users who use public bike for less than once, 1–2 times, and over twice throughout a day are respectively defined as low-frequency users, middle-frequency users and high-frequency users, the ratio among the three is 44%:31%:25%. In a comparative study, simply 18.58% Kunming residents use bike sharing service everyday [20] and 15.2% Hefei residents use bike sharing service everyday [21]. According to the statistics of Mobile in August 2016, even the average daily ride of Mobike registered users is only 56.7% [13]. Obviously, bike sharing traveling mode has become one of the main traveling modes of 50% college students. The survey data for campus bike sharing service satisfaction reflects college students' positive attitudes towards bike sharing: 24.9% respondents are satisfied with present campus bike sharing service, 56.9% respondents are basically satisfied, and 83% respondents advocate or encourage the development of bike sharing in college campus.

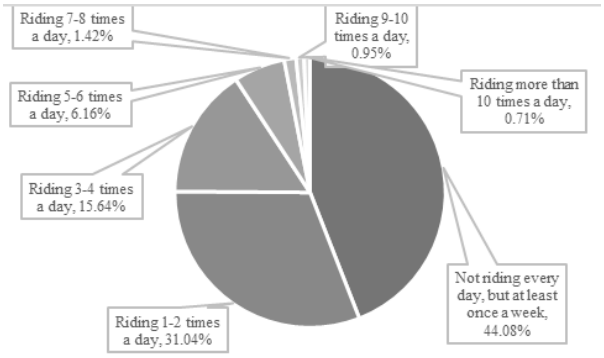

Figure 4: Comparison of the frequency of campus respondents using shared bicycles

Therefore, bike sharing has substantial demands in college campus. Short supply issue will come into being if public bikes in college campus are released on the same scale with those in cities, but excessive supply may also cause difficulty to parking and management. In the survey, 27.9% respondents agree that public bikes in college campus are in short supply now.

From the perspective of schooling years, there is no significant discrepancy among respondents from different grades in bike sharing use frequency. But comparatively speaking, sophomores have supreme bike sharing use frequency, and freshmen have lowest bike sharing use frequency. Gender leaves great impacts on bike sharing daily traveling times. Among all respondents, 50.5% women use less than once public bike per day on average, while the counterpart among men is just 38.9%.

4.3 Campus Bike Sharing Traveling Durations is the Same with the Outside World but Campus Bike Sharing Traveling Distance is Much Shorter Than the Outside World

Respondents' average use duration of bike sharing service is 14.1 minutes. 79.7% respondents say that they use public bikes for less than 20 minutes. On the whole, the use frequency of bike sharing gradually decreases with the growth of duration. As to bike sharing traveling duration, college students' use condition is basically the same with other users in other urban areas. For instance, Shanghai Mobike users' average traveling duration is 14.8 minutes, and 76% users use for 20 minutes [13]. The figure in Tianjin is 13.3 minutes [19].

In accordance with collected data, campus bike sharing users mostly travel for less than 2 km (61.5%), and the average traveling distance is 1.2 km. By contrast, Shanghai Mobike data suggests that the ratio of traveling distance below 2 km is just 46.71% and the average traveling distance is 1.84 km [13]. Likewise, public bike traveling distance in Tianjin [19] and Xiaoshan downtown is much longer than in-campus bike sharing traveling distance [17,22].

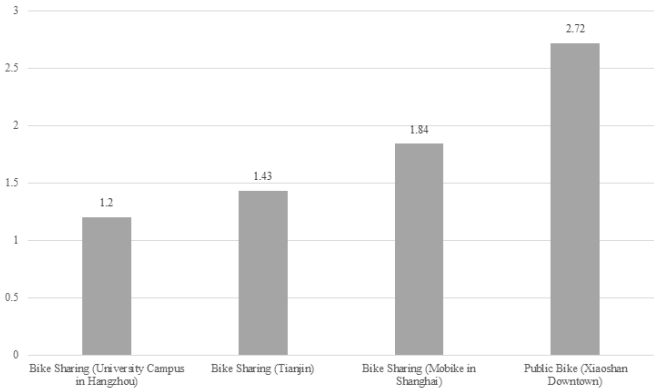

Figure 5: Comparison of travel distances of shared bicycles (public bicycles) in different cities (unit: km)

4.4 Bike Sharing Replaces Former Short-Distance Traveling Mode Dominated by Walking, Bus and Subway

College campus respondents mainly replace bike sharing with former walking (33.3%), bus (20.4%) and subway (18.0%) traveling mode, and moreover, the discrepancy between daily users and non-daily users is not so significant. On college campus, bike sharing has most appalling attraction to students who formerly rely on walking mode, as approximately 1/3 bike sharing users are converted from walkers. At the same time, bike sharing competes with bus traveling mode, such as bus and subway, as a great many bus travelers now choose bike sharing for short-distance traveling. This is consistent with findings in city bike sharing use characteristics research [13–14,19].

4.5 The Prime Reason of Bike Sharing Use is Efficiency, and There is Discrepancy Between Daily Users and Non-Daily Users in Secondary Reason

As to the prime reason of bike sharing use, college campus questionnaire survey indicates that "saving time" (27.5%), "saving money" (16.7%) and "convenience for transfer to subway or bus" (17.3%) are three foremost reasons. This finding basically conforms to off-campus research results [13–14,19].

Throughout further research on the reason why daily users (who at least use bike for once a day) and non-daily users (who use less than once a day) choose bike sharing, it turns out that another reason for non-daily users is that "they have more freedom in traveling, because they do not have to take the bike anywhere and can exchange the bike in traveling at will" except above-mentioned three ones. While daily users comment that "they do not have to worry if the bike will be stolen". Thus it can be seen that apart from efficiency, daily users focus more on reliability, and non-daily users focus more on freedom.

As proved by the survey, main problems faced by bike sharing use in three college campuses are "inadequate quantity of bike", "disorderly parking of bike" and "bike hardware or software". The proportion of the three is respectively 27.9%, 21.8% and 19.8%.

4.6 College Campus Bike Sharing Use Payment Means is Related to Use Frequency

The prime payment means of respondents in college campus is "month card" and "pay per view". The proportion of the two is respectively 42.7% and 38.2%. 55.1% daily users purchase month card, while 54.3% non-daily users pay per view. As indicated by the survey, college campus daily users more would like to pay more for bike sharing service than non-daily users.

5 Comparison of Bike Sharing Use Characteristics in Different Types of College Camps

5.1 Daily Traveling Times is Inversely Proportional to Campus Coverage, and Bike Sharing Daily User Proportion is Related to Campus Location

As indicated by the survey data, daily average traveling times in college campus is inversely proportional to campus coverage, which means that the daily average traveling times is higher in smaller campus. On the whole, college campus bike sharing traveling frequency distribution is related to campus location. The greater distance from downtown, the higher proportion college campus bike sharing daily users.

The proportion of bike sharing daily users in Zhejiang Sci-Tech University Xiasha Campus located in urban periphery district is 68.71%, and that in Zhejiang University Zijingang Campus located in urban central district and Zhejiang University of Technology Chaohui Campus located in urban downtown is 60.61% and 38.46% respectively. If the grouping is further made according to high-frequency, medium-frequency and low-frequency criterion, then both low-frequency users and medium-frequency users will be affected by location. As to high-frequency users, larger college campuses have more high-frequency bike sharing users. For instance, the proportion of high-frequency users in largest Zhejiang University Zijingang Campus is 32.58%, and that in medium Zhejiang Sci-Tech University Xiasha Campus and smallest Zhejiang University of Technology Chaohui Campus is 29.25% and 13.29% respectively.

Table 1: Comparison of average traveling frequency and bike sharing use frequency

	Zhejiang University Zijingang Campus	Zhejiang Sci-Tech University Xiasha Campus	Zhejiang University of Technology Chaohui Campus
Campus coverage	2.13 km^2	647,000 m^2	355,000 m^2
Average traveling frequency	7.83 times/day	8.59 times/day	10.20 times/day
Distance to downtown	8 km	19 km	2.5 km
Daily user proportion	60.61%	68.71%	38.46%
Low-frequency users	39.39%	39.39%	39.39%
Middle-frequency users	28.03%	28.03%	28.03%
High-frequency users	32.58%	32.58%	32.58%
Total	100.00%	100.00%	100.00%

5.2 Bike Sharing Primarily Serves in-Campus Traveling, and Bike Sharing Off Campus Traveling Rate is Higher in College Campus Located in Urban Downtown

This survey reveals that comparing with urban bike traveling distance, the traveling scope of bike sharing users in college campus is more limited. Most college students just ride a bike to travel inside or around the campus. 55% respondents use the bike mostly inside the campus, and 45% of them mainly use the bike outside the campus.

There exists significant discrepancy between different types of campus in bike sharing use scope. With the growth of distance from downtown, bike sharing serves more on-campus conditions. Likewise, 40.1% bike sharing traveling in Zhejiang Sci-Tech University Xiasha Campus serves on-campus. While the figure in Zhejiang University Zijingang Campus located in urban central district is 34.1%. And in Zhejiang University of Technology Chaohui Campus located in urban downtown which has been dominated by off-campus traveling, the figure is 42%.

6 Suggestion

In view of the special campus bike sharing traveling characteristics, and campus users' high satisfaction and support rate for bike sharing, the paper combines with the main contradictions and problems in current campus bike sharing service, and begins with bike parking, maintenance and management, and hardware design to propose suggestions in favor of the development of bike sharing in intelligent campus and IoT-based community [23–28].

6.1 Colleges and Companies Should Collaboratively Formulate the Dispatch and Maintenance Proposal, Plan in Advance, and Regularly Make Dispatch

Campus bike sharing traveling has strong regularity, and the main traveling purpose is to go to class, go to dining hall or return to dormitory. As a consequence, the campus manager and campus bike sharing operator may use information technology to collect traveling track information, and precisely predict the supply and demand of bikes with campus teaching arrangement and functional architecture layout, formulate regular scheduling and prescribe dispatch plan in advance.

At the same time, such repeatable traveling characteristics in college campus requests repeatable scheduling of bike sharing. As college class usually lasts for 90 minutes, the scheduling time of most bikes should be maintained within 90 minutes. Under such circumstances, fast scheduling is indispensable. Now, bike sharing service has developed patents such as auxiliary handling device, automatic loading and unloading carriage.

Moreover, for guaranteeing the optimal use of campus bike sharing service, colleges and companies should collaboratively formulate the scheduling and maintenance proposal, in which companies dispatch specialists to regularly supervise and maintain hardware, and colleges take

charge of bike scheduling and management.

6.2 Establish Large Parking Area in Key Stations and Normalize Parking Area

College campus has a fixed and uniform timetable. There are multiple traveling peak hours on workdays for class or dining, and the traveling peak hours are very concentrated in time and space. Therefore, colleges may establish large parking area in key stations like teaching buildings, dining halls, dormitory buildings, normalize parking area and satisfy parking demands in peak hours.

If the parking area is still limited, the colleges may temporarily install new parking area, and retain specialists to maintain the order in peak hours.

6.3 Turn Campus Bike Sharing Mode Flexible and Increase the Number of Exclusive Shared Bikes in College Campus

Pursuant to the feedback of campus respondents, teachers and students still hold positive attitudes towards bike sharing. Shortage of bike is deemed as the main problem in the development of bike sharing service in college campus. Considering the restriction of bike sharing use in college campus, a great many users use bikes at school. Therefore, colleges may flexibly regulate in-campus bike sharing mode, employ electronic fence technology, add exclusive in-campus bikes and charge scheduling fee for those bikes traveling outside the campus. Meantime, colleges should also properly add more exclusive in-campus bikes to compensate slow traffic shortage according to the use condition.

6.4 Realize the Data Connection between Campus Manager and Social Bike Sharing Operator and Allow in-Campus and Off-Campus Use of Campus Custom Bikes

Considering the chronic defects of bike sharing order and management, the paper advises to realize the data connection between campus and bike sharing operating companies, share information of the shared bikes in the campus, such as bike number and campus card number information, and allow students to go to school by shared bike. Disorderly parking issue may be solved by daily evaluation, electronic fence and other similar measures. Specifically, bike sharing operators may develop customized bikes for college campus, and allow college students to use such bikes inside and outside the campus. For ensuring the adequacy of bikes in college campus, colleges can charge high scheduling fees for off-campus parking.

6.5 Realize Special Campus Bike Sharing Design, Simplify Process and Make Bike Sharing Service Convenient

Campus bike sharing has special characteristics of short distance and high-frequency traveling. Therefore, colleges may develop customized bikes for campus, specialize the design and simplify bike borrowing and returning process.

In comparison with traditional borrowing and returning mode by slot card, conventional code sweeping technology for bike sharing service takes multiple links including phone unlocking, opening the application and sweeping code to borrow the bike. Such technology brings about convenience free of card, and lengthens the process duration. The paper advises to take technologies like campus card and phone NFC to further increase convenience.

7 Citations

On the basis of questionnaire data concerning bike sharing traveling time in three types of college campuses in Hangzhou, the paper discovers that bike sharing traveling mode in college campus has unique characteristics, and bike sharing in college campus has more pertinent objectives, higher usage ratio, and shorter traveling distance. While average traveling time is basically the same with off-campus public bikes. College campus users use bike sharing replace former short-distance traveling mode

dominated by walking, bus and subway. Saving time and money and convenience for transfer to subway or bus are the prime reasons why college campus users choose bike sharing. There exists discrepancy between daily users and non-daily users in secondary reason. College campus bike sharing use payment means is related to use frequency.

In different types of college campus, the survey also finds that daily average traveling times is inversely proportional to campus coverage, and bike sharing daily user proportion is related to campus location. Bike sharing traveling on college campus mostly serves on-campus traveling, and bike sharing off-campus proportion is higher in college campuses located in urban downtown.

Aiming at the main issue in campus bike sharing service, the paper proposes five suggestions for college campus bike sharing operation from the perspective of paring, maintenance and management, and hardware design, including normalizing parking facilities in parking area, organizing regular scheduling and maintenance, turning campus bike sharing mode flexible, connecting campus manager and social bike sharing operator data, specializing campus public bike, simplifying borrowing and returning process.

As campus bike sharing traveling characteristics research data is collected from three colleges in Hangzhou, the paper has a limited sample size. We hope future studies should make further improvement at this point. The author sincerely hopes that the research finding may offer beneficial reference to the release of bike sharing facilities consistent with urban system in all sorts of independent parks, especially college campus.

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