

# Linking commuters and tourists transportation needs. Case study of Erasmus students in Valencia, Spain.

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## Abstract

In the face of growing interest in travel, enhancing the tourist experience, especially through public transportation, has become increasingly crucial. This study is particularly investigating Erasmus exchange students behaviour in Valencia, Spain and their relationship with the urban bus transport provided by EMT Valencia. By analysing this specific group of people, who combine the characteristics of regular commuters and tourists, this research aims to deliver actionable insights for urban mobility and tourism management. In order to achieve this, we created a questionnaire surveying satisfaction with public transport, to which 104 Erasmus students responded. Using statistical methods, we combined the results obtained with quantitative open-source transport data, to identify key areas for improvement within Valencia's public transportation system. The findings underscore the availability of nighttime services, punctuality and importance of the connection between crucial neighbourhoods. Ultimately, this research offers a compelling narrative for urban planners and public transport authorities, not only in Valencia but worldwide, to improve their transportation services. These enhancements hold the potential to significantly improve the overall quality of urban life, rendering cities more navigable, accessible, and enjoyable for both residents and visitors alike.

**Keywords:** Smart City, Valencia, Transportation, Tourism, Erasmus exchange

## 1 Introduction

The city of Valencia, Spain, hosts more than 3000 Erasmus students every year (Visit Valencia [1]). This group, while being familiar with the lifestyle of normal city dwellers, combines the characteristics of tourists. Their large scale mobility develops the local economy and the city's multiculturalism. At the same time uniqueness of the group requires improvements in tourist experience quality, with public transportation being a key satisfaction indicator. This study focuses on collecting perceptions from

Erasmus exchange students in Valencia, and analysing open-source data from EMT Valencia, the public transport authority.

In order to develop an appropriate public transport strategy and planning for a group of mobile students, it is first necessary to understand their behaviour. As researchers, we felt that the most appropriate method to achieve this would be through a questionnaire sent out to students. The questions were divided into two separate parts. The first general one covered aspects such as punctuality, availability of stops, quality of information and satisfaction with night transport. The second section contained specific questions about the quality of transport between the most important tourist districts in Valencia, as well as the respondents' place of residence. The aim of obtaining this data was to highlight positive aspects, but most importantly identify general problems and faulty connections in the tourist context. By comparing the survey responses with actual bus timetables, the study aimed to provide valuable information on both subjective opinions and objective transport data.

After distributing the questionnaire to the Erasmus student community, we managed to receive as many as 104 responses that formed the basis for analysis. Its primary objective was to furnish the Valencia City Council with robust data, highlighting key areas of concern as reported by this specific group of users of Valencia's public transport system. By achieving this, the study seeks to streamline the decision-making processes related to urban transport planning and management. Furthermore, the insights garnered from this analysis aim to serve as a valuable resource for other public transport entities, enabling them to identify and implement targeted improvements in their services.

The structure of this manuscript is designed to effectively address the objectives and findings of our study in the following way:

1. **Introduction:** This section sets the stage by introducing the research aims and highlighting the importance of enhancing public transport for Erasmus students in Valencia. It identifies the main beneficiaries and the structure of the study.
2. **Literature Review:** Here, we delve into the current state of ensuring sustainable public transportation across the world, with a particular focus on Valencia, Spain.
3. **Methodology:** This part details the comprehensive approach taken for data collection, including surveys among Erasmus students and examination of open-source EMT Valencia datasets. It also outlines the analytical techniques applied to assess public transport efficiency and satisfaction levels.
4. **Results:** This section, we present the analysed data from various sources, highlighting key areas of concern and satisfaction among Erasmus students regarding Valencia's public transport. Additionally, we map the geographical distribution of preferred bus stops and routes among the student population.
5. **Conclusions:** Here, we provide specific, evidence-based suggestions for improving the public transport system in Valencia.

## 2 Literature Review

In 2022 Erasmus+ programme had a total budget of €4 billion and approximately 1.2 million participants in mobility activities ([2]). Research suggests that international mobility has a profoundly positive impact on students, enhancing their professional and academic knowledge, while also improving language proficiency and interpersonal skills (Dolga et al. [3]). This experience fosters greater flexibility, innovation, and productivity among Erasmus students in teamwork processes (Bracht et al. [4]).

The programme undoubtedly represents a great opportunity for the students, but also for the host cities. Students have a positive impact on the cities' multiculturalism, economy and tourism. At the same time, this is a group with unusual behaviour that requires an appropriate approach. This study particularly focuses on the transportation aspect of it.

We have not been able to find detailed documentation focusing on the specific approach of the city of Valencia towards Erasmus students. However, the city is highly developed when it comes to sustainable tourism and sustainable transport. In fact, Valencia has earned the Green Capital title for 2024, because of its ambitious sustainability strategy, and it has learned from lessons in the past (European Commission [5]).

Local government regularly invests millions euro promoting sustainable transportation. As of October 2020, Valencia had 159.1 km of bike lanes (Mateu and Sanz [6]). City actively buys hybrid electric buses (HEB) and battery electric buses (BEB). With the planned investment of 30 million euros in 2024, there will be 48 vehicles 100% electric and 285 hybrids, resulting in a 68% more energy-efficient fleet (UPPER Project EU [7]).

In the era of rapidly evolving technology, especially AI, one of the most impacted areas is transport. Examples of AI methods that are finding their way into the transport field include Artificial Neural Networks (ANNs), Genetic Algorithms (GAs), Simulated Annealing (SA), Artificial Immune System (AIS), the Ant Colony Optimiser (ACO), Bee Colony Optimisation (BCO) and the Fuzzy Logic Model (FLM) (Abduljabbar et al. [8]). Smart Cities also utilise Internet of Things (IoT) to improve efficiency, enhance connectivity, and optimise resource management through real-time data collection and analysis (Porru et al. [9]).

Another growing sector that is attracting more and more attention is smart tourism (Shafiee et al. [10]). Smart cities uses several techniques to provide intelligent services to visitors (Lee et al. [11]). To promote tourism in Korea the Korea Tourism Organisation (KTO) provides “VisitKorea,” an application, that offers the latest travel information, categorised information (shopping, accommodation, dining and more), customised travel plans and discount coupons. In 2014, Singapore started making an extensive effort to build a smart nation program by collecting data on urban daily life. Based on its findings, the government is now deploying systems that monitor the city’s crowdedness, cleanliness of public spaces and traffic. The collected data are incorporated into an online platform called “Virtual Singapore”.

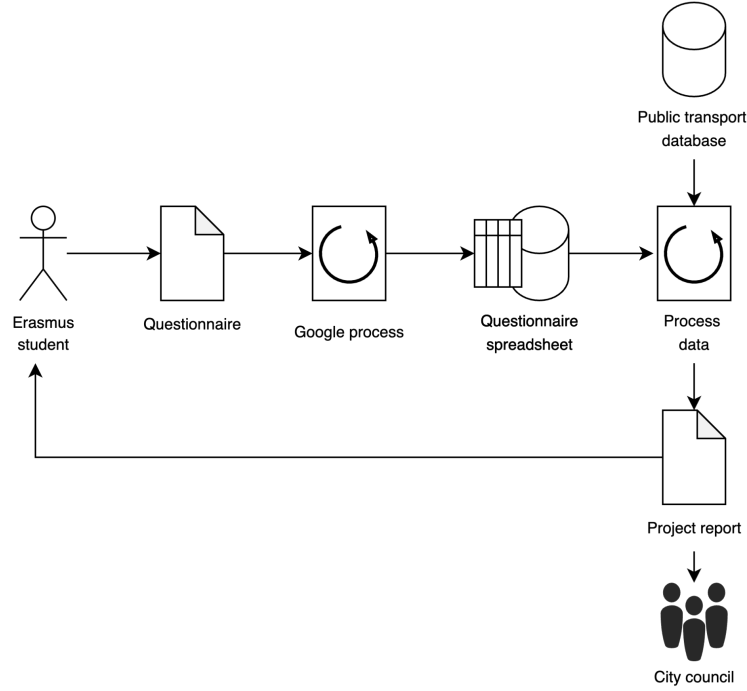
## 3 Methodology

### 3.1 Framework

In the delivered project the sensors which provide the data and the actuators can be defined. In the depicted case we collect data by surveying Erasmus students living in Valencia. The physical sensors that can be highlighted are mobile phones, notebooks and other electronic devices that the students use to fill up the survey. However, we mainly work with the software on these devices - the questionnaires, which help us understand their experiences and satisfaction level. In the context of the delivered report the actuators that interact and provide data diverge from conventional physical devices. Instead, the actual actuators are indirect and intellectual. They could be identified as the Valencia City Council reactions after providing them the suggestions and solutions. The proposal also focuses on pointing out the phenomena that students miss in their day-to-day life.

The data gathered from the survey is processed and thanks to this analysis the common issues among respondents are identified. It provides us with the knowledge necessary to draw conclusions. By identifying the disparities between the identified needs and the current state, we propose solutions for both the Valencia City Council and Erasmus students. For authorities, recommendations include adjustments to schedules or the addition of new transportation lines. As for Erasmus students, recommendations involve modifying their behaviour or proposing solutions that may not have been previously considered.

For a better understanding of the elements within the project and the relationships that exist between them, the conceptual model diagram is presented below:



**Fig. 1:** Conceptual Model - Framework

### 3.2 Data needs & Data acquisition

The specific aspect we aim to address is enhancing the quality of experience for tourists visiting Valencia, with a focus on improving the reliability and standard of the city's bus network. In more details, the objective is to identify transportation issues faced by Erasmus students and provide the valuable analysis to the city hall to enhance the overall experience of staying in the city. Additionally, there are solutions for Erasmus students and the guidelines they should follow for a better experience.

The data needs for this work are quite complex. The comprehensive analysis could be done with the combination of a few datasets. First of all, to enhance tourists' satisfaction with the utilisation of bus lines, it is crucial to understand the patterns that lie behind the structure and timetables of the bus network in Valencia. Another valuable source of data could be obtained from the devices that people use to validate their tickets before using the bus service (ticket scanners). Similar to smart travel cards, they have become a valuable source of information in public transport networks (Pelletier et al. [12]). They allow the classification of tourists and the profiling of their behaviour (Briand et al. [13], Gutiérrez et al. [14]). It would be beneficial to identify the routes that are most popular among tourists. For instance, analysing cases where individuals need to use two lines to reach a destination could provide insights. If a significant number of people follow this pattern, it may indicate the need for a new bus line. Lastly, since the focus is on tourists, particularly Erasmus students, their feedback is required. This is collected from a spreadsheet that was created based on the survey answers.

Although not all of the data needs were met, a significant amount of data was accessed. Initially, our attempts to contact an EMT company that could provide us

with information from ticket scanners and EMT cards were unsuccessful. However, during our research, an open source dataset of bus lines in Valencia was found, which provided us with valuable data. In addition, the survey gave us enough data to conduct a comprehensive analysis.

### 3.3 Datasets

The most important subset of data was obtained from the spreadsheet, which stored the questionnaire data. The survey consisted of 10 short, basic questions about the factors that affect the quality of EMT Valencia company. Questions were sent to Erasmus students, who stayed in Valencia during the academic year 2023/2024.

The questions in the survey were divided into two sections. The first one covered the following topics:

- Frequency of the bus services
- Punctuality of buses
- Accessibility of bus stops
- Frequency of the bus services
- Overall evaluation of bus travel time
- Assessment of night transport availability
- Information made available to travellers (application, information provided at the bus stops)

In the second part, the focus was on assessing the quality of connections between important points in Valencia. Students were asked to choose their residential area and later evaluate the most popular routes. There were questions about connections between:

- Beach
- Ciudad de les Artes y las Ciencias (City of Arts and Sciences)
- Old Town
- Location of the student's stay

Finally, there was an open question to leave the comments, requests and other complains.

The other dataset was Google Transit data gathered from Google Transit Data EMT Valencia [15] service. This dataset comprises the timetables sent by public transport companies to Google, enabling the display of timetables and lines network on Google Maps. The dataset consists of nine CSV files. However, in case of this project only a few of them were applied, which are as follows:

- frequencies.csv - A file indicating the interval between two buses of the same line over a specified period.
- stopsData.csv - A file providing the location (longitude and latitude) and names of the bus stops.
- shapes.csv - A file containing latitude and longitude coordinates representing points along the route. Sequence numbers indicate their order along the route.
- trips.csv - A file containing the information about the route id combined with the subsequent shape points on the route.

Apart from the datasets described above, there was also used the file downloaded from Open Data Valencia [16] about the geographical coordinates of the districts in the city.

### 3.4 Data Analysis

The main objective of the analysis is to connect the feedback from tourists with how Valencia's EMT bus network actually operates. By combining survey data with real facts

about the bus system, our goal is to find out where tourists struggle the most and which bus routes are the most used by tourists. The analysis focuses on understanding factors such as the frequency of buses, their punctuality and the availability of night lines. To do this the different ways of presenting the data are used - the spatial visualisations, graphs and histograms.

The generated insights could be used to fix problem areas in connection with the bus network and make its quality better for everyone. Moreover, the suggestions provided for tourists should help them pick the right place to stay and get around the city of Valencia more easily. Overall, the analysis aims to make Valencia's bus system smoother and more user-friendly.

In more details, to achieve the results, the analysis listed below are employed. They are the key in understanding the issues and make it possible to draw conclusions for the city hall and tourists:

- Mapping bus routes and stops: utilising Google Transit data, the number of bus stops and the bus lines going through each neighbourhood are counted and depicted on the plot.
- Identifying key features: the survey responses are analysed on the histograms and basic statistic (median, mean, mode) are calculated to detect the factors influencing students' overall satisfaction with the bus system.
- Evaluating landmark connectivity: the student feedback regarding the efficiency of bus connections between significant landmarks in Valencia is assessed. Through the use of informative charts and graphs, we intend to identify areas where the bus connections may be inadequate and propose strategies for enhancing connectivity between key destinations.
- Residential areas analysis: the most popular districts where Erasmus students live are identified and the results are analysed in order to detect the worst and the best neighbourhoods to live in.

## 4 Results

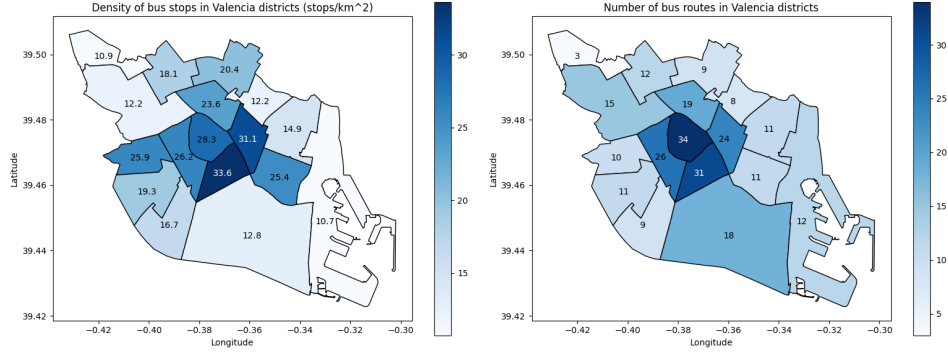
### 4.1 Survey outcome

The survey was completed by 104 participants, covering various aspects of bus transportation in Valencia, aiming to comprehensively understand the situation. It is notable that the sample size is sufficiently large for conducting a thorough analysis, drawing conclusions and proposing solutions. For most questions, responses were collected on a scale of one to five, where one was the most negative response, while five was the most positive. Overall, the mean for the most questions is around three. However, there are specific questions that highlight both the strengths and weaknesses of the services provided by EMT Valencia. Additionally, respondents demonstrate a good understanding of the issues related to the subject matter. Among the 104 respondents, 35 of them (33.7%) utilise Valencia's bus services daily, while the majority - 44 students (42.3%) - do so 2-4 times a week. The remaining 24% of respondents use the service less frequently.

### 4.2 Accessibility

The aspect that receives the highest rating is the accessibility of bus stops in Valencia. The mean score for this criterion is 4.15, with a median of 4. These figures suggest that the average tourist user is content with the distribution of bus stops throughout the city. To substantiate this, an analysis was conducted, revealing that across an area of  $112.94 \text{ km}^2$ , there are 1114 bus stops, resulting in a density of  $9.86 \frac{\text{stops}}{\text{km}^2}$ . While this density is notable, a closer examination reveals even more impressive figures. By excluding districts situated far from the city centre, such as Poblats del Sud and Poblats del Nord—where bus stop numbers are low relative to the district's expansive

area—the density increases significantly to  $16.84 \frac{\text{stops}}{\text{km}^2}$ . Furthermore, when focusing solely on the most frequented districts among respondents—Algirós, Camins al Grau, Poblados Maritimos, and Benimaclet—the density is equal to  $13.93 \frac{\text{stops}}{\text{km}^2}$ . The average distance between the closest bus stops in a straight line is equal to 162 metres. While detecting the closest bus stops, those on the opposite side of the road were excluded. Below we present graphics with the densities of bus stops and number of lanes in particular residential areas in Valencia:



**Fig. 2:** Bus stops density and number of bus lines

Based on the graphs visible above, some conclusions can be drawn. Firstly, with regard to the density of the bus stop network, the closer to the centre, the greater the availability of bus stops. For the district of L'Eixample, for example, more than  $33 \frac{\text{stops}}{\text{km}^2}$  can be found. Although in some districts the density studied is three times lower, all values are impressive. Regarding the second graph, which shows the number of lines that cross the streets of the neighbourhoods in question, a certain correlation to the first graph can be observed - again, the most central neighbourhoods obtained the highest score (the most lines pass through Ciutat Vella - 34). The above graphs and the survey results illustrate that the availability of stops and the range of available lines in Valencia's neighbourhoods are high and meet the expectations of tourists.

Such a dense network of stops, on the other hand, makes it necessary for the bus to stop frequently, which was stated by the respondents in the attached comments:

- 'Just slow [...]',
- 'The main problem is [...] slow speed caused by frequent stops.',
- 'take so much time, stops everywhere [...]'.

However, this problem was only highlighted by some people and the overall average bus travel time was rated at 3.02 with almost symmetrical distribution.

### 4.3 Provided information & Punctuality

One of the most criticised aspects highlighted by the survey's responses concerns the information supplied by EMT to its users, encompassing both the EMT application and the information displayed at the bus stops. The mean score for this aspect was 2.55, with a median of just 2, indicating a widespread dissatisfaction among respondents. This deficiency in information provision also significantly influenced the assessment of punctuality. Despite the high ratings for bus frequency and accessibility, a considerable 33% of respondents assigned only 2 points for punctuality. Issues

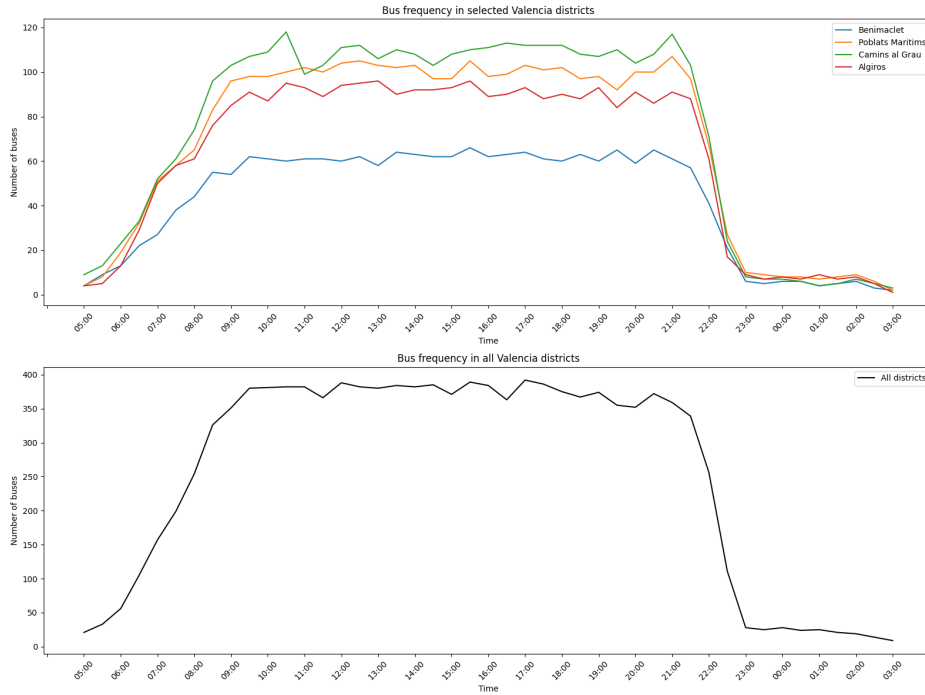
such as the malfunctioning EMT application and insufficient real-time information regarding bus arrivals or delays were among the most frequently cited problems in the comments section. Below, we outline some of the highlighted issues:

- ‘Lack of information about the hours of arrivals on the website and the bus stops.’
- ‘[...] the most important factor to be changed is the information about the delays provided to the users via application [...]’
- ‘Delays and buses not coming at all even though the schedule says differently.’
- ‘Mobile app should offer more precise info about routes’ timetable.’
- ‘First, there’s no schedule so you can’t really plan your trip beforehand. You can use the app but it’s still more difficult.’
- ‘The key problem is that most of the buses don’t have a schedule [...]’
- ‘[buses] are not punctual. And the app with the time tables never works’
- ‘Delays and buses not coming at all even though the schedule says differently’
- ‘It would be better to have an actual plan and not ”every x minutes”’

#### 4.4 Night transport

However, the most negatively rated feature of bus transportation in Valencia is night transport. Although EMT Valencia provides citizens with 12 night lines, the obtained average in this question was just 1.82 and the mode value identified is equal to 1 with 48 responses (46.2%). This may be because the night lines are run around to collect as many passengers as possible. However, this has a very negative impact on the quality of the journey and its duration. In addition, the buses do not run late at night and their punctuality leaves considerable room for improvement.

In order to understand the magnitude of the problem addressed, an analysis of the number of stops at bus stops every 30 minutes during the day is carried out. The whole week’s journeys were considered for the analysis, so the number of stops does not represent an exact value during the day. Instead, it is important to understand the trend and scale - how bus availability differs during the day and at night.



**Fig. 3:** Courses of the buses during the day



The trend depicted in the charts above remains consistent across all districts, including both the most popular regions and the city as a whole. Only the number of stops at the bus stops differs. The highest bus traffic can be seen in the Camins al Grau district, while the lowest volume among the most popular districts is in the Benimaclet area.

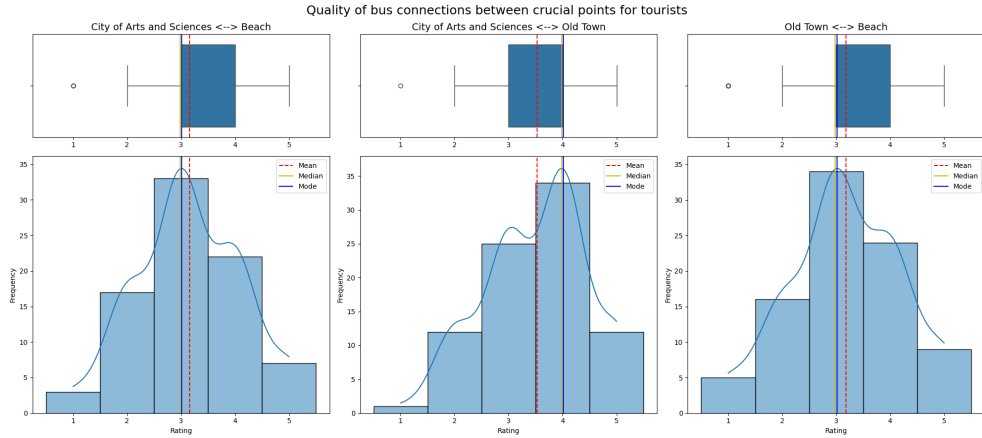
In general, from early morning hours until around 9AM, the number of buses running gradually increases. Later, a practically constant number of trips with slight fluctuations is maintained throughout the day. However, after 10PM the drop is huge and the number of buses running in the late evening and night decreases fast. The phenomenon observed in the graph explains the degree of dissatisfaction of the Erasmus student community with the availability of night transport.

Furthermore, again the complains were placed in the additional comments section:

- ‘The biggest problem for me was the absence of night connections.’
- ‘[buses] during the night hours, sometimes they just never show up.’
- ‘No public transport at night.’
- ‘Night buses and night connection with the airport’

#### 4.5 Connections between key tourists locations

Areas that are more likely to be visited are without a doubt the City of Arts and Sciences (a scientific and cultural leisure complex), beach and old town. In the survey we asked respondents how they rated the level of transport between these locations. The average, median, mode and distribution of ratings can be seen in the plot below.



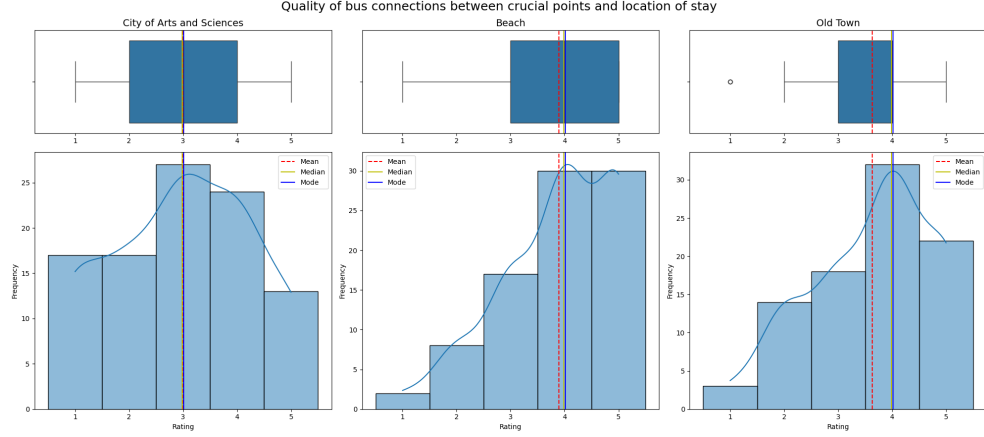
**Fig. 4:** Quality of connections between landmarks

As we can observe, all three connections received quite positive ratings. The average ratings for the connections between City of Arts and Sciences and the beach, City of Arts and Sciences and the old town, and the beach and the old town were 3.16, 3.52 and 3.18, respectively. Moreover, respondents did not mention any potential issues with these routes in the open question. Among these connections, the one between City of Arts and Sciences and the old town received the highest rating. This higher rating might be because this route covers the shortest distance compared to the others.

#### 4.6 Residential areas analysis

In addition to asking respondents how they feel about communication between Valencia’s main tourist attractions, we also inquired about the connections between

these attractions and their place of residence. In the plot below we can observe the average, median and distribution of these ratings.

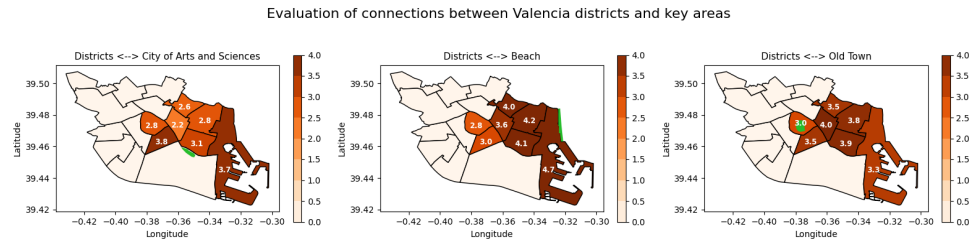


**Fig. 5:** Quality of connections to residential areas

As we can see, the rating for transport to the beach and the old town is quite high, and transport to the City of Arts and Sciences is rated slightly worse than average rating of 3. However, as we group the rating of transport to the City of Arts by neighbourhood of residence we observe one particular that is rated very poorly - El Pla del Real with an average of 2.25. The area is located between 1 and 3.5 kilometres on foot from the City of Arts and oftentimes predicted walking time is similar to the bus transportation. In most cases it requires changing buses and taking a detour.

Furthermore, the Benimaclet neighbourhood is also impacted, given that El Pla del Real lies between it and the City of Arts and Sciences. Consequently, travellers from both of these neighbourhoods are likely to encounter similar issues. The average rating for this connection was also relatively low at 2.62, with a median of 2.

These observations can be seen on the graph below showing the average rating of the quality of connections from the most popular neighbourhoods (the number of respondents from these neighbourhoods was at least 5) to key points in Valencia (indicated by the green areas on the graph).

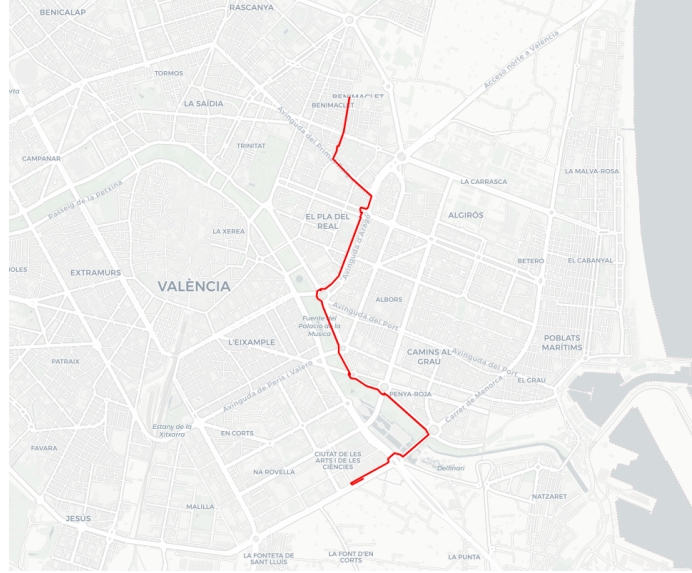


**Fig. 6:** Connections from residential areas to the landmarks

The phenomenon noticed prompted further research in this direction. An analysis of the number of direct links between the district and the City of Arts and Sciences showed a poor connection between the above-mentioned districts and Valencia's modern facilities. The average number of lines running through the district and connecting it directly to the City of Arts and Science is 3.11. In the case of Benimaclet, on the other hand, there is not a single such connection, while for El Pla del Real, despite

its very close location, we can find four such lines. This may not be a tragic result, although an analysis of the routes of these bus lines has shown that all the lines found do not cross the centre of the El Pla del Real district, but travel along the outskirts.

The above findings led us to conclude that, in order to improve tourist satisfaction, it may be necessary to introduce a new line running from the Benimaclet district, through the middle of the El Pla del Real district, up to the City of Arts and Sciences. The proposed route is shown on the map below.



**Fig. 7:** Benimaclet < -- > City of Arts and Sciences

Another observation may be the low average ratings for connections from the old town. Those in the Ciutat Vella neighbourhood rated connections to the City of Arts and Sciences, the beach and the old town itself at 2.8, 2.8, 3.0, respectively, all ratings below the overall average (2.99, 3.9, 3.63). It may be surprising that even the connection within this neighbourhood was rated so low. In our opinion, this should be attributed to the harshness of the assessors living in the Ciutat Vella neighbourhood. Furthermore, given the relatively small sample size (only 5 respondents), these figures may be influenced by human assessment bias.

#### 4.7 Erasmus student context

Overnight transportation was rated by far the worst. The mode was equal to the worst possible rating. One reason it may have been rated so badly is that the survey was conducted on Erasmus students. Valencia is famous for its rich nightlife, popular especially among young people. That's why it is so important for them to be able to go home at night. One of the most popular locations for students to return at night is L'Umbracle located in the City of Arts and Sciences. Additionally, other locations are popular (the old town, the area around Plaça de Cánovas). It would be a good idea to introduce a higher frequency of night lines connecting the above-mentioned popular points with the most popular neighbourhoods inhabited by Erasmus students.

The analysis presented above can also be of great value to future Erasmus students coming to Valencia. With the results presented, one can make a better choice of the neighbourhood in which to seek housing. Based on the data presented, it seems that the best-connected neighbourhoods are Poblados Maritimos and Camins al Grau. However, everyone can analyse the data to be more satisfied - choose whether they

prefer to be better connected to the old town, the modern city centre or live close to the beach. In addition, it is worth mentioning that for young people, public transportation in Valencia is completely free, which was often mentioned in the free applications section as a very positive aspect.

## 5 Conclusions

In summary, our study sheds light on several key aspects of public transportation in Valencia. The city boasts a dense network of bus stops and frequent bus services. However, some users perceive longer travel times due to this density. Additionally, the reliability of information provided by EMT Valencia has been questioned, especially in the case of night transport where users often experience a lack of available services or buses not adhering to scheduled timings.

Despite these challenges, connections between major tourist points of interest in the city have generally been positively rated. Connections between those places and residential areas were also graded highly, with a few exceptions, such as the connection between El Pla del Real and Benimaclet neighbourhoods with the City of Arts and Sciences. Despite their close proximity, these connections often require transfers, affecting user satisfaction.

To address these issues, we propose introducing a new bus route, which would connect Benimaclet directly with the City of Arts and Sciences through El Pla del Real district. This proposed route aims to improve accessibility and enhance the overall transportation experience for residents and tourists alike, particularly on this problematic route.

Although the responses were gathered from 104 students, the distribution across neighbourhoods was uneven, limiting the depth of our analysis in some areas. Additionally, suggesting the use of EMT long-term tickets (similar to smart travel cards) could enhance future studies by providing more accurate data on tourist behaviour.

Our findings highlight the need for greater stability in the information provided by EMT. Improvements to the application or website, with real-time updates on delays or cancellations, could enhance user experience and confidence in the public transportation system. Night transport emerges as an area most affected by information inadequacies. Despite numerous night bus lines, users perceive a lack of service reliability.

Addressing concerns regarding information reliability, particularly regarding night transport, is pivotal for enhancing overall user satisfaction and increasing EMT Valencia service utilisation. Resolving the identified issues can yield positive outcomes, not only in alleviating traffic congestion and environmental pollution but also in improving the mobility experience for both commuters and tourists. The Erasmus group represents a distinctive mix of individuals who reside in a specific location for an extended period while exhibiting tourist-like traits. Tackling the challenges they have highlighted will not only improve their mobility experience but also elevate Valencia's appeal as an even more desirable destination for all tourists.

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