applied sciences

MDPI

Article

How do University Student Cyclists Ride? The Case of University of Bologna

Roberto Battistini , Alessandro Nalin *, Andrea Simone , Claudio Lantieri and Valeria Vignali

Department of Civil, Chemical, Environmental, and Materials Engineering—DICAM, School of Engineering, University of Bologna, 40126 Bologna, Italy
* Correspondence: alessandro.nalin2@unibo.it; Tel.: +39-51-20-93522

Abstract: In a general urban planning context, in which sustainable active mobility progressively takes up increasing attention, studies of cyclists' attitudes and behaviors represent a relevant step to help any enhancing measures for urban cycling. Among different categories, university student cyclists represent a still unidentified class, despite the relevant impacts in terms of mass and variability of attitudes in urban areas. The novelty of this paper is to propose an innovative overview on the specific category of university student cyclists. The integrated methodology, based on direct observation through GPS detection, GIS processing, and qualitative survey, permits the evaluation of some interesting issues related to students' propensity to cycling and their mobility patterns. The approach finds relevance in speed, frequency of movements, routing, and related infrastructure preferences. The methodology has been applied to a sample of more than 300 students of the University of Bologna who were allowed an original university-designed bicycle from February 2021 to June 2021. The analysis was applied in the Bologna urban area and allowed the evaluation of students' preferences of using existing cycle paths, when available, the limited relevance of speed factors, the main distribution of commuter journeys concentrated in the main avenues directed to city center, and other behaviors.

Keywords: behavioral; Big Data; cycling; cyclist behavior; GPS; GIS

check for updates

Citation: Battistini, R.; Nalin, A.; Simone, A.; Lantieri, C.; Vignali, V. How do University Student Cyclists Ride? The Case of University of Bologna. *Appl. Sci.* **2022**, *12*, 11569. https://doi.org/10.3390/app122211569

Academic Editor: Marco Guerrieri

Received: 28 October 2022
Accepted: 11 November 2022
Published: 14 November 2022

1. Introduction

In recent years, makers have directed increasing attention to the cycling phenomenon, in terms of Sustainable Urban Mobility Plans (SUMPs), road safety, and accessibility. In particular, SUMP, as an integrated planning approach that addresses all modes and forms of transport in cities and their surrounding areas, contributes to the European climate and energy goals set by the EU. SUMPs challenge transport-related problems in a more sustainable way, in which cycling is a relevant part. Even if information on cycling is not specifically detailed in the SUMP guidelines, since 2011, ELTIS counted more than 325 cycling projects in SUMPs (besides 325 pedestrian projects and 770 road projects). Cycling is framed in SUMPs within the concept of "Active sustainable mobility", together with walking, representing a solid alternative to private cars, introducing a lot of health and environmental benefits.

In order to efficiently enhance active sustainable mobility, cities must devote attention to safety and to cyclists' behaviors, with the aim of identifying strategies and actions to improve the cycling conditions [1]. In general, the strategies concerning cycling infrastructure design and transportation will demand soft measures, for example, in the shape of introducing innovative cycling services, adopting specific communication approaches, and enhancing a different urban perception. In both issues, of the dominant topic is road safety. Aa total of 9500 people were killed on urban roads in the EU in 2017, which represented about 38% of all road deaths; additionally, in urban areas, cyclists and pedestrians together made up over half of all the road deaths and cyclists alone accounted for 12% of road deaths [2]. However, cyclists form one of the most vulnerable groups of road users [3]. The design of safe infrastructures for all categories of travelers, including cyclists, becomes a primary requirement, as stated by [4]. Consequently, safety is a relevant topic connected both to infrastructure quality and cyclists' demands [4]. On the other hand, city governances are struggling with the decisions on which kind of cycling infrastructure is better to invest in, with the aim of improving cycling, i.e., cycle lanes on the carriageway or on separated paths, or bicycle crossings located in the middle of blocks, as argued by [5]. In fact, as the authors of [6] found in Toronto, Canada, some of the major factors that affected the choice of a cyclist route were distance, road type, and the presence of cycling facilities. Some other authors stressed the importance of infrastructure dedicated to cycling. In particular, it was found that higher levels of bicycle infrastructure are positively and significantly correlated with higher rates of bicycle commuting [7], while the presence of facilities at roundabouts and junctions generally has not had a significant effect on perceived risk or acceptability of cycling [8]. The main implication is that the provision of facilities at a junction may have a counter-intuitive effect and suggest to potential cyclists that the junction is riskier than it might otherwise have been perceived to be. Bicycle facilities along trafficked routes contribute only a little to the moderation of perceived risk, but the major component of the reducing risk perception effect is for facilities that are off-road or adjacent to the road [8].

The relevance of data harvesting on cyclists' behaviors to establish a database for collision analysis was highlighted by the Rhône Road Trauma Registry, a population-based registry which collects data on all new cases of injuries occurring in the French Département du Rhône following a road collision, or in the case of the city of Oldenburg, which focuses on the increase in both the attractiveness of cycling and cycling safety. One significant technical development has been found to be the installation of cyclist sensors at junctions with traffic lights. Both cases represent how modern technologies and the use of GPS devices or smartphones, combined with software or apps, make it easier to gather exposure data, even for cyclists and pedestrians [9]. In terms of urban policy, surveys conducted in several Canadian cities confirmed the importance of dedicated infrastructure and demonstrated that coordinating public transport with cycling is a crucial factor in encouraging the use of both of these modes of transport [10]. Such integration can be achieved by the provision of convenient and secure cycle parking at both rail and bus stops, cycle racks on all buses, and accommodation of cycles on all rail transit vehicles. Indeed, respondents to a survey conducted at the University of Maryland, College Park, mentioned the lack of cycle lanes as the most important reason that keeps them from cycling [11]. This finding reveals the fact that a connected cycle network is the backbone of a successful bicycle program. In general, all surveys in both Canadian and American cities clearly indicate that more separate cycling facilities—cycle paths and lanes—would most encourage people to cycle. Others studies have underlined the correlation between cycling and proximity to cycle paths on separated carriageways [12].

A different perspective stems from studies on an individual basis. As pointed out by [13], cyclists quantify the importance of environmental factors such as traffic volume and surface quality before choosing cycling routes. Age was positively correlated with a preference for on-road facilities (striped cycle lanes, wide curb lanes), with importance placed on the surface quality, scenery, and cycle safety education, but was negatively correlated with a preference for cycle paths separated from the roadway. Cycling experience was negatively correlated with a preference for off-road facilities and concerns about safety, traffic, and terrain [13]. A survey conducted by the College of Engineering at the University of Texas at Austin [14] indicated that for commuter bicyclists, travel time is the most important factor in choosing a route. The presence of a bicycle facility (especially a cycle lane or a separate path), the level of automobile traffic, the pavement's or riding surface's quality, and the presence of a bicycle facility on a bridge are also very important determinants. An adaptative stated preference survey conducted in the US [15] demonstrated that cyclists prefer to increase the travel time with the aim of using designated cycle lanes. Their preferences are followed further by the absence of parking on the street and by taking a cycle lane facility off-road. A thought-provoking survey has been conducted by The LAB's Bike-friendly University SM (BFU) program, whose aim was the detection of and the promotion /facilitation of cycling levels at universities, through some specific items such as quality bicycling infrastructure connecting campus and surrounding areas, various educational initiatives and resources, cycle share accessibility, a written cycle plan, regular transportation surveys, and secure bicycle storage areas and theft deterrents. The most relevant findings provided a foundation for universities aiming to increase cycle-friendliness for students and employees and informing them about future active commuting interventions on college campuses [16].

At the Technological Educational Institute (TEI) of Athens, a similar survey submitted to students demonstrated the relevance of introducing specific actions for the promotion of cycling to and from the TEI, including the design of a safe as well as functional cycle road path, taking under consideration several traffic-calming measures. Therefore, some proposals for efficient bicycle paths and traffic-calming action were developed [17]. With the specific aim of investigating the connection between environmental, social, and personal factors in cycling among university students, a survey was conducted in the City of Graz. It highlighted students' cycling habits (41% of the students were regular cyclists) and the key factors impacting on cycling such as traffic safety and bicycle theft [18].

Another online survey submitted to young adults (18–25 years) studying at an urban United Kingdom university demonstrates that cycling motivators were enjoyment and improving fitness, especially amongst regular cyclists. However, weather and safety concerns were the main barriers. This study suggests that levels of cycling within a university setting may be higher than in the general population and the appreciation of the merits of cycling are well recognized [19].

A study conducted through focus groups methods at the University of South Australia, at the Metropolitan location of Mawson Lakes, offered an overview of university students' views on cycling, finding key factors for the motivation to cycle in health, affordability, environmental concerns, journey time, and pleasure. Safety is important for all cyclists contemplating the ride to university but staff and students differed over the importance of affordability, on-campus facilities, and the integration of cycling into broader transport networks [20].

Another piece of research on the use of bicycles among the students in the university city of Maribor, Slovenia, was aimed at finding the role of social or infrastructural determinants. The findings of the questionnaire, conducted among 382 students, showed that only 10.7% of students cycle daily, whereas 63.3% do not cycle at all. There were no statistical differences noticed between the impact of infrastructural and social factors; convenience was exposed as a statistically significant determinant, whereas the sustainability aspect proved to be an insignificant factor for students cycling [21]. Routing choices was the main focus of other researchers, who revealed the attractiveness of the different types of infrastructures, examining the effect of traffic volumes, topography, and traffic control devices on route choices [22]. The above-mentioned research relied on GPS data collection in Portland (US) with a participation primarily composed of regular cyclists and a sample of 44% females and 89% aged between 25 years old and 64 years old. The study, based upon a Path-size Logit Model (PSL), demonstrated that cyclists prefer shorter routes, and find relevance of some factors on routing, such as the preference for a separated lane and lane with less exposure to high traffic level. Some interesting deductions were drawn concerning average trip distance (from 3.5 km to 3.7 km) and average speed (from 16.1 km/h to 19 km/h).

All the mentioned studies analyzed regular cyclists with a mixed composition of the sample and a distinction on the basis of the nature of the trip (commute home–work and non-commute, such as shopping, errands). Categorizing the types of cyclists is a relevant topic among this kind of behavioral analysis, in which the need to find a general and common approach and key factors acting on cycling by homogeneous groups are underlined. On this point, the authors of [23] defined their analysis by two main categories: bicycle commuting and non-work cycling, while an analysis conducted in Canada revealed four distinct types of cyclists: dedicated cyclists; path-using cyclists; fair-weather utilitarian;

and 10 leisure cyclists. A survey conducted at the University of Cagliari analyzed the way in which the cycle is perceived by "utilitarian cyclists", "leisure cyclists" and "non-cyclists" categories [24]. More recently, ref. [25] define three users' categories using a dataset made up of GPS traces: risky and hasty, sly and informed and inexperienced and inefficient. In literature, findings in cyclist categories have been generally based on behavioral factors such as social, attitudinal, experiences, safety perception and similar.

On that basis, a lack in the literature has been found analyzing the specific university student category, that embraces a well-defined age range, a behavior bounded by academic activities and studies, and attitudes to city lifestyle and transportation patterns. This issue is more relevant within an urban context such as Bologna, a city that may be described as traditional 'town-based University', in which students represent approximately about 17% of the entire resident population. The housing distribution of students affects urban patterns and dynamics such as the home–study commuting, which offers a wide overview on cycle use and a distribution in temporal and consistency terms. The main innovation and added value of this research is related to findings, indicators and parameters that may help to describe university student cyclists' behavior and the impact of the urban structure on cycling, in terms of habits, speed and cycle paths' relevance to commuting.

Information about student cyclists can be useful to target the enhancing of ecological mobility in university campuses, to analyze the economic value shared by the student presence within hosting cities and to have a Decision-Support system with which to improve the cycling infrastructures towards and near campuses. With respect to universities, they represent an ecosystem that can be external or fully integrated into an urban context. They attract several categories of people (students, professors and researchers, administrative staff, etc.) often covering long distances to reach different places at different hours of the day, thus requiring a sustainable planning approach. Universities may be considered as a cross-section of the population from different socio-economic backgrounds and ages, that generate irregular schedules and the constant movement of people throughout the day, with a risk of social exclusion related to the urban position of the campuses [26]. This is even more noticeable in university campuses located in suburban settings to which the daily commuting of the university population requires longer distances to be travelled, and the predominance of private car use over non-motorized means of transport [27]. Consequently, various transport policies and plans have been adopted internationally to improve the overall quality of mobility around university campuses, in the terms of applied SUMP into a local urban dimension. To orient SUMP design and measure the effect of sustainability actions, in recent years an increasing number of universities spread around the world have begun to make inventories and analysis based upon greenhouse gas emissions (GHG) through the assessment of the carbon footprint, to evaluate and improve the sustainability of the activities [28] produced by universities. Direct emissions come from sources controlled or owned by the universities, while indirect emissions are from the generation of electricity, steam and heating/cooling, as well as from sources not owned or directly controlled by the universities such as travel and commuting that technically have a variable impact ranging from 8% [29] to 51% [30]. These studies demonstrate the relevant impact of university activities on the hosting cities. Indeed, transportation has a wide responsibility for the overall quantum of GHG emissions, and in those terms, SUMPs on university campuses are aimed at reducing the use of private cars and enhancing active mobility.

In general, students' mobility has a relevant impact on urban transportation, and often it shapes the mobility requirements of any city, as indicated in a study conducted at Danang, Vietnam at several universities, in which the findings evidenced that students were more likely to travel by walking or cycling rather than by riding a motorcycle if most of the roads to school were not lanes separated for four-wheeled and two-wheeled vehicles, and that an effective urban strategy to encourage the use of active modes by university students might be to provide more student apartments on or near university campuses [31]. Studies conducted on campuses reveal that university students, young, less-oriented to possess a car and strongly committed to living near campuses, tend to travel by public transport and active modes. In particular, in the case of University of Alabama, the results indicated that areas within one mile of the University of Alabama's campus have the highest levels of bicycle and pedestrian network connectivity and accessibility, increasing the level of active mobilities [32]. A study on the America University of Beirut demonstrates that increasing parking fees and decreasing bus travel time through the provision of shuttle services or taxi sharing could be promising strategies for mode switching from cars to public transport for students [33]. They are also known for being more environmentally conscious and open-minded to new ideas, including in the transport domain [34]. Consequently, the role of cycling is highly impacting on student mobility in urban areas. Even if there is a current lack in the literature on specifically focused studies on university student cyclists, some interesting findings identify the lack of dedicated infrastructure (e.g., cycle paths, safe cycle lanes, and cycle stations [32]) as major barriers preventing students from commuting by bicycle. Other critical factors for cycling are travel distance and travel time. For example, the authors of [35] found that proximity to bicycle infrastructure and the distance from campus were important factors in bicycling to the Ohio State University, USA. In the case of the Autonomous University of Barcelona, Spain, the authors of the studies at [27] and [36] showed that long travel distances were the second main barrier preventing students from cycling to the university (the first was not having a bicycle). In addition, to evaluate solutions able to increase the ratio of cyclists among students, it is relevant to categorize student cyclists in terms of their behaviors and their approaches to the infrastructure and routing.

On the basis of the literature overview and of the relevance of the impact of university campuses in terms of urban sustainable mobility, the present research focused on the findings about the specific category of university students. Following this purpose, the case of the University of Bologna was taken into account, characterized by a higher urban complexity and a wide population of students, oriented in cycle commuting. The main purpose of this research is to shine a spotlight on the undiscovered category of university student cyclists. In the next chapters, the relationship between environmental issues and the university is examined and additionally the case study of the University of Bologna is explained. The scientific interest lies in the framework of the University of Bologna itself, whose complexity permits the creation of an overall perspective on this category.

The paper is organized as follows: in Section 2 a brief overview of the context of Bologna is drawn. In Section 3, the applied methodology will be extensively described. In Section 4, a detailed overview of the results will be presented, which will be discussed in Section 5. Section 6 contains the conclusions with possible future research streams.

2. The Case of the University of Bologna: A General Overview of Cycling Policies

The University of Bologna (informally called "Unibo") has a complex and spread-out setting displayed through a multicampus architecture. This means campuses are based in different cities of the Emilia-Romagna region: Bologna; Imola; Forlì; Cesena; Ravenna and Rimini. Each campus has a different spatial distribution: from a campus with facilities and locations spread-out in the town's historical center, to peripheral campuses placed in isolated surroundings resembling a micro-citadel similar to an Anglo-Saxon setting. Unibo attracts more than 80,000 students and 6000 staff including professors, researchers, PhD students and administrative personnel. This large community has a key role in urban mobility, investing many transportation means, from individual mobility (cars, bicycles, walking) to collective or shared transportation means (local public transportation, railways, car sharing/cycle sharing, etc.), with an evident effect on traffic congestion and consequent pollution. Figure 1 shows the Bologna city center and the main university buildings. The red perimeter represents the city's historical limit; where once a wall defended the city, nowadays a well-designed cycle path ("Tangenziale delle biciclette", Italian for "Cycle Ring-road") allows cyclists a safe ride.

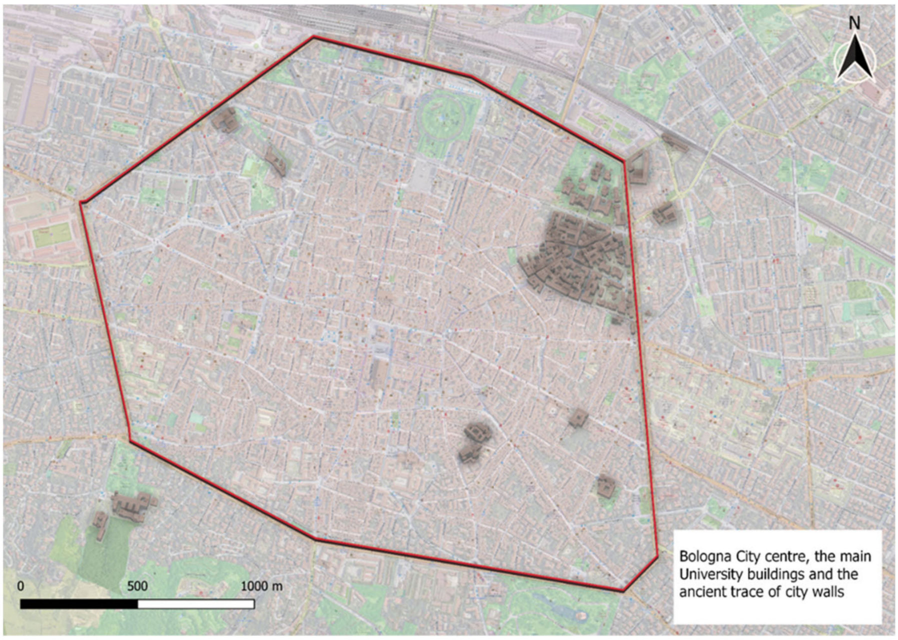

Figure 1. Bologna City center, the main university buildings located in the central area and the ancient trace of city walls.

In 2017 and 2018, online surveys were carried out in order to understand and study mobility choices of staff and students. Their analysis offers an interesting overview on the modal share of each category: specifically, in 2017, the modal share detected for mono-modal trips has been (for all students and workers) 11% of commuting home–university by bicycles, 7% by bus and 10% by car. Regarding cycling, the University of Bologna has developed some specific actions between 2017–2020 with the aim of increasing the share of cycling. The main strategic axes have been concretized on the following three areas: to enhance the image of bicycles, to increase the infrastructure for cycle-hosting in campuses and to increase bicycle lanes connecting the city center with the peripheral campuses. In the first area, the Almabike Project is placed, which designed and produced 600 connected cycles to be freely given to students. The project was born through a student contest in which the winner had to submit the design of a cycle. Consequently, from this design, with the cooperation of a professional designer, the Almabike Project was moved to a production phase. The final result was a connected cycle with added GPS technology able to monitor the cycle's trajectory during both movement and stopping phases, enhanced by an alarm, through a push-mail system, in case of unauthorized movements of the bicycle. This alarm provided a response to the widespread phenomenon of cycle theft in the Bologna area, which has been a traditional and consistent barrier against urban cycling. This particular action could assist in directly reducing the role of the black market in cycles. In the second area, 500 new parking slots were provided for cycles in the cities of Bologna and Cesena. In the third area, a co-design was conducted between the University of Bologna- Civil, Chemical, Environmental and Materials Engineering (Dicam) Department and the Municipality of Bologna for a new public cycle-path, such as the Via Carracci, Vicolo del Pellegrino in Bologna and the main connections between the train station and the new campus in Cesena. Following the first few years, after having applied and communicated these actions, the modal share of cycling increased from 11% to 24%. Furthermore, in 2020–2021, with the spread of the COVID-19 pandemic, the framework suffered from a general reduction in transportation means due to the frequent lockdowns and smart working policies and online lessons adopted by the university. Anyway, cycling represented an exception in 2020 with a modal share of 46%. This increase in factors had to be associated with the relevance of the individual mobility during pandemic, but it seems that the increase did not represent a permanent result, after lockdown/high risk of contagion. Specifically, the Almabike represented the main element of this research project: by exploiting the technical aspects of the Almabike, it has been possible to harvest GPS data representing student routing in the urban area. The privacy limitations linked to GPS usage have been managed by the selection criteria of students. Specifically, the agreement for granting the cycle to students integrated detailed privacy documents, in which the students were advised of the purpose of the position detection and the data usage was described to them. The document required, in mandatory terms, the students' authorization for data usage. The scope of this research is to show a quali-quantitative assessment methodology developed to categorize university student cyclists.

3. Materials and Methods

The research was developed based on the opportunity to have access to the GPS data of the Almabikes. The bicycles were distributed to 321 students, through a series of calls between late 2020 and 2021. The period of observation was from March to June 2021. Figure 2 shows the surveying bicycle.

Figure 2. Almabike vehicle.

The Almabike project concerned only students, and not university staff. It was not configured as a traditional cycle-sharing system, but the cycles were granted though a free loan basis. The selection of students was made through a specific public call, open to all first- and second-degree students, without creating limitations of targeted samples (by gender or type of students, etc.). GPS sensors were integrated by online applications, for Smartphone and PC access through the registration of users, that permits students to have a real-time vision of owner cycle positions and also may activate an anti-theft alarm in case of unauthorized movements of the cycles.

Raw data were registered by GPS sensors installed on the bicycles. The sensors had to be manually recharged by users. Sensors were able to automatically save one entry per minute on average, and the recorded information was both spatial (the coordinates) and temporal (day and time). All the information was unequivocally associated to the relevant bicycle. With respect to privacy limitations, during the data analysis it was never possible to identify the user's identity, and the bicycles were recognizable only by an anonymous ID code. The GPS spatial accuracy for this application was 5 m. This value, when sensors receive the signal under ideal conditions, can be generally accepted [37], but at this stage of analysis, the mentioned spatial accuracy and the absence of complementary devices or data sources introduced some problems in the assessment of cycle paths' usage and choices, with particular regards for travelling along the roadway [38]. To find specific relevance about cyclists' behavior, a short online survey was developed, limited to Almabike users with the aim of detecting specific information able to integrate the GPS data analysis.

Before starting the analysis, a deep data review was conducted in order to filter the outliers from the set of data and to increase the overall database value. In fact, according to [39], and [37], GPS-based analyses should be conducted within a specific workflow, which should contain different steps, from database overview and cleaning to map-matching. In this work, a definite workflow was used, whose main components were already applied and validated by the cited previous works. The preliminary scrutiny, as the rest of the analysis, was conducted by using GIS (QGis software, 3.16 version), spreadsheet (Microsoft Excel) and business intelligence (Microsoft PowerBi) software. Some filtering conditions were manually elaborated, while most of the used algorithms were based on the software features (native or specific plug-ins).

An extensive general overview of the raw data was operated in order to solve most of the recurrent biases and errors registered during the recording such as incoherent tracing and position accuracy of the GPS receiver in function of urban shape and urban canyon impact, that may have reduced the data quality [40]. In order to focus the analysis on Bologna and those surrounding municipalities where Almabike usage was registered (i.e., Casalecchio di Reno, San Lazzaro di Savena, Sasso Marconi and Zola Predosa), a spatial filter was applied. Whilst Almabike vehicles were distributed to the entire university population, records outside the metropolitan area of Bologna were discarded. This constraint was required due to both statistical (about 59% of original records were registered within Bologna and its surroundings) and technical (reference data and GIS layers were more structured here) reasons. GPS sensor outputs were structured in .csv files; every record was characterized by a set of attributes such as the ID number of cycles, the timestamp (hours, minutes, seconds and the date) of the GPS records and the coordinates (in WGS84 reference system). Another attribute related to the speed was not correctly recorded due to GPS biases. However, even if it was less accurate than the computed one [11], the speed was calculated on the basis of timestamps of succeeding points. After the overview, a database extension was performed. Starting from the original attributes, some other fields were calculated. These elaborated fields were meaningful to increase the value extracted from the original data because they gave the opportunity to detect the starting point of a new trip, to intensively study the time distribution of the Almabike usage, according to the date and the time and to deeply analyze the users' behaviors and usage (how many trips were made within the reference period, which is the average speed and trip length, which are the predominant origin/destination patterns, etc.). These new fields were calculated by taking into account the characteristics of the GPS data such as the GPS sensor average recording interval and the so-called "warm start/cold start problem", which means that, during a GPS survey, some points were missing at the beginning of the trip because the GPS receiver needed to acquire the position of at least four satellites in view [37,38]. After reviewing and extending the database, an exhaustive map-matching procedure was conducted. As the authors of [41] stated, during a GPS survey analysis, map-matching is a necessary procedure to determine the travelled distance and to count the number of trips along a specific street or path. Consequently, the original coordinates were translated and mapped to the road network through QGis. Figure 3 shows the differences between non-processed, original GPS records (red points) and processed records (blue points).

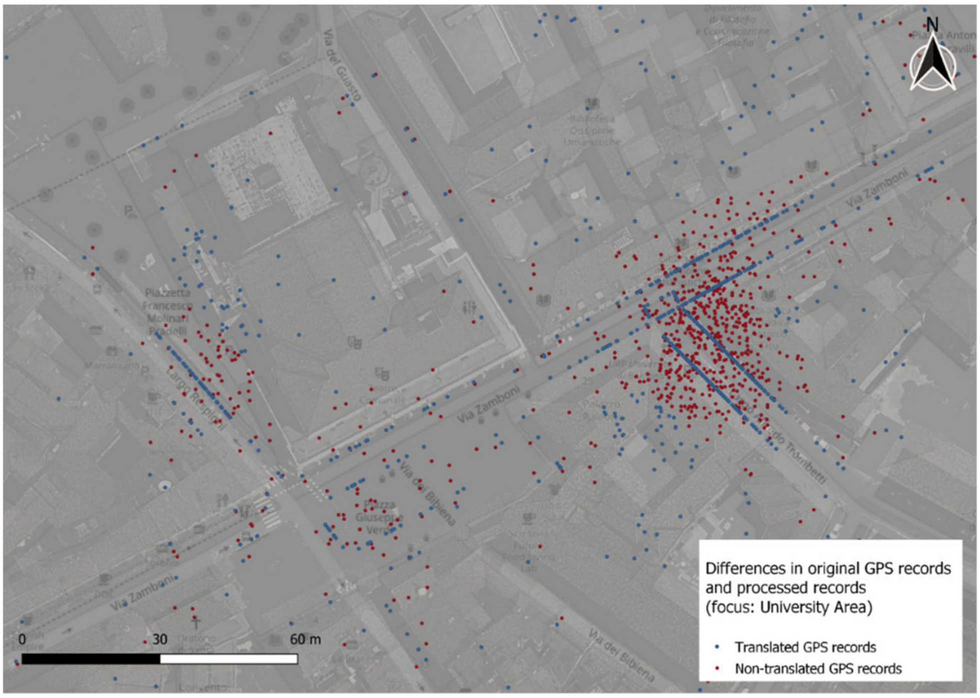

Figure 3. Differences in original GPS records and processed records.

Thanks to the unique ID field, every point was always correctly detectable. In addition, a more detailed characterization of the points was conducted. Even if cyclists usually preferred non-interrupted routes, they may face elements and variables both in natural and built environments that affected the entire trip and which can change trip directions. It meant that the global journey speed decreased, and consequently the covered distance was shorter, within the equal time span, than the average. In these cases, even if spatial and temporal attributes were appropriate, records were affected by the presence of some obstacle to the free flow. In order to properly detect all those short movements which cannot be counted as part of a non-interrupted trip (e.g., moving bicycles during the parking maneuvers, positioning for the green light, waiting for the 'free spot', etc.), entities were used such as traffic lights, road crossings and cycle racks positions and consistency by datasets in Bologna and its surroundings from OpenStreetMap database and uploaded in QGis; these entities were encompassed by a 20-m-wide buffer. In these terms, records within the given buffers were detected. Figure 4 shows an example of this analysis: the location—Porta San Donato—is a crowded node of mobility close to some Unibo buildings and facilities such as university museums and administrative offices, and due to the heavy traffic on the roads, a complex system of traffic light was set. In order to provide appropriate parking services, lots of bicycle racks were placed here, both within the university area (within the courtyards) and in public spaces.

With the aim of integrating observations through the GPS tracking with more qualitative information about perception of usage and comfort of Almabike users, an online survey was employed based on Google forms. It was submitted through the institutional e-mail to all Almabike users. The questions were structured in four sections, as indicated in Table 1. The survey was submitted to Almabike riders (i.e., students with cycles).

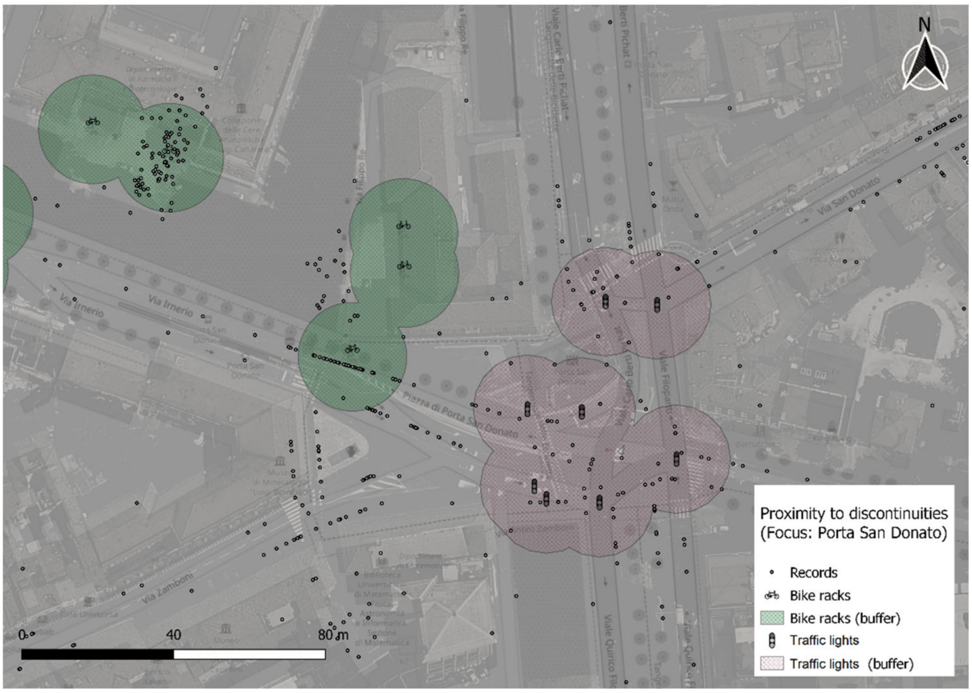

Figure 4. Proximity to discontinuities records.

Table 1. Questions of the online survey for Almabike users.

Questions about the users' profile and their knowledge about the urban form	During the Almabike use, did you live in Bologna?
	In which neighborhood/municipality did you live?
	Were you already confident with Bologna city (i.e., were you able to orient yourself within urban structure?)
Questions about mobility behaviors	How did you get to the university before Almabike?
	Has COVID-19 impacted on your mobility choices?
Questions about vehicle usage	Did Almabike affect your mobility choices?
	When you were riding your Almabike, did you ride more frequently on cycle paths
Questions about users' satisfaction	According to your experience of the usage, how much are you satisfied with Almabike (please indicate a value, where 1 = totally unsatisfied, and 5 = totally satisfied)
	I frequently used to mainly cycle the Almabike . . . - for study reasons - for leisure or week end travel - for personal daily needs (i.e., shopping, nightlife, etc.)

4. Results

After the aforementioned procedures, the reviewed database was extensively analyzed in order to obtain information about the university student cyclists category, in terms mainly of users' choices and behaviors. The survey took place from 15 February 2021 till 18 June 2021. This period was characterized by some peculiarities related to local policies for controlling the COVID-19 pandemic. In particular, these policies were represented by specific restrictions of movement and imposition of curfews, distance learning for university students and the closure of commercial activities from 15 March to 11 April 2021. Progressively, these limitations were removed until June 2021. In these terms, the COVID-19 policies impacted on altering almost a month of the category of bicycle usage by students. Other factors had some effects on the survey. While the quantity of deployed cycles amounted to 322 vehicles (189 distributed to male users and 133 distributed to female users), this was then reduced by six stolen cycles and by six other unusable vehicles due to irreparable GPS sensors, the applied thresholds filtered 65 eligible cycles. The apparently low ratio between the deployed number of cycles and the amount of analyzable vehicles can be explained by the general framework of the Almabike project (application for cycle rentals were totally voluntary with no planned rewards for the virtuous riders) and the aforementioned legislation in terms of mobility during the survey period. The number of analyzable vehicles should hence be seen as a 'statistically-valid' subset of the entire set of cycles, while none of the cycles was totally inactive during the surveying period. Outcomes were assessed by the authors as solid and meaningful, so analyses of both records (i.e., punctual actions) and movements (i.e., trips) were conducted. The following paragraphs trace the main results for the two areas of focus. In order to synthethize the main attributes used during the analysis, Table 2 shows the most relevant basic parameters.

Table 2. Main parameters (+: The set of value comprises only the filtered trips. *: This value was obtained from the ESRI Shapefile. **: A fixed-distance buffer area (100 m) was calculated).

Road network length *	m	853,609
Road network length within the city center *	m	157,997
Reserved cycleway network length within Bologna Municipality *	m	225,151
Reserved cycleway network length within the city center *	m	39,491
Average trip length +	m	14,050
Share of trip in transit with origin, destination or in transit through the city center	%	59% (578)
Share of trip in transit at proximity to university zones **	%	33% (323)
Share of records within the city center	%	40% (10,469)
Share of records within a reserved cycleway, within Bologna Municipality	%	11% (2729)
Share of records within a reserved cycleway, within the city center	%	16% (1659)
Share of records within a reserved cycleway, within the city center, with respect of the total number of records within a reserved cycleway	%	60% (1659)

4.1. Analyses of Records

While the original number of recorded points within the study area boundaries (i.e., Bologna city and the bordering municipalities) was 43,043, the total amount of analyzable data comprised 25,694 records (approximately 60% of the total). The chosen criteria for filtering points were restrictive time thresholds: eligible records should have had an associated time span between 30 and 60 s or equal to 0 s in the case of the starting point of a new journey. Most of the discarded records (i.e., points) had GPS errors, while the search in linked outliers detected unpredictable or unrealistic movements (i.e., those whose records were affected by coordinate biases). Due to the GPS average time interval in saving two subsequent records (60 s), assumptions on position jumps and related quality segments were not conducted. Figure 5 shows the spatial distribution of records in Bologna and surrounding municipalities.

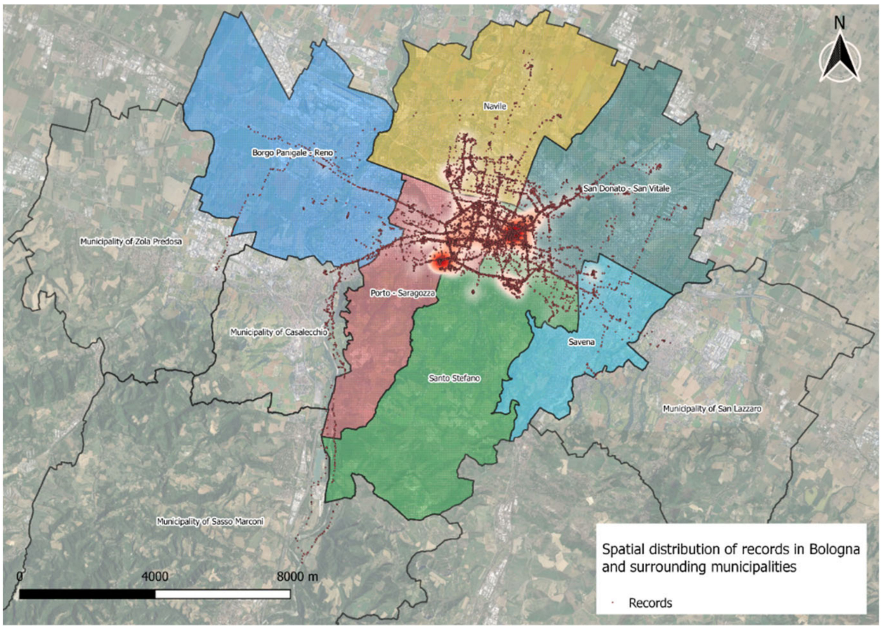

Figure 5. Spatial distribution of records (points and heatmap) in Bologna and surrounding municipalities.

From a general point of view, the aforementioned movement limitations affected the temporal distribution of travels. With respect to days of the week, Wednesdays were the days of the most rides (6627 records, 25.79% of the total). Considering the dates, the overall days of the most rides were Wednesday 24 February 2021 (1082 records), Sunday 25 April 2021 (1071 records) and Wednesday 19 May 2021 (1062 records). The two Wednesdays affected the global share, while Sunday 25 April was a civil holiday. According to the mobility patterns, records during the weekdays were registered mostly within the urban area, with a significant correlation between the records' location and the academic buildings, while records on Saturdays, Sundays and holidays were generally more dispersed and in proximity to leisure facilities. With regards to the time analysis, the only noteworthy correlations were the usages in early morning during weekdays (635 registered records between 7 AM and 9.30 AM, 570 of them between Monday and Friday) and during evenings in the spring months (6807 registered records between 7 PM and 11:59 PM, 4752 of them between late April and the end of the survey in June). Surprisingly, Saturday evenings counted only 282 records with well-defined patterns which did not embody any significant point of interest or leisure in the city center. Nocturnal rides (i.e., records registered between 12 PM and 5 AM) amounted to a very low share of registrations (112, 0.43% of the total) and were registered during the lighter limitation periods.

4.2. Analyses of Trips

Trips were created in QGis by applying pertinent geoprocessing algorithms to the filtered database. Thanks to the attributes, and additionally the records, the trips' 'identity' (i.e., the vehicle, the day, the time) was always detectable. To provide a better representation of users' movements and study their behaviors, records were processed through two different approaches, so trips could be characterized by different attributes:

Trips extracted by "day" threshold: this procedure was conducted in order to focus the time distribution of trips. Links were properly aggregated with respect to date, so output vectors (i.e., movements sequence) were made up of the concatenation of subsequent records. This procedure, even if sufficiently detailed, is not time-sensitive, i.e., an extended interval between two different trips cannot be detected. In fact, within the same day, users can ride more than once for different purposes (e.g., home–work/study trip, then work/study–leisure trip, then leisure–home trip). In order to intensively analyze the trips, the timespan was introduced as a threshold.

Trips extracted by "day" and "timespan" thresholds: these two thresholds allowed a sort of "splitting" in the trip sequence. This more detailed procedure was based on the previous assumptions, but it highlighted disconnected trips made for different purposes and, thanks to the associated attributes, it could be aggregated with respect to the date.

Every trip was created automatically by the algorithm from the processed database. Indeed, in order to strengthen the set of outputs, a manual check was conducted, so links that were valid from a statistical point of view but improvable were discarded. Even if this work did not focus on the relationships between urban form and travel, instantaneous speed was considered instead of average speed to reduce the propagation of biases. In fact, the links were geometric (Euclidean) distances between the two pertinent reference points, so it minimized the links' non-sensitiveness to the "real" world (i.e., road structure, environmental characteristics, users' behavior, etc.), both in planar (i.e., the aforementioned discontinuities, the presence of turns, voluntary travel interruptions, etc.) and vertical profiles (i.e., slopes, roughness of the terrain, gradient, etc.). Figure 6 shows an overview of the trip distribution. With respect to each bicycle, a preliminary analysis concerned the number of days with at least one record, the total number of registered records and the number of trips. On the basis that vehicles were recognizable by an ID number, the three 'most active' bicycles were ID number: 280, which accrued 1081 records and 79 trips in 33 days with an average speed = 7.65 kmph; ID number: 278, which summed 830 records and 85 trips in 24 days with an average speed = 8.22 kmph and ID number: 606, which summed 687 records and 51 trips in 12 days with an average speed = 9.51 kmph.

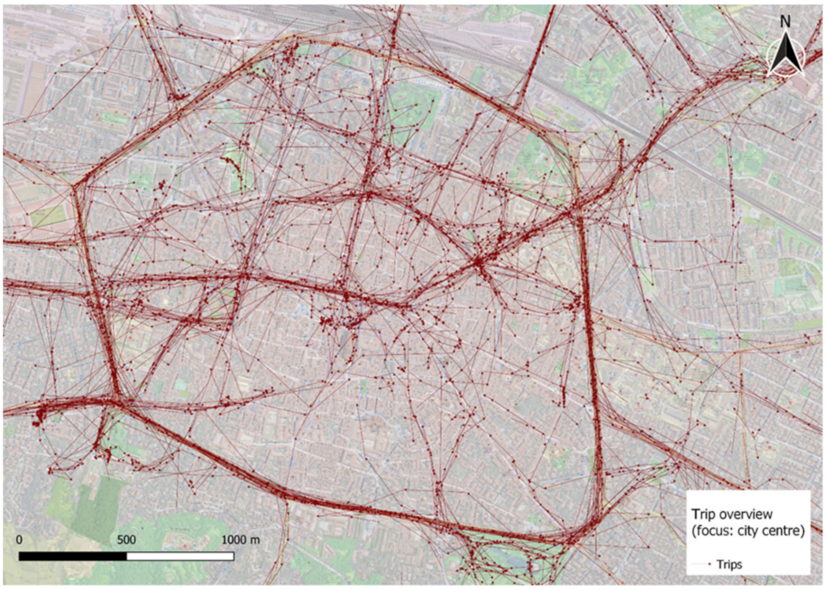

Figure 6. Trip distribution overview in city center (applied threshold: "day" and "timespan").

The map-matching procedures described in the previous chapter allowed detection of the origin and destination of each trip. In order to have a meaningful and solid outcome, a neighborhood subdivision for Bologna municipality was used as the reference and, by using geoprocessing algorithms, it was attributed to records. Other types of spatial splitting (e.g., census areas) were not used for technical reasons regarding territorial heterogeneous characteristics and excessive presence of open spaces. On these bases, a neighborhood-based O/D matrix was traced. The analysis was also extended to bordering municipalities, such as Casalecchio di Reno, San Lazzaro di Savena, Sasso Marconi and Zola Predosa, strongly involved in commuting movements to Bologna. Both internal (i.e., trips with origin and destination within the same area) and interzonal trips were considered. Figure 7 shows the O/D matrix flows filtered for trips within the Bologna municipality; the size of the line corresponds to the trip number.

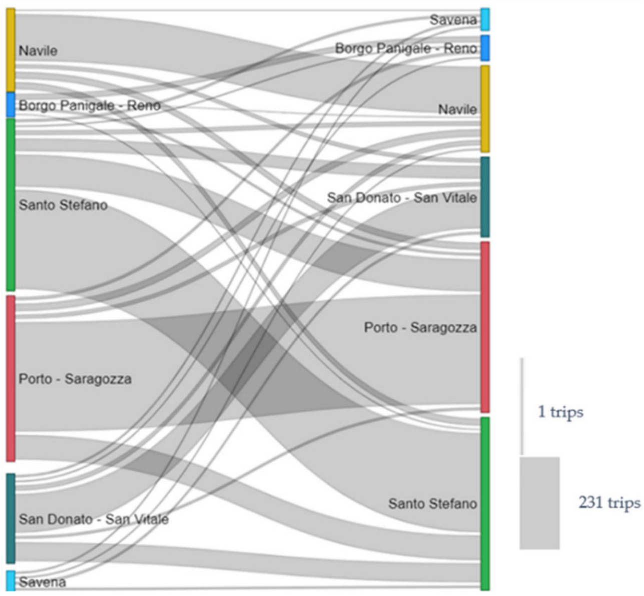

Figure 7. O/D matrix flows (color ramp is consistent with Figure 5).

4.3. Analyses of Cycle Path Usage

Thanks to the coordinate translation, an overview of cycle path usage was observable. With this regard, and with the aim of deepening the study of cycle path usage, an overlapping analysis of records and trips to infrastructures was conducted in QGis. Shapefiles of records and trips were processed in order to detect how many points and trips involved a cycle-dedicated infrastructure and the percentage of involvement. The geometries, both points and lines, were associated to buffers of the specific subset of road network comprising those arches where the cycle circulation is allowed. This kind of analysis was conducted thanks to specific attributes in the road network database, freely available from the Open Data web portal of Bologna municipality, which describes road typologies and roads where cycle circulation is allowed; moreover, by using the pertinent GIS algorithms, analyses of the presence of Almabike riders in the city center and the university zones could be traced.

The city center area comprises about 4.5 square kilometers of the oldest city (equal to 3.19% of municipality's surface; see Figure 1), some of the main monuments and some university buildings, such as the "University Area" in Via Zamboni. With regards to the city center, a considerable share of 40% of analyzable records (equal to 10,469 points) were detected within the city center perimeter. Focusing on the trips, 146 started and ended within the city center, 399 originated from the city center (destination: internal or external to the city center), 421 ended within the center (origin: internal or external to the city center), while 430 didn't register any point within the city center. The global amount of the abovementioned trips was not equal to the total number of studied trips (i.e., 969) because some of the trips (e.g., those with either origin or destination within the city center) could have been counted twice. With regards to the proximity to the university zones, 323 trips were detected within a distance of 100 m from the main university buildings or facilities. They were detected by a fixed-distance buffer (100 m) calculated by a QGis native algorithm. The distance was chosen in order to encompass both those riders who parked their bicyles in the dedicated cycle racks within the university areas and those who used to chain their bicycles far from the buildings. This phenomenon can be seen, for example, within the city center, where the racks are quite spread out and there is multipurpose use (e.g., for study, shopping, etc.). An extensive analysis can even be completed for the cycle paths' usage. As previously shown, the data can be reported only as an assumption because of the GPS errors and instrument limitations, which necessitated the aforementioned procedures and corrections in coordinates. Figure 8 shows those points assumed as part of a journey involving a cycle path (green), in comparison with those assumed as recorded on a multipurpose road. Approximately 11% of them (2729) were supposed to be recorded along a cycle path, reserved cycleway or a road where cycle circulation is allowed (such as cycle lanes), while Figure 9 shows the distribution of those sections of trips ridden for at least 30% of their length along a cycle path or a cycle-dedicated infrastructure. The red magnitude represents the percentage: the lighter red, the lower percentage; the darker red, the higher percentage. On the aforementioned basis (969 analyzable trips), 167 (17%) trips rode along a cycle path for at least 20% of their length, 75 (8%) for at least 30% of their length, 39 (4%) for at least 40% of their length and 15 (1.5%) for at least 50% of their length. On the other hand, 216 (22%) never used a cycle path during the ride.

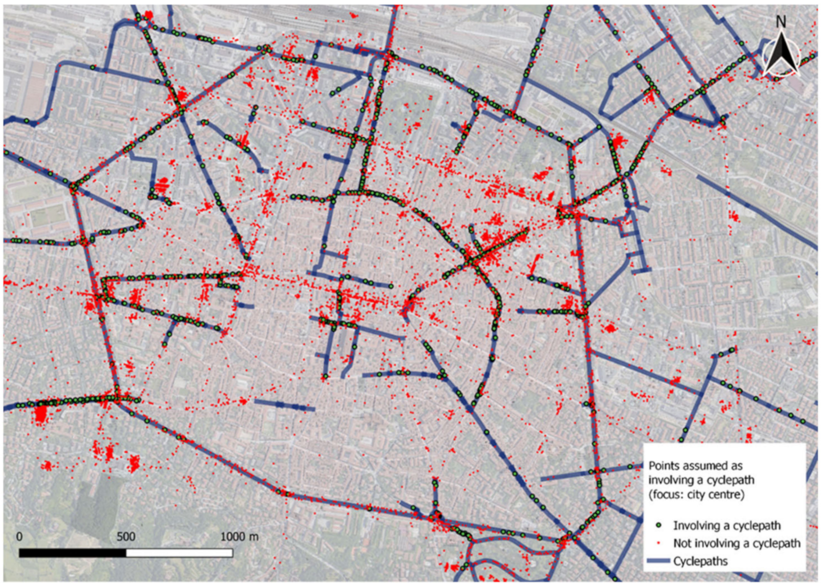

Figure 8. Cycle path usage; records involving/not involving cycle paths.

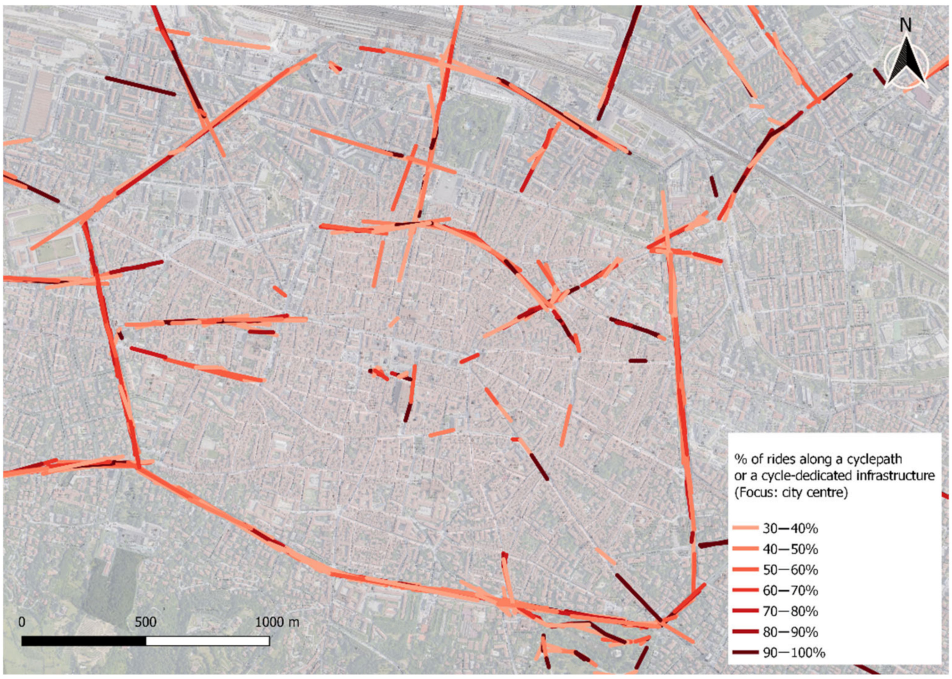

Figure 9. Distribution of sections of trips ridden at least 30% of their length along cycle-dedicated infrastructure.

4.4. Feedbacks from Riders: Results from Almabike Survey

As previously mentioned, a survey was submitted to users. Globally, 145 answers were submitted; with regards to the number of registered users, the rate of answer was 50.5%. As previously mentioned, even if only a subset of cycles was analyzed, none of the cycles was totally inactive during the surveying period, so all of the cycles' users could have been counted in the sample. It was possible to obtain interesting findings about student perceptions of cycling. Considering the knowledge of the city ("Were you already confident with Bologna city (i.e., were you able to orient yourself within the urban structure?"), 90% of answers showed that the user was confident with the urban configuration. Questions about behaviors tried to find some changes in mobility patterns before and after the Almabike experiment and the COVID-19 pandemic. Before using Almabike, almost all of the users used to travel to the university by sustainable modes (144; 99%), while only one sampled person stated driving car habitually. Consequently, the Almabike seemed to represent a consistent driver to change mobility behaviors: only 13% of those surveyed was a regular cyclist (19 answers; 17 were owner of a proprietary bicycle, while 2 of them moved from Mobike, the public cycle sharing system, to Almabike), while 65 people (44%) were public transport users and 60 (41%) were walkers. With regards to the impact of the COVID-19 pandemic on mobility choices, a general and foreseeable reduction was visible from the answers. A total of 75 responders stated they had reduced their movements (51%), while 28 (19%) both reduced their movements and changed their means of transport towards more individual means. The reductions in movements were localizable in all the analyzed zones, both within the Bologna municipality and outside. With regards to Almabike usage, 109 people stated their mobility choices were affected by Almabike. In particular, 46 of them reported a sensitive increase in bicycle use; this is more evident in the San Donato–San Vitale neighborhood, which totaled 12 answers (26%). With regards to the behaviors while riding, a specific question was included in order to understand the usage of cycle paths. A total of 75% of the respondents (110 out of 145) stated they used the cycle infrastructure while riding, while 17% answered that they did not habitually ride on cycle paths due to the absence of dedicated paths on their habitual routes. The other answers stressed different aspects, such as the 'efficiency' of the network and its safety: only 4% showed that the reason for not using cycle paths was related to lower speed on cycle paths than on traditional lanes. The answers about the reasons for the trip confirmed the prevalent use of Almabike: most of the riders mainly used the rented cycles for personal daily needs (71, equal to 49%), while 64 (equal to 44%) used the cycles for study reasons. Only 10 people (7%) used to ride for leisure or for weekend travel. This trend was coherent with the database analysis, which highlighted a comparably low share of records during Saturdays, Sundays and during the evenings/nights. The aggregated analysis of the above-mentioned answers shows that those who used the Almabike for study and personal needs proportionally increased their bicycle use (in fact, despite a general reduction in the number of movements, 15 switched to individual transportation means, equal to 17%). According to the questions about users' satisfaction, 83 people rated Almabike with 4/5 or 5/5 points. The sample mean is 3.47/5, while the mode and median values are both 4.00/5. Considering the three monitored trip purposes, the rates were closely similar: study-reasons users' evaluations totaled an average rate of 3.59/5, with the mode and median values equal to 4.00/5; personal-needs users' evaluations totaled an average rate of 3.38/5, with the mode and median values equal to 4.00/5; leisure-reasons users' evaluations totaled an average rate of 3.30/5, with the mode and median values equal to 3.00/5.

5. Discussion

Overall, the average number of records per each bicycle was 165; the records were registered in an average time interval of 5 days and they summed an average value of 15 trips, whose average speed was 7.36 kmph. This value was affected by traffic conditions and it appeared lower than previous analysis of cyclists' usage [25] with respect to the average speed for urban cyclists. With respect to routes, the three longest journey represented 14 km, 13.52 km and 13.50 km, respectively, and they were registered by ID number: 606 on 20 April 2021, with an average speed of 10.75 kmph; ID number: 223, 27 February 2021, with an average speed of 4.49 kmph; ID number: 324, 17 June 2021, with an average speed of 15.69 kmph. Overall, the riders totaled 1426 km (1.47 km on average), with an average speed equal to 7.8 kmph. Even in this analysis, a remarkable correlation between time and space can be found: in the weekday time window of 7 AM–9.30 AM, 544 records were registered, and some concentrations were localized close to academic buildings, denoting the use of Almabike to travel to the university.

After the data were filtered, some considerations can be stated. Almost two-thirds of the total amount of trips concerned the Santo Stefano and Porto–Saragozza neighborhoods, which comprise the city center, most of the university departments and, as a consequence, it is conceivable that a conspicuous part of the students' residences are here. Peripheral neighborhoods (Savena and Borgo Panigale–Reno) represented a low number of trips, while Navile and San Donato–San Vitale represented only some records and trips due to the presence of other university facilities. From a general point of view, most of the trips were made within the same neighborhood, while the bordering municipalities accounted for a very low share of trips.

As Figures 8 and 9 show, spatial distribution is not homogeneous: this is due to the dedicated infrastructure network and the traffic limitations, which are higher within the city center than the rest of the municipality. In fact, with regards to the share of records along dedicated infrastructures, 49% of them (1352) are located within the city center. Focusing on the total number of points recorded along dedicated infrastructures and with regards to the location, the share was 13% of the points recorded within the city center and 9% of the points recorded outside the city center. These values show the level of 'cyclability' within the central area. Thanks to the masked data of users' registry, a gender analysis can be conducted. Overall, Almabike vehicles were prevalently used by male users (18,926 records, equal to 74%). With regards to the usage of the dedicated infrastructure, the proportion is maintained: 73% of points (2005 of 2729) were recorded by male users. Detailing the share of records, no significant gender difference can be found: 10.53% of male-recorded points were along a dedicated infrastructure, while the female share was equal to 11%.

As the main remarks from the survey, the users' general evaluation about Almabike was positive. Rates and answers highlighted the utility of this kind of initiative, both as a sustainable (and active) means of transport for the university population and as a 'diverter' from the modal share. In fact, the above-seen trend (i.e., a slight but significant modal shift towards cycling) is particularly stressed by the answers of the survey. Almabike and the related survey were useful tools to detect some of the issues in the cycle-dedicated infrastructure. In fact, even if there were only ten responses to the specifically written question about cycle path usage, it was included in the survey in order to compare the declared behavior with the GPS data and to understand if something was missing from the delivered policies. However, with regards to the comparison between the registered data and the survey answers, the usage of cycle paths appears to be overestimated: while 76% of the respondents indicated their use of the dedicated infrastructure, only 11% of the GPS records were associated with cycle path usage. This difference between users' perception and their acutal behaviors was explained on the basis of two converging factors: (a) the fact that the distribution of the movements were almost entirely within the city center in which, even if cycle paths in reserved lanes are not that common, the lanes are all subject to 30 kmph limits, and it is possible to find many pedestrian zones in which bicycles could ride in proximity with pedestrians; (b) the fact that there is no exact correspondence between the number of trips and 76% of users that have answered about their use of dedicated lanes, because this 76% of users may have made less trips than the group that declared a preference for shared lanes.

The overall study has to be considered as a valid instrument for the behavior evaluation of university student cyclists. The main reason is that the existing restrictions followed by COVID-19 protocols reduced the use of public transportation by the student category and promoted an increased use of cycling. On that basis, the findings relating to the university student cyclists represents a significant sample, in which cycling should be more relevant than other years and consequently offered a wide overview on attitudes and characteristics. Furthermore, the research offers a methodology to also investigate an urban point of interest for students, and identifies urban spaces in which cycling infrastructures should be implemented to cover the spectrum of services and facilities for cyclists.

6. Conclusions

The research identified specific behavioral issues in the category of university student cyclists, in quantitative terms of movement characteristics (average speed, number of trips per week, average length, frequency of trips, origin-destination patterns) and also in qualitative terms, regarding user perception on motivations and behavior on routing. The methodology based upon map-matching and data analysis provided by GPS detection, offers a valid criterion for categorizing cyclists and permits an understanding of the urban impact of the category of university students in terms of an ecological approach to campus accessibility.

The university student category appears to be a frequent user, with a lower speed than other evaluated cyclists, strictly connected to cycle usage for commuting from home–university, and as a category has a preference to have their residence within city centers and prefer to use existing dedicated cycle paths wherever possible. Only a very limited number of student users prefer to use shared lanes for maintaining an adequate speed. Speed seems not to be a priority for university students, with average speed values, depending on the period of observation, varying from 7.36 to 10.56 kmph. Cycle lanes that represent a relevant point of origin or destination are placed basically on the main avenue directed to city center. Investigated heat islands demonstrate how there are a high density of places of bicycle aggregation in proximity to university facilities. That analysis, associated with time distribution, may have an interesting application as a Decision Support System for university urban mobility policies, and may have an impact of hours of opening of specific university services, such as the library or common study rooms. Furthermore, the analysis could have a relevant role also in the location of university student residences and related services.

Almabike also represents a key instrument to improve the image of cycling among university students. The project impacted in terms of the university sustainable mobility brand and also offers a valid way to facilitate the urban knowledge and the ecological accessibility to university spaces.

As indicated in the Section 5, the fact that the impact of the COVID-19 pandemic permitted a wide evaluation of university student cyclists, also introduced the need to create a comparison with a year with less restrictions on public transportation, in order to establish a set of indicators and characteristics with a more in-depth period of analysis. Future application of this methodology may be conducted on the design of new cycle parking areas, new dedicated cycle paths towards university campuses and multi-modal hubs for students.

Author Contributions: C.L. and R.B.: conceptualization; A.N. and R.B.: methodology, writing—original draft; A.N.: formal analysis, data curation; V.V. and C.L.: writing—review and editing; A.S.: visualization: V.V.: investigation, supervision. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki, and approved by the Privacy Office of University of Bologna.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Data cannot be shared.

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

References

1. Pazzini, M.; Lantieri, C.; Vignali, V.; Simone, A.; Dondi, G.; Luppino, G.; Grasso, D. Case Studies in the Emilia Romagna Region in Support of Intermodality and Accessibility of Public Transport. In Proceedings of the Conference on Sustainable Urban Mobility, Skiathos Island, Greece, 17–19 June 2020; Springer: Berlin/Heidelberg, Germany, 2020; pp. 65–74.
2. European Commission Road Safety 2017: How Is Your Country Doing? 2018. Available online: https://road-safety.transport.ec.europa.eu/system/files/2021-07/scoreboard_2017_en.pdf (accessed on 10 October 2022).
3. Pazzini, M.; Cameli, L.; Lantieri, C.; Vignali, V.; Dondi, G.; Jonsson, T. New Micromobility Means of Transport: An Analysis of E-Scooter Users' Behaviour in Trondheim. *Int. J. Env. Res. Public Health* **2022**, *19*, 7374. [CrossRef] [PubMed]
4. Pazzini, M.; Lantieri, C.; Vignali, V.; Simone, A.; Dondi, G.; Luppino, G.; Grasso, D. Comparison between Different Territorial Policies to Support Intermodality of Public Transport. *Transp. Res. Procedia* **2022**, *60*, 68–75. [CrossRef]
5. Ghasemi, N.; Acerra, E.M.; Lantieri, C.; Simone, A.; Rupi, F.; Vignali, V. Urban Mid-Block Bicycle Crossings: The Effects of Red Colored Pavement and Portal Overhead Bicycle Crossing Sign. *Coatings* **2022**, *12*, 150. [CrossRef]
6. Li, S.; Muresan, M.; Fu, L. Cycling in Toronto, Ontario, Canada: Route Choice Behavior and Implications for Infrastructure Planning. *Transp. Res. Rec.* **2017**, *2662*, 41–49. [CrossRef]
7. Dill, J.; Carr, T. Bicycle Commuting and Facilities in Major US Cities: If You Build Them, Commuters Will Use Them. *Transp. Res. Rec.* **2003**, *1828*, 116–123. [CrossRef]
8. Parkin, J.; Wardman, M.; Page, M. Models of Perceived Cycling Risk and Route Acceptability. *Accid. Anal. Prev.* **2007**, *39*, 364–371. [CrossRef]
9. Engels, D.; Akkermans, L.; Vansevenant, P.; Adminaite-Fodor, D.; Santacreu, A. Urban Road Safety and Active Travel in Sustainable Urban Mobility Planning. 2019. Available online: https://www.eltis.org/sites/default/files/urban_road_safety_and_active_travel_in_sumps.pdf (accessed on 10 October 2022).
10. Pucher, J.; Buehler, R. Cycling Trends and Policies in Canadian Cities. 2005. Available online: https://trid.trb.org/view/769261 (accessed on 10 October 2022).
11. Akar, G.; Clifton, K.J. Influence of Individual Perceptions and Bicycle Infrastructure on Decision to Bike. *Transp. Res. Rec.* **2009**, *2140*, 165–172. [CrossRef]
12. Moudon, A.V.; Lee, C.; Cheadle, A.D.; Collier, C.W.; Johnson, D.; Schmid, T.L.; Weather, R.D. Cycling and the Built Environment, a US Perspective. *Transp. Res. D Transp. Env.* **2005**, *10*, 245–261. [CrossRef]
13. Antonakos, C.L. *Environmental and Travel Preferences of Cyclists*; Transportation Research Record 1438; Transportation Research Board, National Research Council: Washington, DC, USA, 1994; pp. 25–33.
14. Stinson, M.A.; Bhat, C.R. Commuter Bicyclist Route Choice: Analysis Using a Stated Preference Survey. *Transp. Res. Rec.* **2003**, *1828*, 107–115. [CrossRef]
15. Tilahun, N.Y.; Levinson, D.M.; Krizek, K.J. Trails, Lanes, or Traffic: Valuing Bicycle Facilities with an Adaptive Stated Preference Survey. *Transp Res Part A Policy Prac.* **2007**, *41*, 287–301. [CrossRef]
16. Wilson, O.; Vairo, N.; Bopp, M.; Sims, D.; Dutt, K.; Pinkos, B. Best Practices for Promoting Cycling amongst University Students and Employees. *J. Transp. Health* **2018**, *9*, 234–243. [CrossRef]
17. Mavromatis, S.; Yannis, G. Cycling Acceptability Investigation among University Students in Athens, Greece. In Proceedings of the International Cycling Safety Conference 2015, Hannover, Germany, 15–16 September 2015.
18. Titze, S.; Stronegger, W.J.; Janschitz, S.; Oja, P. Environmental, Social, and Personal Correlates of Cycling for Transportation in a Student Population. *J. Phys. Act. Health* **2007**, *4*, 66–79. [CrossRef]
19. Swiers, R.; Pritchard, C.; Gee, I. A Cross Sectional Survey of Attitudes, Behaviours, Barriers and Motivators to Cycling in University Students. *J. Transp. Health* **2017**, *6*, 379–385. [CrossRef]
20. Bonham, J.; Koth, B. Universities and the Cycling Culture. *Transp. Res. D Transp. Env.* **2010**, *15*, 94–102. [CrossRef]
21. Pogačar, K.; Dežan, L.; Lamot, M.; Renčelj, M. Determinants of Bicycle Use among Student Population: Exploratory Research of Social and Infrastructure Factors. *Appl. Syst. Innov.* **2020**, *3*, 6. [CrossRef]
22. Broach, J.; Gliebe, J.; Dill, J. Bicycle Route Choice Model Developed Using Revealed Preference GPS Data. In Proceedings of the 90th Annual Meeting of the Transportation Research Board, Washington, DC, USA, 23–27 January 2011.
23. Kroesen, M.; Handy, S. The Relation between Bicycle Commuting and Non-Work Cycling: Results from a Mobility Panel. *Transportation* **2014**, *41*, 507–527. [CrossRef]
24. Sottile, E.; Diana, M.; Piras, F.; Meloni, I.; Pirra, M. Chapter 12—To Play but Not for Travel: Utilitarian, Hedonic and Non-Cyclists in Cagliari, Italy. In *Mapping the Travel Behavior Genome*; Goulias, K.G., Davis, A.W., Eds.; Elsevier: Amsterdam, The Netherlands, 2020; pp. 209–228. ISBN 9780128173404.
25. Poliziani, C.; Rupi, F.; Mbuga, F.; Schweizer, J.; Tortora, C. Categorizing Three Active Cyclist Typologies by Exploring Patterns on a Multitude of GPS Crowdsourced Data Attributes. *Res. Transp. Bus. Manag.* **2021**, *40*, 100572. [CrossRef]
26. Kenyon, S.; Lyons, G.; Rafferty, J. Transport and Social Exclusion: Investigating the Possibility of Promoting Inclusion through Virtual Mobility. *J. Transp. Geogr.* **2002**, *10*, 207–219. [CrossRef]

27. i Guasch, C.M.; Avellaneda, P.G.; Frontera, À.C. Los Condicionantes de La Movilidad En Un Nodo de La Ciudad Metropolitana: El Caso de La Universitat Autónoma de Barcelona. In *La ciudad: Nuevos Procesos, Nuevas Respuestas*; Secretariado de Publicaciones y Medios Audiovisuales, Universitad de Leon: Leon, Spain, 2003; pp. 97–106.
28. Bertolin, A.; Tolentino, S.; Beria, P.; Perotto, E.; Guereschi, F.C.; Baglione, P.; Caserini, S. Assessing the Impact of Changes in Mobility Behaviour to Evaluate Sustainable Transport Policies: Case of University Campuses of Politecnico Di Milano. In Proceedings of the Conference on Sustainable Urban Mobility, Ho Chi Minh City, Vietnam, 12–14 November 2008; Springer: Berlin/Heidelberg, Germany, 2018; pp. 89–97.
29. Clabeaux, R.; Carbajales-Dale, M.; Ladner, D.; Walker, T. Assessing the Carbon Footprint of a University Campus Using a Life Cycle Assessment Approach. *J. Clean. Prod.* **2020**, *273*, 122600. [CrossRef]
30. Mendoza-Flores, R.; Quintero-Ramírez, R.; Ortiz, I. The Carbon Footprint of a Public University Campus in Mexico City. *Carbon Manag.* **2019**, *10*, 501–511. [CrossRef]
31. Nguyen-Phuoc, D.Q.; Amoh-Gyimah, R.; Tran, A.T.P.; Phan, C.T. Mode Choice among University Students to School in Danang, Vietnam. *Travel Behav. Soc.* **2018**, *13*, 1–10. [CrossRef]
32. Lundberg, B.; Weber, J. Non-Motorized Transport and University Populations: An Analysis of Connectivity and Network Perceptions. *J. Transp. Geogr.* **2014**, *39*, 165–178. [CrossRef]
33. Danaf, M.; Abou-Zeid, M.; Kaysi, I. Modeling Travel Choices of Students at a Private, Urban University: Insights and Policy Implications. *Case Stud. Transp. Policy* **2014**, *2*, 142–152. [CrossRef]
34. Gurrutxaga, I.; Iturrate, M.; Oses, U.; Garcia, H. Analysis of the Modal Choice of Transport at the Case of University: Case of University of the Basque Country of San Sebastian. *Transp. Res. Part A Policy Prac.* **2017**, *105*, 233–244. [CrossRef]
35. Wang, C.-H.; Akar, G.; Guldmann, J.-M. Do Your Neighbors Affect Your Bicycling Choice? A Spatial Probit Model for Bicycling to The Ohio State University. *J. Transp. Geogr.* **2015**, *42*, 122–130. [CrossRef]
36. Miralles-Guasch, C.; Domene, E. Sustainable Transport Challenges in a Suburban University: The Case of the Autonomous University of Barcelona. *Transp. Policy* **2010**, *17*, 454–463. [CrossRef]
37. Schuessler, N.; Axhausen, K.W. Processing Raw Data from Global Positioning Systems without Additional Information. *Transp. Res. Rec.* **2009**, *2105*, 28–36. [CrossRef]
38. Pritchard, R. Revealed Preference Methods for Studying Bicycle Route Choice—A Systematic Review. *Int. J. Env. Res. Public Health* **2018**, *15*, 470. [CrossRef]
39. Naumov, V.; Banet, K. Estimating Parameters of Demand for Trips by Public Bicycle System Using GPS Data. In *Smart and Green Solutions for Transport Systems. TSTP 2019*; Sierpiński, G., Ed.; Advances in Intelligent Systems and Computing; Springer: Cham, Switzerland, 2019; Volume 1091. [CrossRef]
40. Kumar, P.S.; Dutt, V.B.S.S.I.; Laveti, G. A Novel Kinematic Positioning Algorithm for GPS Applications in Urban Canyons. *Mater Today Proc.* **2020**, *33*, 3359–3365. [CrossRef]
41. Park, C.; Lee, J.; Sohn, S.Y. Recommendation of Feeder Bus Routes Using Neural Network Embedding-Based Optimization. *Transp. Res. Part A Policy Prac.* **2019**, *126*, 329–341. [CrossRef]