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Pedestrian mobility and University campus accessibility: an analysis of student preferences

Michela Le Pira[1], Natalia Distefano[1], Elena Cocuzza[1], Salvatore Leonardi[1], Giuseppe Inturri[2], Matteo Ignaccolo[1]

[1] *Department of Civil Engineering and Architecture, University of Catania, Via S. Sofia 64, Catania, Italy*
[2] *Department of Electrical, Electronic and Computer Engineering, University of Catania, Via S. Sofia 64, Catania, Italy*

Abstract

Prioritizing pedestrian mobility is crucial to foster urban liveability and sustainability, particularly on university campuses that are experienced by students. This paper examines the University of Catania (Italy) campus, a significant open space facing accessibility challenges. Two surveys were conducted within a Living Lab framework to assess student opinions on campus walking experiences and identify key criteria for promoting walking to and within the campus. The Chi-square Automatic Interaction Detector (CHAID) algorithm and the Analytic Hierarchy Process (AHP) were chosen for the analysis, deriving insights for policy-makers and mobility managers to enhance accessibility and encourage active mobility. The specific case study demonstrates the importance of creating pedestrian-friendly environments to foster sustainable lifestyles by addressing accessibility barriers in large open spaces. However, this research provides a wider framework which is applicable to urban planning in similar contexts, emphasizing the pivotal role of pedestrian-centric design in creating vibrant and sustainable university environments.

Keywords: Mobility management, Traffic calming, University mobility, Walkability.

1. Introduction

The design and implementation of pedestrian-friendly environments is fundamental to foster sustainable mobility in cities, making cities more accessible, safe and liveable (Soria-Lara and Talavera, 2013).

Accessibility, in particular, is a key measure for evaluating transport policies since it links land use and transport systems (Giuffrida et al., 2020). It is nowadays a consolidated opinion that an accessibility-oriented approach and a person-centered planning are fundamental for sustainable transport planning (Banister, 2008; Rossetti et al., 2015).

The call to make mobility more sustainable has also been undertaken by managers of university systems (Sgarra et al., 2022). Universities and, in particular, University campuses, can be considered as closed environments, since they are typically related to limited geographic spaces that are a smaller representation of dynamics and characteristics present in a larger community, such as a city (Papantoniou et al., 2020). Ensuring campus accessibility is fundamental, since an accessible campus encourages active mobility, also including students with disabilities, promoting equity and inclusion.

Besides, it can help reduce traffic congestion in cities and improve air quality, leading to benefits for both the university community and the surrounding environment.

Investigating user satisfaction and accessibility to university campuses is important to implement strategies aimed at reducing private transport and encouraging the use of sustainable transport modes (Fernandes et al., 2019). Academic institutions are therefore adopting more user-oriented approaches, conducting periodic surveys or polls to gather feedback and measure student satisfaction on their campuses to identify strengths and areas for improvement (Inturri et al., 2021).

However, preferences (and behaviours) can be heterogeneous and, therefore, there is no one-size solution that fits all. Besides, it would be advisable to constantly and directly involve the University community in decision-making so to increase the legitimacy and acceptability of any solutions (Le Pira et al., 2020). In this respect, the Living Lab (LL) approach has proved particularly useful in urban contexts to address transport issues (Gatta et al., 2018) as an "experimentation environment in which design is given shape in real-life contexts and in which users are considered 'co-producers'" (Ballon, 2005). Universities can be considered as LLs for the implementation and further development of sustainability, as reported in Leal Filho et al. (2019).

This paper follows this path by presenting the case of the University of Catania (Italy), where a LL has been set up to involve the University community in decisions to make the campus safer and liveable, and overall foster sustainable mobility. Students were mainly involved in multi-step process where they co-created and assessed different solutions regarding transport and mobility services within the campus.

The main results of the first steps of the LL are presented in Leonardi et al. (2023). In the present paper, the results of two surveys conducted within the context of the LL are discussed and analysed in details, with the aim to understand the most important criteria to promote walking to reach the campus and their walking experience inside the campus. Two methods have been chosen to conduct the analysis, i.e. the Analytic Hierarchy Process (AHP) and the Chi-square Automatic Interaction Detector (CHAID) algorithm.

AHP is a multicriteria decision-making method that is particularly useful to derive priorities (of interventions, criteria or objectives) starting from their pairwise comparisons. It can be used to elicit individual decision-maker opinions, but it can also be extended to group decision-making, and allow to derive different priorities according to specific groups.

The CHAID (Chi-square Automatic Interaction Detector) analysis is an algorithm employed to uncover relationships between a categorical response variable and other categorical predictor variables. This method proves beneficial when seeking patterns within datasets featuring numerous categorical variables, offering a convenient means of summarizing data, given that the relationships can be readily visualized.

Both methods allow to unveil patterns and characteristics that can be useful to propose tailored measures according to the needs preferences and needs of different groups.

The remainder of the paper is organized as follows: section 2 presents the methodological approach, including the methods used for the analysis of students' preferences and opinions. Section 3 introduces the case study and illustrates the results. Section 4 concludes the paper with future research development.

2. Methodological approach

The methodological approach is based on the LL concept, which has user involvement as a fundamental element. A LL is a continuous process composed of different and intertwined phases, according to the Plan-Do-Check-Act cycle (Deming, 1986). In this respect, solutions should be planned base on shared objectives and agreement on the current state of the system ("Plan"), experimented ("Do") and assessed ("Check") together with stakeholders, so to adapt the future actions ("Act") by learning from the previous stage (Quak et al., 2016).

The LL presented in this study has been set up for the context of a University community with the aim to plan and experiment sustainable mobility strategies together with stakeholders. The LL consists of different steps, starting from a preliminary survey aimed at exploring travel behaviours and student travel satisfaction, and a co-creation and experimentation phase, involving students both in the design and in the temporary implementation of improvement scenarios inside the campus. During this phase, users' opinions were collected and analysed via an interest/sentiment analysis. The evaluation is fundamental to understand the level of agreement and the preference of the stakeholders involved so to refine the actions proposed and start a new LL cycle. In this respect, an on-site survey was also performed to elicit student opinions regarding important criteria to promote walking to reach the campus. The overall process is summarized in figure 1. While in Leonardi et al. (2023) the main results of the preliminary survey, aimed at setting the conditions for the co-creation experiment, together with the evaluation via the interest/sentiment analysis were presented, in this paper the results of the two surveys (the preliminary one and the on-site survey) are analysed more in detail (bold text in figure 1).

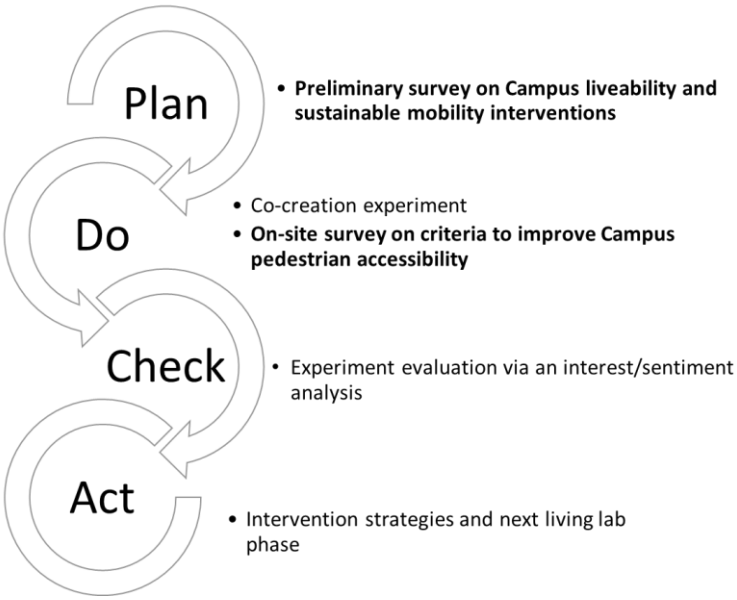

Figure 1: Methodological approach and phases.
Source: Own setup.

The rationale behind the analysis performed is to gain a deep understanding of users' behaviours and preferences related to both their walking experience inside the campus

and to reach the campus. Two different methods have been employed to analyse in detail the data obtained with the two surveys. They are presented in the following subsections.

2.1 Chi-square Automatic Interaction Detector (CHAID) analysis

The CHAID algorithm is employed for constructing decision trees, specifically for segmenting variables based on their interactions with target variables. Differently from conventional decision trees, CHAID utilizes chi-square tests to autonomously identify optimal splits. In other words, CHAID is often used to understand how different groups of users respond to a survey based on their characteristics.

The results of the CHAID analysis can be visualised with a so-called "tree diagram". At the first level all respondents are shown with their respective response rate. As we progress down the tree to the first "branch", the factor that has the greatest impact on the likelihood of response is identified, and the overall population is broken down into groups ("leaves") based on their differing values of this characteristic. At the next branch, for each of the new groups, one should see if these can be further split into subgroups so that there is a significant difference in the dependent variable (the response rate). At each step, every predictor variable is considered to see if splitting the sample based on this factor leads to a statistically significant relationship with the response variable. Where there might be more than two groupings for a predictor, merging of the categories is also considered to find the best discrimination. If a statistically significant difference is observed, then the most significant factor is used to make a split, which becomes the next branch in the tree.

In recent years, CHAID analysis has been used in transport studies. For example, Sari et al. (2023) applies this analysis to determine the preference of people in Padang city in choosing public transport. Distefano et al. (2021) used it to investigate pedestrian behaviour when crossing the legs of urban roundabouts.

2.2 Analytic Hierarchy Process (AHP)

AHP is a well-known multi-criteria decision-making method introduced by Thomas Saaty in the '80s. It is based on the representation of a decision-making problem into a tree structured decisions' hierarchy with different decision-making levels (e.g. objectives, criteria, alternatives). The elements of each level are compared with respect to the upper level using pairwise comparisons, expressing a judgment on a qualitative scale that is turned into a quantitative one (from 1 – equal importance - to 9 – extreme importance of one element over the other) (Saaty, 1988). For each level, pairwise matrices are built to derive local priority vectors with different methods (Ishizaka and Nemery, 2013). Finally, a ranking of alternatives is obtained by combining all the levels into a global priority vector. Since pairwise comparisons can lead to some judgment inconsistency, a consistency analysis is performed by comparing the judgments with the one obtained by purely random ones (Saaty, 1988).

AHP has been widely used in transport studies, both to elicit single decision-makers' opinions and for group decision-making (e.g. De Luca, 2014; Ignaccolo et al., 2018). Its wide use is due to the easiness to elicit opinions based on pairwise comparisons without the need to define utility functions (Ishizaka and Nemery, 2013). Besides, preferences of multiple individuals can be aggregated to derive group judgments. While in the single decision-maker case the only condition to respect is judgments' consistency, for group

decision-making it is also necessary to define an appropriate procedure to aggregate the individual judgments. Sometimes, a consensus vote should be preferred over mathematical aggregation to avoid the possibility of average evaluations that are not representative of the real opinions of the stakeholders involved in the evaluation (Ignaccolo et al., 2018). Besides, it is easy to obtain rankings per sub-category, allowing to unveil heterogeneity of preferences. Even if AHP is typically used to derive rankings of alternatives, it can also be used in single-level hierarchies, e.g. to understand the priorities of objectives in a multi-stakeholder process. However, it is typically used to elicit preferences of a restricted group of stakeholders. In this paper, it has been used to elicit student's preferences. Therefore, results have been analysed both in an aggregate way, and by segmenting the sample according to specific characteristics. The main results are reported in the following.

3. Case study

The case study is Catania, a medium-sized city in Southern Italy (Sicily) of about 300,000 inhabitants with a greater metropolitan area of about 700,000 inhabitants. Catania suffers from a high motorization rate and share of private vehicles trips. This is partly due to a lack of suitable infrastructures for active mobility, and to an insufficient urban public transport supply (Fazio et al., 2021).

Catania can be considered a student city, with the University of Catania counting about 40,000 students and 2,500 employees among professors, researchers and technical/administrative staff. About a quarter of students and personnel commute every day in the main campus, one of the biggest open spaces in Catania (about 70 ha) located up on a hill in the north of the city (Figure 2).

Figure 2: The Campus with its main entrances (blue) and paths (yellow).
Source: Own setup based on Google Earth.

Notwithstanding the efforts to improve the mobility of the University community in the last years, many trips to and from the campus are performed using private vehicles. Besides, the Campus is surrounded by roads characterized by high speeds where, unfortunately, deadly accidents occurred in the last years, also involving students. The dramatic events point to the need to find *ad-hoc* solutions to increase safety while reducing private transport use and, overall, to promote sustainable mobility.

The LL approach seems appropriate to involve the University community in planning future scenarios towards sustainability.

In a first phase of the research, a LL was set up, and students were involved in co-creating and evaluating solutions to increase campus safety and encourage walking, as explained in section 2 and reported in Leonardi et al. (2023). In particular, after a preliminary survey to explore students' travel behaviors and satisfaction, a co-design phase allowed to define measures with stakeholders and then test them while recording users' opinions and analyse them via an interest/sentiment analysis.

The test took place on the 15th May 2023. Infrastructural measures (curb extensions, mini-roundabout, 3D pedestrian crossings, etc.) were designed by the students with coloured chalks, while other measures as shared bicycles and electric buses were made available to the students. During the experiment, Campus users were asked to express their opinion on the proposed measures by placing stickers (green for a positive opinion, yellow for a neutral opinion, and red for a negative opinion) on *ad-hoc* posters describing the measures.

Main results showed that the purely infrastructural measures, such as the mini-roundabout and the chicane, as well as the use of electric buses were met with interest and appreciation. Conversely, the introduction of parklets to increase the spaces for socialization generated interests but also some doubts, since it would imply a reduction of parking spaces in the campus.

To gain more insights into these results and, in general, to have a deeper understanding of users' behaviours and preferences related to both their walking experience inside the campus and to reach the campus, the results of two surveys are analysed in this paper: the preliminary survey and the on-site survey.

3.1 The surveys

The questionnaire used for the preliminary survey was created using Google Forms, and included questions related to: socio-demographic characteristics, travel behaviour, assessment of the liveability of the campus, judgment on pedestrian paths inside the Campus, interventions to encourage walking in the campus. The survey was conducted through face-to-face interviews involving 242 students in one week in April 2023.

The on-site survey was distributed during the experimentation day with the aim to elicit student opinions regarding important criteria to promote walking to reach the campus. Also in this case, Google forms was used and the questionnaire consisted of three parts: (a) socio-demographic characteristics, (b) travel behaviour, (c) criteria for promoting walking. The last part of the questionnaire consisted of pairwise comparisons of criteria on a 1-9 scale, as proposed by Saaty (1988).

Four criteria were chosen after a debate phase with students, i.e.:

1. adequacy of the sidewalk, in terms of width, continuity and absence of obstacles;
2. average path slope, which can be a discouraging factor even for short-distance trips;
3. pedestrian crossing safety, in terms of adequate signalling, length, etc.;
4. distance from/to the University site to/from the closest public transport stop/station, which is particularly important for multimodal trips.

While the first questionnaire was specific for the students attending the Campus, the second one was conceived to be distributed to all students attending the different

University sites, which are scattered throughout the city with some venues in other cities (Siracusa and Ragusa). However, for the purpose of this study, only answers from students of the Departments inside the Campus were considered.

4. Results and discussion

4.1 Preliminary survey results

CHAID analysis was applied to the database obtained by collecting the responses to the preliminary survey. Table 1 shows the variables considered for the analysis. CHAID analysis was performed using IBM SPSS software.

Table 1: Variables used for CHAID analysis.

Variable	Description	Items
V1	Gender	0: Male 1: Female
V2	What activities do you do on campus besides taking classes?	0: None 1: Study rooms or library 2: Sport center 3: All
V3	Degree program	0: Bachelor degree program 1: Master degree program
V4	Department	0: Engineering 1: Math and physics 2: Chemistry and Pharmacy
V5	Are you a commuter student?	0: Yes 1: No
V6	Which transport mode do you mainly use for your trips?	0: Private car 1: Public transport 2: Walking
V7	Which transport mode do you mainly use to get to campus?	0: Car 1: Subway 2: Bus 3: Motorcycle 4: Bicycle/e-scooter 5: On foot
V8	How long does it take you to get to campus?	0: Less than 15 minutes 1: Between 15 and 30 minutes 2: Between 30 and 60 minutes 3: More than 1 hour
V9	Which entrance do you use the most to access the campus?	0: West 1: East 2: South
V10	Are you satisfied with your trip to the campus?	0: Yes 1: No
V11	Do you think the campus is liveable?	0: Yes 1: No 2: I don’t know
V12	Which of these critical issues do you encounter in the campus?	0: Few green spaces 1: Too many cars 2: Absence of paths for sustainable mobility 3: Few places to socialize/Inadequacy of existing facilities 4: High vehicle speed

Variable	Description	Items
		5: None
V13	Are you satisfied with the pedestrian paths inside the campus?	0: Yes 1: No 2: I don't know
V14	How would you improve the pedestrian paths inside the campus?	0: Removal of architectural barriers 1: Lighting system 2: Pedestrian crossings 3: Condition of sidewalks 4: Pleasantness of the pedestrian paths 5: Nothing 6: Path cleaning

The analysis starts from students' opinions about the quality of life on campus. In response to the direct question "Do you think the campus is liveable?", 64.2% of respondents positively answered, while 17.5% could not give a clear answer. Figure 2 shows that the only significant independent variable is the degree program, suggesting that students have different opinions depending on the maturity of their studies. In particular, Master degree students are much less satisfied with the quality of life on campus, with only 54.8% of them considering it liveable. This can be ascribed to the greater experience of the Campus, and therefore knowledge of main issues and problems, with respect to Bachelor degree students.

The survey also examined student satisfaction with respect to their trip to the Campus (Fig. 3). The majority of respondents (68.3%) are dissatisfied. In this analysis, the decision tree diagram has only one level of depth, which is influenced by the variable "time to travel to campus". Students who take more time (more than 30 minutes) to get to the campus are the most dissatisfied, while a significant percentage (60.7%) of those who take less than 15 minutes to get to campus are satisfied.

The high percentage of students who are dissatisfied with their trips makes it clear that transport to reach the campus is a major problem. The significant differences in opinions regarding travel time, with those travelling a longer distance reporting higher dissatisfaction, underlines the need to optimize transport and improve accessibility to enhance the overall campus experience for all students.

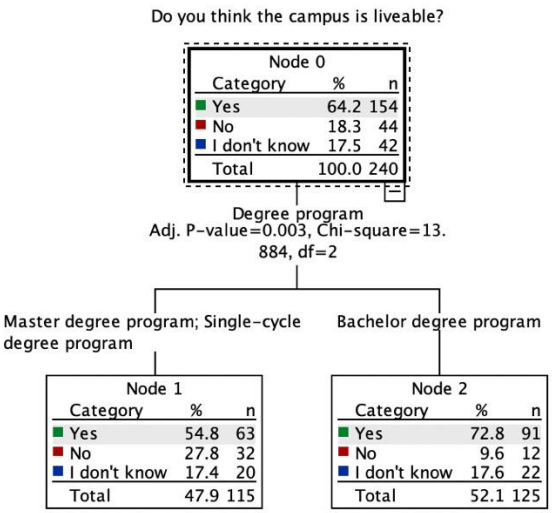

Figure 2: Decision tree relating to students' judgment on the campus livability.
Source: Own elaboration.

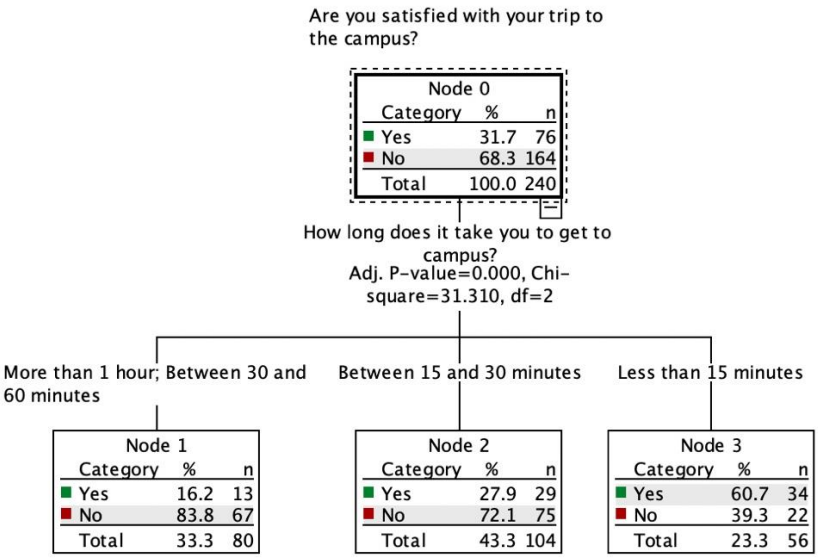

Figure 3: Decision tree relating to students' satisfaction on their trip to the campus.
Source: Own elaboration.

In response to the general question "Which of this critical issue do you encounter in the campus?" few students (7.5%) answered "absence of paths for sustainable mobility" (Fig. 4). This percentage increases slightly, especially among male students studying Engineering, Chemistry, and Pharmacy, while it is significantly lower among students studying Physics and Mathematics (2.7%). However, when students are directly asked if they are satisfied with the pedestrian paths within the campus (Fig. 5), only 50.8% of them answer positively. Once again, the respondents' degree program plays an important role in distinguishing their responses. The majority of Bachelor students are satisfied with the pedestrian walkways on campus, while only 37.4% of Master students say the same. The discrepancy between the answers to the generic question on sustainable mobility paths and those on the more specific question relating to pedestrian routes suggests a general misunderstanding and lack of knowledge of concepts related to sustainable mobility. These results should be the basis of awareness campaigns on sustainable mobility, which aim to make students more aware of the benefits of green transport modes.

Finally, students were asked to indicate how to, according to them, improve current pedestrian paths inside the campus to promote active mobility. According to them, the physical characteristics of sidewalks (width, surface, and continuity) are the most important aspects to focus on. Responses vary depending on the modes of transport students use to get to campus. Students who use public transport also suggest improving pedestrian crossings, while those who walk emphasize removing architectural barriers and making the environment generally more pleasant for pedestrians (Fig. 6).

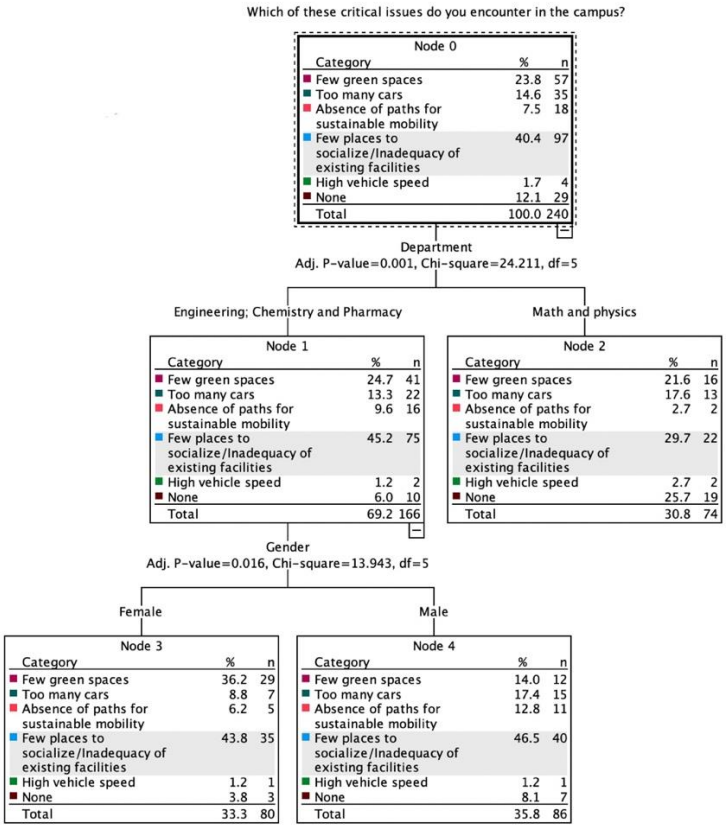

Figure 4: Decision tree relating to students' opinion regarding critical issues inside the campus.
Source: Own elaboration.

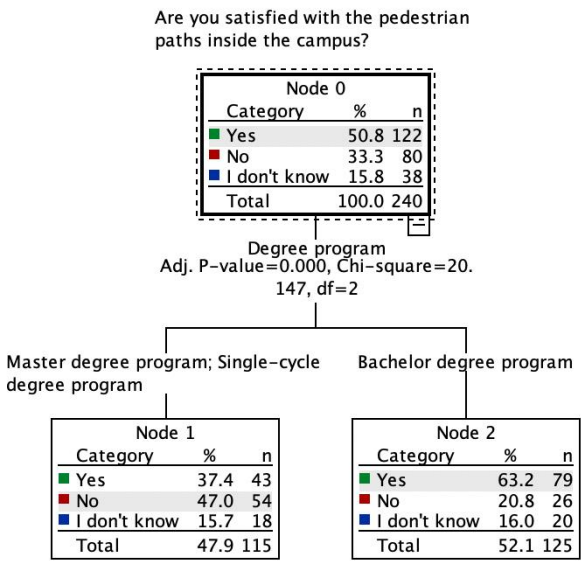

Figure 5: Decision tree relating to students' satisfaction with pedestrian path inside the campus.
Source: Own elaboration.

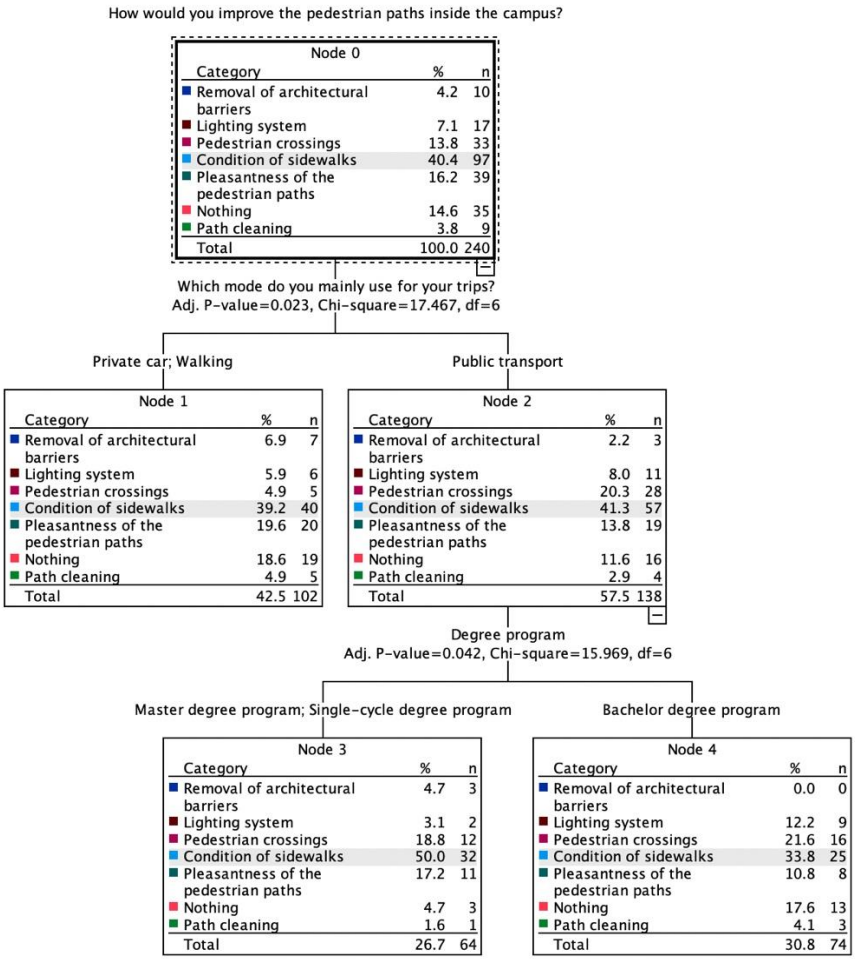

Figure 6: Decision tree relating to students' opinions on how to improve on pedestrian paths inside the campus.
Source: Own elaboration.

4.2 On-site survey results

The results of the preliminary survey are partly confirmed by the AHP survey that allowed to establish a priority of criteria to promote walking to reach their destinations and, in particular, to the Campus.

Out of 199 respondents, 96 attended the Campus and were selected for the analysis. For what concerns socio-economic characteristics, the subsample is mainly composed of students (only 3 of them were researchers/teachers), 60% female, with an average age of 22. The subsample is composed for the 45% by students that mainly use private transport to reach the Campus, while 31% use public transport and 24% walk or cycle to the Campus. Besides, 62% state that they walk to perform their daily activities. 13% never walk, but among them, 77% would be willing to walk to the University if an adequate network of pedestrian paths was available.

For what concerns the pairwise comparisons of criteria, they were aggregated using the geometric mean method, and the main results are presented in Table 2.

Adequate sidewalk characteristics (in terms of width, continuity, absence of obstacles) and path's slope are considered the most important criteria to focus on, while the safety of pedestrian crossings and the distance to/from the closest public transport stops result

to be less important. This result is quite expected, since the Campus is in the northern part of the city, with a quite high slope from the closest metro station to the entrance (on average 8%). However, results change if we consider sub-samples related to the (1) main transport mode used (private transport, public transport, active mobility) and (2) travel purpose (home-to-study trips, recreational trips). In this respect, for those that mainly use private transport (45%), the distance to/from public transport is the most important criterion, followed by the adequacy of the sidewalk. Vice versa, for those that use public transport to reach the Campus (31%), path's slope is more important, while for those walking or cycling the most important criterion is the adequacy of the sidewalk (24%).

These differences show that the transport mode used to reach the Campus highly influences the perception of walking and of pedestrian paths. Car users do not experience pedestrian paths and believe that the main problem is that the distance to/from public transport is too high (thus, preferring the private car). Conversely, those who experience walking (or cycling) for the last-mile of a multimodal trip or for the overall trip, do have a better knowledge of the characteristics of the paths. This suggests that it is important to improve the characteristics of paths, while improving the information (e.g. related to the current public transport stops/stations and the lines to reach the Campus) to promote the use of public transport combined with walking. Besides, if one considers the trip purpose, those that usually walk for home-to-study trips perceive the adequacy of the path sidewalk as the most important criterion, while those that walk for recreational trips are more sensitive to the distance from/to public transport, which is fundamental for multimodal trips to perform different activities scattered in the city.

Table 2: Priority weights derived from AHP (for the overall sample and each sub-sample, the criterion with the highest weight is underlined in bold).

Criteria/priority weights	overall sample	Sub-samples: main transport mode			Sub-samples: walking trip purpose	
		private car	public transport	active mobility	home-to-university	recreational
Adequacy of the sidewalk	**0.286**	**0.262**	**0.272**	**0.340**	**0.364**	0.237
Average path slope	**0.280**	0.232	**0.360**	**0.270**	**0.303**	0.236
Pedestrian crossing safety	0.215	0.225	0.179	0.238	0.191	**0.255**
Distance to/from public transport	0.218	**0.282**	0.189	0.152	0.143	**0.272**

5. Conclusion

The exploration of the University of Catania's LL initiative presented in this study aimed at offering a comprehensive understanding of its influence on campus safety, liveability, and the advocacy for campus sustainable mobility. Through collaborative engagement with students in the co-creation and assessment of mobility solutions, the objective was to tackle challenges associated with high motorization rates and the predominant use of private vehicles for commuting.

The case study of Catania, a medium-sized city in Southern Italy, with notable obstacles, particularly the lack of adequate infrastructures for active mobility and insufficient public transport options showed that the LL approach is an effective strategy

to engage the university community in shaping sustainable solutions and future scenarios. The methodology, including interest/sentiment analysis, Analytic Hierarchy Process (AHP), and Chi-square Automatic Interaction Detector (CHAID) algorithm, facilitated a detailed comprehension of user preferences and decision-making processes.

The initial survey results brought attention to diverse opinions on campus liveability, with master degree students expressing lower satisfaction. Dissatisfaction with travel experiences, especially among those with longer commute times, underlined existing mobility challenges. Notably, the gap between the awareness of sustainable mobility paths and satisfaction with specific pedestrian routes emphasized the need for targeted awareness campaigns.

The original contribution lies in the comprehensive analysis within the LL, supported by the integration of AHP and CHAID methods. By exploring infrastructure preferences, travel satisfaction, and sustainable mobility perceptions, valuable insights were gained for tailored interventions. The influence of transport modes on preferences highlights the need for customized approaches catering to diverse user groups.

However, it is essential to acknowledge certain limitations. The study primarily focuses on a single university case, potentially limiting the generalizability of findings. Future research could expand the scope to encompass multiple institutions, offering a broader perspective on the efficacy of living lab initiatives in diverse settings.

Additionally, while our methods provide valuable insights into preferences and decision-making processes, the dynamic nature of mobility behaviours suggests the need for continuous observation. Long-term studies and real-time data collection could enhance the depth of understanding and capture evolving trends in campus mobility.

Furthermore, the awareness campaigns proposed for sustainable mobility paths represent a potential area for further investigation. Assessing the effectiveness of such interventions and refining strategies based on feedback could contribute to the success of future initiatives. Overall, ongoing research endeavours are crucial for refining and expanding the applicability of LL approaches in promoting sustainable mobility.

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