Sottile, E., Giacchetti, T., Tuveri, G., Piras, F., Calli, D., Concas, V., Zamberlan, L., Meloni, I., & Carrese, S. (2021). An innovative GPS smartphone based strategy for university mobility management: A case study at the University of RomaTre, Italy. Research in Transportation Economics, 85, 100926.

The publisher's version is available at:

http://dx.doi.org/10.1016/j.retrec.2020.100926

Title Page (with Author Details)

An innovative GPS smartphone based strategy for university mobility management: a case study at the University of RomaTre, Italy

Eleonora Sottile
CRiMM - Research Centre for Mobility Modelling
University of Cagliari - Italy
URL: www.crimm.unica.it
Via San Giorgio 12, 09124 Cagliari
E-mail: esottile@unica.it

Tommaso Giacchetti
Department of Engineering
University of Roma Tre - Italy
Via Vito Volterra, 62, 00146 Roma
URL: www.ingegneria.uniroma3.it
E-mail: tommaso.giacchetti@uniroma3.it

Giovanni Tuveri
CRiMM - Research Centre for Mobility Modelling
University of Cagliari - Italy
URL: www.crimm.unica.it
Via San Giorgio 12, 09124 Cagliari
E-mail: giovanni.tuveri@unica.it

Francesco Piras *
CRiMM - Research Centre for Mobility Modelling
University of Cagliari - Italy
URL: www.crimm.unica.it
Via San Giorgio 12, 09124 Cagliari
E-mail: francesco.piras@unica.it

Daniele Calli
Outside contractor
E-mail: dcalli7@gmail.com

Vittoria Concas
Outside contractor
E-mail: vittoriaconcas@hotmail.it

Leonardo Zamberlan
Department of Engineering
University of Roma Tre - Italy
Via Vito Volterra, 62, 00146 Roma
URL: www.ingegneria.uniroma3.it
E-mail: leonardo.zamberlan@uniroma3.it

Italo Meloni
CRiMM - Research Centre for Mobility Modelling
University of Cagliari - Italy
URL: www.crimm.unica.it
Via San Giorgio 12, 09124 Cagliari
E-mail: imeloni@unica.it

Stefano Carrese
Department of Engineering
University of Roma Tre - Italy
Via Vito Volterra, 62, 00146 Roma
URL: www.ingegneria.uniroma3.it
E-mail: stefano.carrese@uniroma3.it

*Corresponding author.

AKNOWLEDGEMENTS

This work was partially supported by the Italian Ministry of University and Research (MIUR), within the Smart Cities framework (Project Netergit, ID: PON04a200490).

An innovative GPS smartphone based strategy for university mobility management: a case study at the University of RomaTre, Italy

ABSTRACT

Private car dependence has adverse effects on both mental and physical health. *Travel Demand Management* (TDM) strategies are adopted by public and private organizations to encourage users to switch to sustainable transport for daily commutes. Originally, mobility management only focused on employees, but recently various universities worldwide have started to adopt policies specifically targeted at students. To improve their effectiveness, an innovative approach to TDM based on a GPS smartphone application is tested at University of RomaTre (Italy) on a sample of students. The strategy identifies the integration of all mobility management activities into one smartphone application called IPET (*Individual Persuasive Eco-Travel Technology*). The IPET enables activity-travel data collection and automatic processing, personalized information provision, use of persuasive technology and implementation of a gamification system. Two questionnaires were conducted before-and-after the measure, to assess its effects on psycho-attitudinal factors. The main objective of the investigation was to analyze individuals' voluntary behavioral changes with regard to travel mode and everyday behavior following implementation of a personalized travel plan. Data analysis indicated a strong positive change in the level of awareness regarding CO_2 emissions and calories burnt after the program implementation. Comparison of GPS data collected in the first and second weeks showed, for those who received a personalized travel plan, an 8.1% shift towards more sustainable transport modes.

Keywords: travel behavior change, persuasive technology, travel demand management, soft measures

1 INTRODUCTION

It is well documented that the intensive use of the car has negative effects on mental and physical health (noise and air pollution, commuting stress due to road congestion, traffic mortality, social exclusion, sedentary life). For example, in 2018 in Italy, where the number of cars saw an increase of 4.1% over 2014, air quality deteriorated, with levels of PM_{10} and $PM_{2.5}$ far higher than standards set by both the European Union and the World Health Organization (ISFORT, 2018).

Hence, to address these issues a growing number of initiatives have been deployed for promoting travel behavior change toward more sustainable forms of transport. Travel Demand Management (TDM) strategies, often referred to as Mobility Management (MM) (Litman, 2003), are crucial activities adopted by public administrations, companies or universities, for encouraging employees or students to switch to sustainable transport modes in daily commutes. The strategic role of TDM policies is widely stated in the international literature in reducing car usage and promoting the environmental and social sustainability of commuting (Brög *et al.*, 2003; Taniguchi *et al.*, 2007). The purpose of TDM strategies targeting employees and students, is to reduce the negative impacts of private car use, such as air pollution and traffic congestion (Bamberg *et al.*, 2011).

TDM measures that aim to change the external context in which choices are made are called *hard* measures. Examples include improving public transport service levels, construction of new bike and pedestrian facilities, road pricing, parking management. Nevertheless, hard measures do not always produce the desired results as they do not succeed in making car use less appealing or triggering behavior change (Piras *et al.*, 2018). Hence, paralleling tendencies in governance and policy-making have recently focused their attention on 'soft' policy measures and smarter choices. *Soft* measures, also named Voluntary Travel Behavior Change (VTBC) programs, aim to change, through communication and information, individuals' perceptions, motivations, knowledge and norms (Steg and Vlek, 2009), so as to steer them towards a more pro-environmental behavior (Piras *et al.*, 2018). One kind of soft measure is Personalized Travel Planning (PTP), where individuals are provided with personalized information, to make them aware of available sustainable means of transport and encourage their use. Numerous PTP programs have been implemented over the last 20 years adopting different methodological approaches (*e.g.* IndiMark and Travelsmart (Brög *et al.*, 2003), Travel Blending (James and Brög, 2002), Travel Feedback Programs (Fujii and Taniguchi, 2006), Personalized Travel Planning (Cairns *et al.*, 2008). Originally TDM strategies only focused on employees, but recently mobility managers from different universities worldwide have started to adopt policies specifically targeting students. In fact, university campuses are special and major destinations in cities, able to generate a significant number of trips, because of their role as centers of employment, teaching, research and dissemination (Rotaris and Danielis, 2014).

So, because travel between home and campus is the main reason for daily trips made by university students (Vale *et al.*, 2018), the key to reducing environmental impacts and improving students' health and quality of life could lie in the promotion of sustainable commute modes. To improve the effectiveness of these TDM measures, in this work we propose an innovative approach to travel demand management, based on a smartphone application. The novelty in the measure implemented is the integration of all mobility management activities into one smartphone application called IPET (Sanjust and Meloni, 2016; Piras *et al.*, 2018). We tested the app on a sample of students from the engineering faculty at the University of RomaTre (Italy). Students were invited to install the application on their smartphone to dynamically and automatically track their daily travel patterns, enabling mobility tutors (mobility management staff or transport researchers) to prepare and upload the PTP in which more sustainable alternatives were suggested. Through a gamification process, students were encouraged to keep the track activity on, enabling mobility tutors to check their mode choices. This approach has multiple benefits for university mobility management activities: i) it enables collection of travel behavior data for guiding urban planning choices; ii) it is a smart and reliable way for promoting new policies or transport solutions; iii) it allows mobility managers to reward the most sustainable students with bonuses or prizes.

The second contribution of the paper concerns the study of which cognitive factors intervene in the process of behavior change. To date, few studies have investigated the evolution of cognitive factors following the implementation of an informative measure. For example, a change of awareness in car-related problems may contribute to a change in travel behavior. Furthermore, informative measures could impact attitudes and intentions toward the use of more sustainable means of transport. Hence, exploring this phenomenon will provide essential information for the design of successful strategies to reduce the use of private motorized vehicles. In our specific case, we asked a set of questions applying the Theory of Planned Behavior (TPB) as described in Ajzen (1991) to measure the psycho-attitudinal aspects before and after individuals had used the IPET application.

The remainder of the paper is organized as follows. Section 2 discusses relevant earlier research studies regarding the implementation of TDM strategies at universities and positions the current study. Section 3 provides a description of the transport context. The application is described in Section 4. Section 5 presents the results in terms of behavioral change. Discussion and conclusions are presented in Section 6.

2 LITERATURE REVIEW

This section provides a review of the travel demand management measures implemented in different university campuses worldwide.

One of the most widely implemented TDM strategies at universities campus is parking management. Two main approaches have been adopted: political and economic. The political approach relies upon rules and regulations (*e.g.* the restriction of the number of parking spots), while the economic approach is based on pricing parking at market value. Different campuses in the USA are restricting parking permits to those who do not have a viable alternative mode of transportation to the university (Isler *et al.*, 2005). Other campuses are stopping providing free parking spaces (Balsas, 2003; Isler *et* *al.*, 2005). Barla *et al.* (2012) evaluated the potential for reducing the commuting mode share of cars at Université Laval in Quebec City (Canada) using stated preference data. They found that the cost of parking lowers the likelihood to commute by car, with clear differences across professional status and income groups. In the context of the University of Idaho, USA, Delmelle and Delmelle (2012) reported that increasing the price of on-campus parking for students disincentivizes driving. Rotaris and Danielis (2014) tested different hypothetical transport policies at the University of Trieste, in Italy, and highlight three policies that lead to a decrease in car use and are also considered as socially and economically efficient: subsidizing bus fares, a mix of bus subsidies with parking restrictions and both parking prices and restrictions. Cruz *et al.* (2017) found that the effective control of illegal parking and abolishing this practice could help to reduce the number of cars in the university campus area of Coimbra, Portugal, by approximately 10%.

Other policies involve the implementation of rideshare programs, such as carpooling incentives. Aoun *et al.* (2013) proposed for the American University of Beirut, Lebanon, a dynamic taxi-sharing service which combines the higher vehicle occupancy of a shared taxi with the reliability and comfort of a private taxi at the reduced cost of a public transport fare. Erdoğan *et al.* (2015) indicated that providing priority parking and cheaper parking options to rideshare program members would help to increase interest in ridesharing and discourage single occupancy vehicle trips.

Often universities work in collaboration with transit agencies to offer students special discounts or free transit passes. These programs have different potential benefits, such as increased student transit ridership, reduced demand for campus parking, use of off-peak transit capacity and improved transit agency performance (Yu and Beimborn 2018). In the USA, more than 50 colleges and universities provides fare-free transit for over 800,000 people (Brown *et al.*, 2001, Brown *et al.*, 2003, Han *et al.*, 2019). Another example is the U-pass or reduced-fare ticket measures implemented in Canada and Germany. Upon enrolment, students have the possibility of paying a sum additional to their tuition fee, which enables them to use all the public transport lines involved in the agreement for free. For example, Letarte *et al.* (2016) showed an increase in public transit share (+18%) and a decrease in car share at the University of Ottawa, Canada, after the program was launched. In Germany, such arrangements benefit one third of the 1.9 million German students (De Witte, 2006).

Some studies have focused on providing information on available transport alternatives. Rose (2008) analyzed the effects of a voluntary travel behavior change program targeted at incoming first-year students at the Clayton Campus of Monash University in Melbourne, Australia. He found a significant effect of the program in terms of reducing single occupant commuting and increasing public transport use (up 5.9%). Piras *et al.* (2018) assessed the efficacy of the implementation of a new light rail line (hard measure) when implementing a VTBC program (soft measure) focusing on individuals going to a university hospital/scientific complex in Cagliari, Italy. They reported that the combination of hard and soft measures achieved a change in travel behavior (from car to light rail) of 34%, when the measure is not personalized, and 46% with the VTBC program.

Concerning soft measures, the possibility of using new technologies to influence students' travel behavior habits is gaining increasing attention. Jariyasunant *et al.* (2015) designed a computational travel feedback system, Quantified Traveler, in which feedback about movements (carbon emissions, calories burned, travel time and cost) is used to change travelers' mode or trip choice. In an experiment conducted at the University of California, Berkley, USA, they found a statistically significant decrease in the average distance traveled by driving, with an average reduction of 39 kilometers or 33% lower than the first week. Di Dio *et al.* (2015) developed a smartphone app called "TrafficO_2" that aims to nudge commuters towards more sustainable mobility by providing monetary incentives for each responsible choice. In a test conducted with a selected sample of students at Palermo University, Italy, they observed a reduction of almost half the carbon dioxide equivalent emissions when compared to their previous habits.

The questionnaire design of our study was based on the Theory of Planned Behavior (TPB) (Ajzen, 1991). The theory of planned behavior postulates that human behavior is guided by three factors, attitudes, subjective norms and perceived behavioral control. In combination, attitudes, subjective norms and perceived behavioral control influence the intention, which is the immediate antecedent of behavior. Later research based on the TPB expanded the influences on one's behavior to past behavior, environmental constraints, and awareness. Only a few studies have investigated changes in cognitive factors after the implementation of TDM measures at universities. Heath and Gifford (2002) used an expanded version of the TPB to evaluate the change after implementation of the U-pass program at the university of British Columbia, Canada. Similarly, Bamberg *et al.* (2003) investigated the changes in the constructs of the TPB after the introduction of a prepaid bus ticket at the University of Giessen in Germany. Jariyasunant *et al.* (2015) evaluated the efficacy of the Quantified Travel platform not only in terms of travel behavior, but also in terms of change in the cognitive factors.

3 CONTEXT IDENTIFICATION

The program described herein was implemented in Rome (Italy) on a sample of students from the University of RomaTre. The road infrastructure network in Rome is based on a radial pattern designed to connect the suburban areas to the city center through arterial roads, following the ancient "consular" routes, and two ring roads, for fast intra-urban trips. The Rome road network extends for over 5,000 kilometers, and the major roads form a subsample of 800 km. Only 100 km of the 5,000 km have dedicated fast lanes for rapid bus transit and in fact the city of Rome ranks among the lowest in Europe for the extension of fast lanes. Compared to the dense and extensive road network, only 300 km of cycle lanes have been created.

In spite of the extensive public transport network managed by the public transit agency (ATAC), with 338 million vehicle-kilometers traveled per year, the level of service is unsatisfactory. The Metro network comprises just three lines (line A, B and C) covering the most congested commuting axes and connecting the city center to the suburbs. ATAC offers a 100-minute travel ticket valid on metros, buses, trams and the 3 suburban railways at a cost of 1.50 €. Monthly and annual passes as well as season tickets, with discounts for students, are also available.

The University of RomaTre is located in the southern part of the city. In addition, the university employs 870 teachers and researchers as well as 714 administrative staff. The campus is situated in an area not far from the city center and was designed to be easily accessible by an extensive network of public transport and the metro stations are within easy walking distance, as shown by the picture of the area where the engineering department of RomaTre involve into (Figure 1).

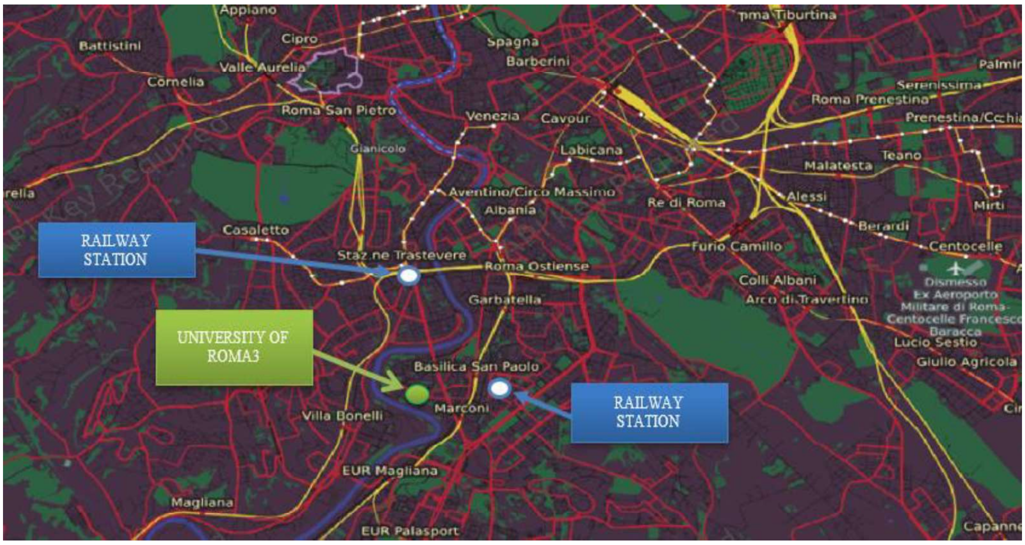

Figure 1: Public Transport Network and railway station.

The campus is easily accessible also by car through the main road corridor Viale Marconi road, which however is characterized by high traffic flows (Figure 2).

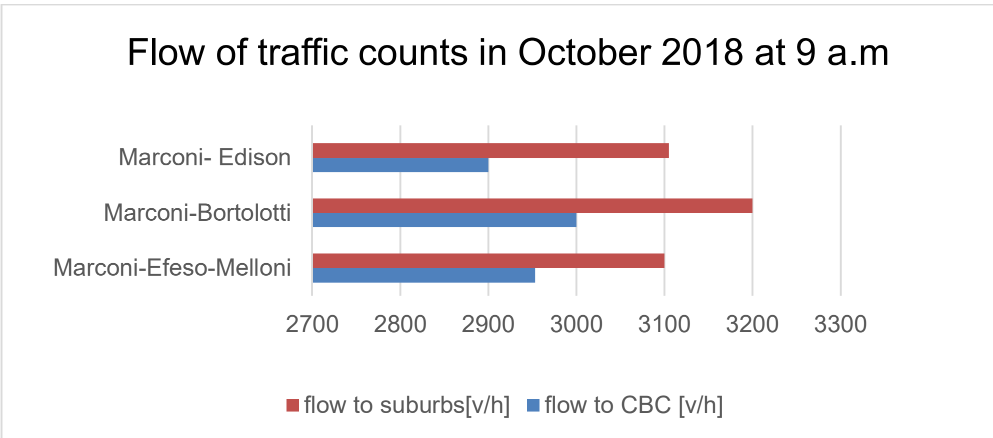

Figure 2: the main corridor traffic flows (October 2018 at 9 a.m)

In addition, a community electric car sharing service, called e-go car sharing, was available at the Departments' private parking spaces (Carrese *et al.*, 2017; Carrese *et al.*, 2018).

Consulting the data (RomaTre Work-Plan, 2015) it emerges that 23% of the employees live within 5 km of the campus and average travel time to reach the university is 30 minutes. 36% of employees stated they commute by public transport, most commonly by metro. Instead, 49% prefer to travel by car or motor scooter. 10%, likely living in close proximity to the campus, walk or cycle to the campus. In terms of road safety, Rome remains one of the most dangerous Italian cities. However, it should be pointed out that for some years there has been a reduction in the negative effects linked to accidents, consistent with what is being recorded on a national scale. In 2012 traffic accidents with victims recorded by local police were 14,622, 14% less than the previous year. The number of fatalities (138; -17% compared to 2011) and the number of injured persons (18,958; -14%) are lower. significant reductions concern two-wheeled motor vehicles (22% less casualties in 2012 than in the previous year), while the conditions for pedestrians and, above all, for children and the elderly remain critical.

However, modest progress is still being made for alternative transport systems. Because of the poor infrastructure and few services dedicated to cycling, despite demand growth potential, this mode still accounted for just 0.6% of modal breakdown for systematic displacements in 2011. The intensive use of private vehicles and, at the same time, a local public transfer supply still not in line with the mobility needs of a city like Rome, generates congestion levels that translate into 135 million of hours lost per year by Roman citizens for their movements. In economic terms a loss of about 1.5 billion €/year of value of time, added to which are the social costs for accidents (about 1.3 billion €/year) and environmental costs.

4 APPLICATION

4.1 Description of the test

The IPET-RomaTre project involved collecting data on the activities and trips of a sample of students from the University of RomaTre using the GPS based mobile application called IPET (Individual Persuasive Eco-Travel Technology) (Sanjust and Meloni, 2018). A survey was conducted between November and December 2017 to collect the data and comprised six macro-phases (Figure 3). The survey was conducted through two different on-line questionnaires and two different smartphone surveys, before and after the delivery of the Personalized Travel Plan (PTP), as suggested by Meloni *et al.* (2013). In the first week, the students of RomaTre were invited to complete an on-line questionnaire containing questions about their habitual travel patterns and personal perceptions and attitudes towards different modes of transport. This was followed by a 2-day period in which the participants were tracked through the IPET platform, so as to record all their daily activities and trips. The choice of two-day diaries was made in order to capture some day-to-day variability, but without excessively burdening the respondents as the literature suggests (Stopher *et al.*, 2009). Student behavior was then analyzed in terms of trip sustainability for Home-Work-Commute (HWC) and Work-Home-Commute (WHC) tours. The personalized travel plans were created from the application for all the non-sustainable students. After delivery of the PTP, the students used the IPET application, recording all their daily activities again for 2 days and persuasive messages were sent informing them about their sustainability. Simultaneously, the data were checked for errors and discrepancies. In the final part of methodology, students were invited to complete a second on-line survey about their usual travel behavior and psycho-attitudinal factors following the PTP experience. Finally, the data from the two waves were analyzed to detect any changes after the information campaign and delivery of the PTP.

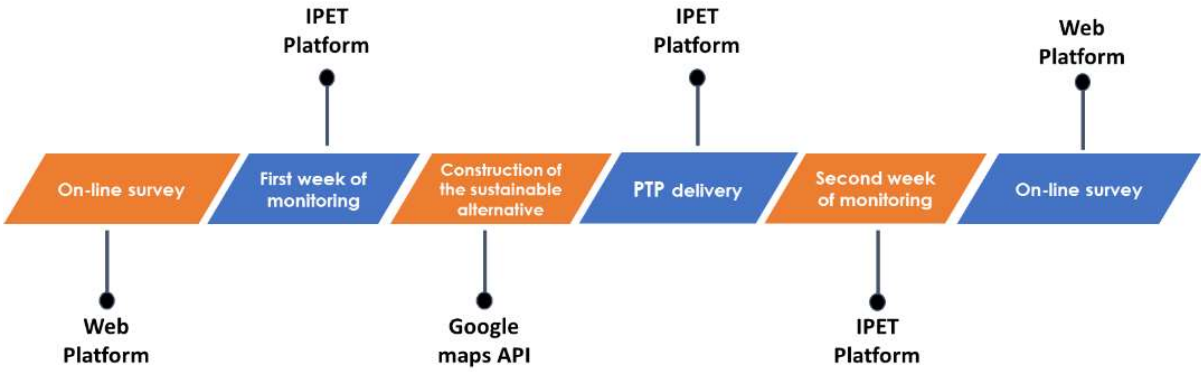

Figure 3. Steps of the program.

4.2 On-line survey design

The on-line questionnaire was designed to measure which cognitive factors may contribute to behavior change. The questions are formulated based on the Theory of Planned Behavior (Ajzen, 1991). Respondents answered different questions designed to measure each of the predictors in the extended theory of planned behavior: awareness, past behavior, attitudes, social norm, environmental identity, perceived behavioral control and intention.

Awareness was measured with four items to assess individuals' level of knowledge of the impacts of their actual behavior, such as the amount of CO_2 emitted and the number of calories burned while traveling, the amount of time and money spent on transportation. All the responses were collected on a 5-point scale, labeled from 1 = *totally unlikely* to 5 = *totally likely*.

The second factor in our questionnaire was "past behavior", as we assumed that not all the decisions concerning the mode of transport are reasoned (Bamberg *et al.*, 2003) but can be influenced by past behavior in different travel situations. We measured past behavior by asking individuals to indicate how often they had performed a specific behavior in the last month. Response options for the questions ranged from 1 (*never*) to 5 (*always*). Note that we included questions concerning not only past travel behavior, but also participation in environmental activities, as they could play a role in deliberate behavior change (Anable, 2005)

In the questions regarding social norm, respondents were asked how they perceived the behavior and attitudes of people important to them with respect to sustainable transportation and pro-environmental behavior. The questions were formulated as "*Most people who are important to me think I should …*" or "*Regardless of what other people do, I believe it is important …*".

The item that measured the attitude toward behavior was based on Ajzen and Fishbein's (1980) operationalization of the construct, and was formulated as: "*In general, I think* . . . (one of the five behaviors) *is pleasant/good/convenient/useful*". Each of these items was followed by a 5-point scale with endpoints labeled *strongly disagree* and *strongly agree*.

"Environmental awareness" was computed as the mean of five 5-point Likert-type questions addressing the respondents' specific environmental concern and commitment. Examples of the items are

"*I am sure that global warming is already happening*" and "*I see myself as a savvy-consumer of the environment*".

Perceived behavioral control was measured through six items 5-point Likert-type, asking respondents to rate how easy/difficult it was for them to complete some activities. As in the *past behavior* and *social norm* section, we investigated their perceived ability toward different pro- environmental behaviors other than travel behavior.

Finally, intention questions measured respondents' specific intentions to use different travel mode alternatives (car, public transport, active mobility, sharing mobility, carpooling, park and ride) on a 5-point scale.

4.3 Demographic Statistics

A total of 60 students, recruited on a voluntary basis among the students attending the degree program in Transportation Engineering, participated in the program.

The data set was further cleaned by removing 5 who refused to use the app, even if they answered both the pre- and post-survey, and another 5 who did not go to the university at least once during either of the two monitoring weeks but worked/studied elsewhere outside the home. Figure 4 shows more clearly the distribution of the sample, describing how many users received the PTP for the systematic trips.

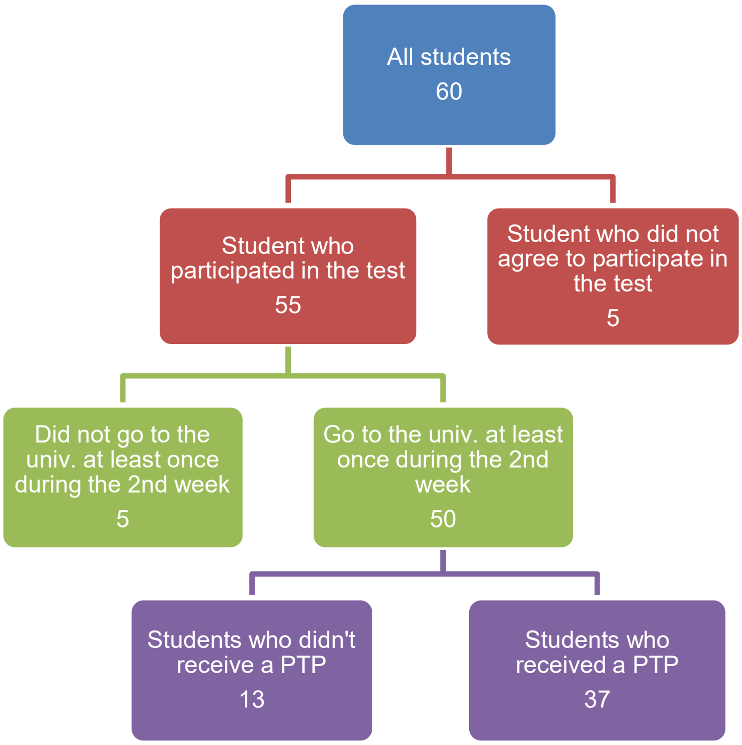

Figure 4. Samples results for PTP analysis.

Analysis of the results are limited to the subsample of 50 students. We are aware of the small dimension of the sample, but it is worth highlight that usually VTBC programs, because of the high level of personalization, are based on small sample sizes of around 50-100 individuals (Fuji et al., 2009; Jariyasunant. *et al.*, 2015; Hsieh *et al.*, 2017; Arroyo *et al.*, 2018; Di Dio *et al.*, 2018; Skarin *et al.*, 2019). In the case of pilot test studies, the sample could be even smaller (Jylhä *et al.*, 2013; Baird *et al.*, 2014).

Regarding socio-economic characteristics, our sample was composed of 72% males and 28% females and average age was around 21 years old. All participants possessed a driving license, while 88% had a personal car available. 30% of the sample lived away from home.

Table 1. Socio-economic characteristics of the sample

Variables	N	[%]	AVG
Total	50	100.0	--
Gender (male)	36	72.0	--
Age	--	--	21.04
# of members in the household	--	--	4.06
Driving license	50	100.0	--
Personal car available	44	88.0	--
# of cars per household	--	--	1.18
Personal income per month			
€ 0-1,000	39	78.0	--
€ 1,001-2,000	4	8.0	--
> €2,000	7	14.0	--
Live outside home	15	30.0	--

5 PROMOTING TRAVEL BEHAVIOR: THE PERSONALIZED TRAVEL PLAN

37 students, who traveled mainly by private vehicle, were selected for whom a feasible sustainable travel alternative could be suggested. Thus, they received a PTP containing a series of travel alternatives designed on the basis of their activity/travel patterns collected in the first wave and constructed using Google Maps. The PTP was sent to all 37 students both by e-mail and through the IPET platform. The PTP could be consulted from any mobile device (pc, tablet, smartphone), so that participants always had the information on hand.

The PTP contained the following information (Figure 5):

- a practical map showing how to use the sustainable travel alternative (public transport, walking or cycling, sharing mobility) suggested;
- a detailed description of the actual individual and environmental effects of the travel behavior adopted. In fact, the PTPs presented a weekly and monthly evaluation of the key factors that come into play in travel choice: monetary cost, journey time, calories burned and CO_2 emissions;
- personalized slogans and other useful information on sustainable travel in general and specifically on the use of the sustainable mobility;
- links that provide useful information on mobility.

Figure 5. Personalized Travel Plan.

The feedback was designed to quantify the effects of the observed behavior following Travel Blending (Taylor and Ampt, 2003), but it was presented also in terms of benefits achievable through the proposed alternative travel mode (time savings, monetary savings, CO_2 reduction and increase in calories consumed).

Table 2 shows the averages for modes observed during the first wave and for the sustainable mode simulated in the PTP. The comparison is expressed in absolute terms. Note that for the mode observed in the first wave, the data reported in the table on weekly and annual basis is calculated as a projection of the feedback detected in the two days of monitoring. It is apparent from this table that suggestions contained in the PTP involved a substantial reduction of both costs and emissions as well as an increase in calories burnt. However, the negative outcome was an increase in travel time on a daily basis of 32.1% on average.

Table 2. Average value for single individual of feedback proposed in the Personalized Travel Plan

Variables	Mode observed in the first week	Sustainable alternative (PTP)	Δ (PTP-Week 1)
Daily cost [€]	3.2	1.7	-1.5
Daily CO_2 emissions [kg]	2.5	0.4	-2.1
Daily travel time [min]	55.1	72.8	17.8
Daily calories burned [kcal]	5.7	108.2	102.4
Weekly cost [€]	16	8.3	-7.7
Weekly CO_2 emissions [kg]	12.7	2.2	-10.5
Weekly travel time [min]	275.4	364.2	88.8
Weekly calories burned [kcal]	28.6	540.8	512.2
Annual cost [€]	641.7	332.6	-309.1
Annual CO_2 emissions [kg]	1,097.4	86.3	-1,011.1
Annual travel time [min]	11,016.2	14,567.6	3,551.4
Annual calories burned [kcal]	1,144.5	21,633	20,488.5

6 RESULTS

6.1 Survey results on psychological variables

Survey results on psychological variables are given in Table 3. The numbers are derived from the answers to the Likert-scale questions on a scale from 1 to 5. Paired-sample t test and χ^2 test were performed to investigate changes before and after implementation of the VTBC program. In making these comparisons note that, because of the small size of the sample, it was not possible to secure a nonintervention control group. The most important differences between the two weeks are the following:

1. The responses to the questions regarding awareness of CO_2 emitted and calories burned from travel indicate that, before the program, the sample had little knowledge of these values. After implementation of the program we observed a significant shift in the answers to the questions regarding the CO_2 and calories. This is not surprising, as one of the main objects of informative measures is to heighten people's awareness about their behavior and the consequences associated therewith.
2. Interestingly, we observed a significant positive change in the frequency of using active mobility after the program implementation.
3. We did not detect any significant change between the two weeks for the social norm items.
4. Though still high, the attitude toward car use significantly decreased in the second week. We also found a significant difference in the cell frequencies between both weeks for the statement regarding shared mobility, although the mean did not differ significantly.
5. We observed a significant and positive change in the answers of the behavioral control question regarding the use of shared mobility. This effect is a direct consequence of the program, as one of the suggested mode alternatives presented in the PTP was the car sharing service. We also detected a significant difference in the cell frequencies between both waves for public transport, although the mean did not differ significantly.
6. The intention questions regarding changes in travel mode split over the next days indicate a significant positive change in the intention to use active mobility. However, the sample showed a negative intention to use public transit and positive intention to drive, which did not change after implementation of the program.

In general, it is apparent that respondents seemed to have significantly more positive knowledge of cost and time spent on traveling.

Regarding past behavior, the participants gave, on average, mixed responses. On the one hand, they responded positively to questions related to their level of commitment in fulfilling pro-environmental activities, such as using drinking water sparingly or being careful to disconnect electronic devices when not in use. They also showed a tendency to keep healthy, as they scored high on the questions concerning physical exercise habits and being careful to consume low fat foods. However, they responded more negatively to those questions about their willingness to use sustainable mobility, such as public transport or carpooling.

We obtained mixed results for the social norm items. People important to the sample do not seem to behave in a pro sustainable way and believe it is important to own a car. However, respondents feel it is important to be committed to pro-environmental behavior, regardless of how other people act.

Attitude towards riding the bus was relatively low at the time of the first week and we did not find any significant differences after implementation of the measure. Otherwise, all the individuals consider active mobility as a healthy travel alternative and driving the car a pleasant activity.

In general, the respondents stated it would be difficult to reduce car, or shared mobility use or travel by public transport. Instead, they displayed a positive perceived behavioral control toward active mobility.

Table 3. Difference in attitudinal response between waves (1 strongly disagree, 5 strongly agree)

		AVG pre	AVG post	AVG difference	T stat	χ^2
AWARENESS	I know how much CO_2 I emit while traveling.	1.88	2.68	0.80	**5.29**	**34.69**
	I know how many calories I burn while traveling.	2.02	2.72	0.70	**5.19**	**25.26**
	I know how much money I spend on traveling.	4.14	4.04	-0.10	-0.90	4.56
	I know how much time I spend traveling.	4.48	4.58	0.10	1.04	0.53
PAST BEHAVIOR	In the last month, I have used active mobility (cycling, walking).	2.74	3.30	0.56	**3.51**	**11.03**
	In the last month, I have used drinking water sparingly.	3.78	3.80	0.02	0.17	2.48
	In the last month, I have used public transport.	2.88	2.98	0.10	0.64	4.36
	In the last month, I have been careful to consume low fat foods.	2.94	3.00	0.06	0.52	0.46
	In the last month, I have used shared mobility (bike sharing, car sharing).	1.22	1.20	-0.02	-0.20	0.25
	In the last month, I have engaged in physical activity constantly.	3.44	3.48	0.04	0.37	2.96
	In the last month, I have been careful to consume organic foods.	2.26	2.30	0.04	0.37	2.49
	In the last month, I have used carpooling.	1.02	1.04	0.02	0.44	1.00
	In the last month, I have smoked.	1.82	1.82	0.00	0.00	0.68
	In the last month, I have been careful to disconnect electronic devices when they are not in use.	3.5	3.36	-0.14	-0.78	0.89
SOCIAL NORM	People who are important to me believe it is important to own a car.	3.32	3.12	-0.20	-1.75	**33.89**
	People who are important to me think I should use sustainable means of transport as much as possible.	2.68	2.74	0.06	0.43	3.20
	Regardless of what other people do, I believe it is important to exercise regularly.	4.26	4.40	0.14	1.41	6.83
	Regardless of what other people do, I believe it is important to use eco-friendly products (solar panels, class A home appliances, electric cars, *etc*.).	3.64	3.80	0.16	1.43	2.22
	Regardless of what other people do, I believe it is important to respect the environment.	4.42	4.34	-0.08	-0.78	5.71
	People who are important to me think I should use shared mobility as much as possible.	1.74	1.72	-0.02	-0.22	1.99
ATTITUDES	In general, I think using shared mobility is useful.	3.14	2.98	-0.16	-1.03	**9.97**
	In general, I think driving the car is pleasant.	4.22	3.90	-0.32	**-3.47**	**8.37**
	In general, I think public transit is convenient.	3.06	3.08	0.02	0.16	0.85
	In general, I think using active mobility (walking, cycling) is healthy.	4.26	4.20	-0.06	-0.57	0.86
	In general, I think that using carpooling is a smart choice.	3.42	3.60	0.18	1.16	4.19
ENVIRONMENTAL IDENTITY	I am sure that global warming is already happening.	4.18	3.94	-0.24	**-2.20**	**11.66**
	According to my personal values, I feel obliged to contribute proactively to build a sustainable society.	3.44	3.60	0.16	1.31	5.04
	I see myself as a savy-consumer of the environment.	3.38	3.32	-0.06	-0.68	1.93
	There is very little I can do to mitigate the effects of the global warming.	3.02	2.98	-0.04	-0.30	3.93
	There are some easy actions I can do to significantly alleviate the effects of global warming.	3.46	3.24	-0.22	-1.85	7.23
PERCEIVED BEHAVIORAL CONTROL	For me, using sustainable means of transport would be difficult.	3.04	2.78	-0.26	-1.20	**8.24**
	For me, using shared mobility (car sharing, bike sharing) for my trips would be difficult.	3.92	3.50	-0.42	**-2.48**	**9.90**
	For me, doing physical activity constantly would be difficult.	2.66	2.72	0.06	0.27	0.66
	For me, reducing car use would be difficult.	3.18	3.22	0.04	0.27	2.24
	For me, disconnecting electronic devices when they are not in use would be difficult.	2.06	2.12	0.06	0.31	2.41
	For me, using active mobility (walking, cycling) for short trips would be difficult.	2.08	2.12	0.04	0.21	6.97
INTENTION	In the next days, I intend to use active mobility (walking, cycling).	2.98	3.44	0.46	**2.98**	**19.11**
	In the next days, I intend to use public transportation.	2.66	2.82	0.16	1.18	4.92
	In the next days, I intend to use shared mobility.	2.70	2.90	0.20	0.75	1.78
	In the next days, I intend to use the car as a driver.	3.80	4.10	0.30	1.72	5.50
	In the next days, I intend to use carpooling.	1.56	1.66	0.10	0.47	0.95
	In the next days, I intend to use park and ride (car + public transport).	3.00	3.06	0.06	0.20	4.81

6.2 Behavior Change Analysis

To evaluate any changes in travel behavior we analyzed the modal share between the first and second weeks. Figure 6 quantifies the effect of the implemented measure on the switch from private vehicle to public transport. 32.4% (12 individuals) of students who received the PTP changed their travel behavior, demonstrating the effectiveness of a personalized measure and of the mobile platform.

These results therefore need to be interpreted with caution, because only 25% of individuals who used the PTP maintained that change for the two days of the second week.

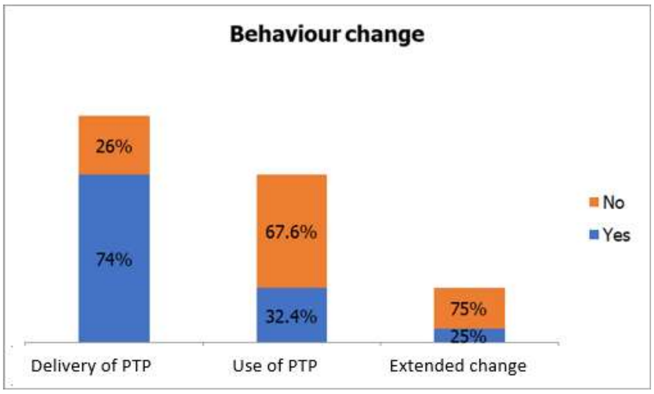

Figure 6. Behavior change (switch from private vehicle to sustainable alternative.

Nevertheless, it is important to note that the approach adopted here has the merit of persuading people at least to try an alternative sustainable mode of travel, making them aware of aspects that they generally overlooked, such as CO_2 emissions and calories burnt. In fact, analysis of the second week questionnaire revealed a significant difference between the first and second weeks, among those who adopted the PTP (12 individuals), regarding the awareness of emissions and calories, while no difference was observed for travel times and costs (Table 4).

Table 4. Comparison of PTP users and non-users regards awareness

AWARENESS	Av N12 PRE	Avg N12 POST	Δ (POST- PRE)	Avg N25 PRE	Avg N25 POST	Δ (POST- PRE)	**t-test_1***	**t_test_2****
I know the quantity of CO_2 emissions I emit for every trip	2.08	3.42	1.33	1.84	2.56	0.72	0.65	2.2
I know the quantity of calories burned for every trip	2.17	3.42	1.25	1.76	2.44	0.68	1.17	2.26
I know how much money I spend for every trip	4.17	4.17	0	4	3.76	-0.24	0.43	1.17
I know how much time I spend for every trip	4.75	4.75	0	4.44	4.48	0.04	1.29	1.19

* t-test_1 has been calculated for AvgN12 and AvgN25 PRE

* t-test_2 has been calculated for AvgN12 and AvgN25 POST

6.3 Tour analysis

Considering all the data collected over the 4 days from all the students, it yielded a total of 732 trips completed during 524 tours, with a total of almost 400 hours spent travelling over 8,300 km. Various categorizations were used to obtain a detailed analysis:

- the day was split into five different time slots, to consider the different travel habits during the day;
- the data was split between PRE PTP and POST PTP, to evaluate whether any notable difference had been recorded in response to delivery of the personalized travel plan;
- seven different categories of tour were identified to differentiate travel based on their origin/destination;
- the transportation modes were split into 4 different categories associated with each tour.

Following the definitions of McGuckin and Murakami (1999), a tour is defined as a series of trips starting and ending in an anchor location (home or workplace; the latter should be intended as a larger category which also includes study related locations, such as college or university). If a tour is interrupted at any location other than the anchor ones, for any non-work-related reason (*e.g.* shopping, entertainment, physical activity), that location is categorized as a stop within the tour, regardless of the length of stay.

The different tour categories are shown in Table 5. The four different modes of transportation derive from the combination of vehicles (or lack thereof) used by each user during a complete tour: i) walking, when no vehicle was used during the tour; ii)private transport, if only cars (either as driver or as passenger) or motorbikes were used; iii) public transport, if only trains, buses, or metro were used; iiii) park and ride, when the trips within the tour used a combination of private and public transport.

Table 5. Tour classification

ACRONYM	NAME	DESCRIPTION
BW	Before work tour	A tour starting and ending at home, before a HWC tour
HWC	Home-work commute tour	A tour starting at home and ending at the workplace
WB	Work based tour	A tour starting and ending at the workplace
WHC	Work-home commute tour	A tour starting at the workplace and ending at home
AW	After work tour	A tour starting and ending at home, after a WHC tour
NW	Non - work tour	A tour starting and ending at home, on a day in which the workplace was not visited
NHB	Non - home based tour	A tour which does not end/start at home whenever the person sleeps out

If the tour included one (or more than one) stop, after which the mode was changed, the mode associated with that tour was considered to be the "main mode", that is the one with the longest distance traveled (Creemers *et al.*, 2015) (with the exception of walking, which is never the main mode if any other mode is used in the tour).

Considering all the tours for all the users and comparing the situation before and after delivery of the PTP, all values decrease slightly, the total number of tours passing from 254 to 239. However, focusing on the commute tours, there are fewer differences, since during both weeks all the students traveled to the campus at least once (after all, the data subsample was selected to get exactly this result), and the number of completed tours is practically the same. Figure 7 shows the distribution of all tours between the different tour categories. Most tours (77%) are commutes, equally divided between home-to-work and work-to-home.

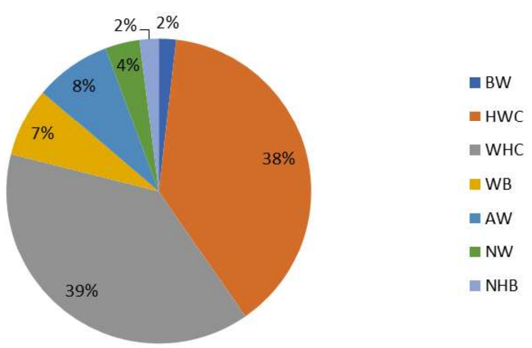

Figure 7. Distribution of all tours among the different tour categories.

This clearly shows that the main and most significant factor influencing the mobility of students is in fact the need to reach the campus. The remaining 23% of tours is split between the other categories, in particular 8% of the total are after-work tours, 7% work-based, 4% non-work tours, while before-work as well as non-home based tours each account for 2%.

Figure 8 shows the percentages of distance for all different tour modes between the two weeks, with a reduction in walking and private transport tours, and an increase in public transport tours. Figure 9 shows in detail the HWC and WHC tours (the most frequent). As can be observed, the decrease in private transport use (and increase in public transport) was mostly due to changes in WHC modes, while the differences are more contained in WHC tours.

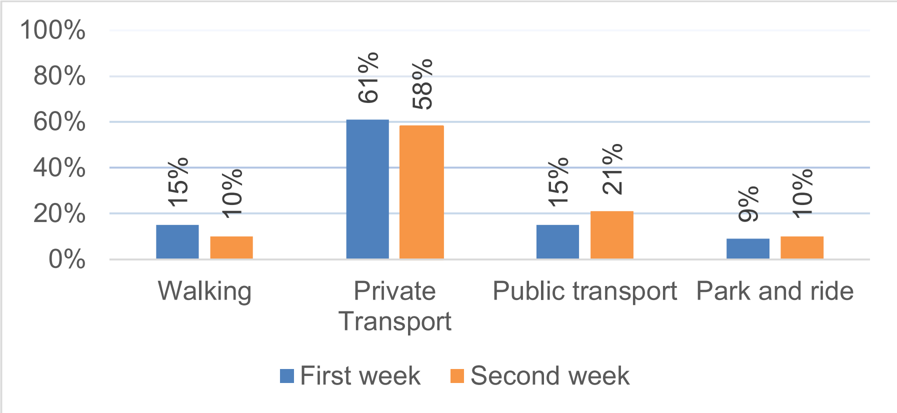

Figure 8. Percentages of distance for all different tour modes between the two weeks.

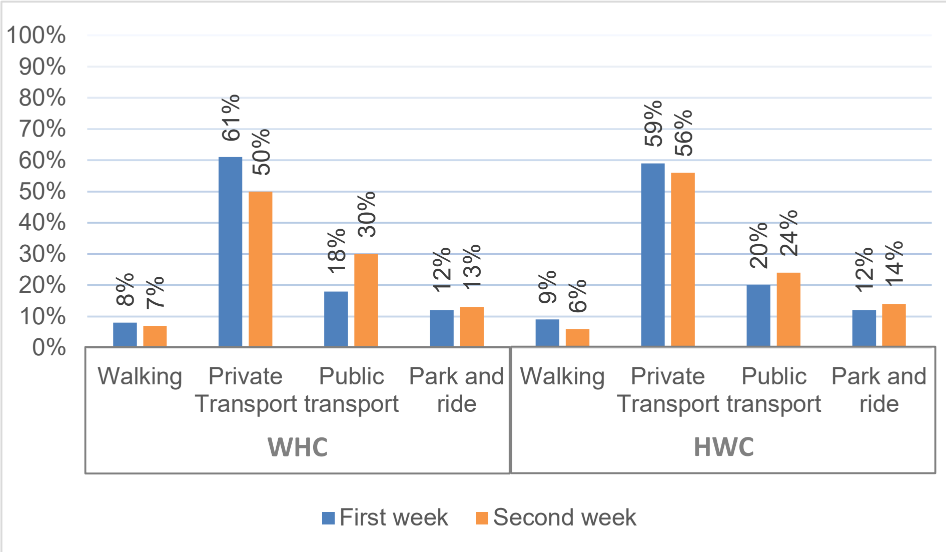

Figure 9. Percentages of distance for all different HWC and WHC tour modes between the two weeks.

6.4 Activity Analysis

The previous section has shown a change between the first and second weeks in terms of use of public and private transport. It is necessary now to explore the problem with regard to activity analysis.

Analyzing in-home (HA) and out-of-home (OHA) activities in the first and second weeks, we observe almost no difference between HA and OHA before and after delivery of the PTP (Figure 10).

Figure 10. Analysis of in-home (HA) and out-of- home (OHA) activities in the second weeks.

As can be observed from Table 6, on average users spend more time at home, also given the larger percentage of HA activity recorded, with a slight increase in the post-delivery phase.

Table 6. Time spent in activities

	First week		Second week		First + Second week		Δ (Post-Pre)	
	N. Act. [-]	Avg. duration [h.min]	N. Act. [-]	Avg. duration [h.min]	N. Act. [-]	Avg. duration [h.min]	N. Act. [-]	Avg. duration [h.min]
In-home activity	609	2.21	591	2.29	1,200	2.25	-18	0.08
Out-of- home activity	543	1.27	522	1.28	1,065	1.27	-21	0.01
Trips	660	0.16	650	0.15	1,310	0.15	-10	-0.01

It is interesting to show (Figure 11) the breakdown of activities (in percentage) over 24 hours for 3 samples of users:

- 50 students who participated in the survey and went to the University of RomaTre at least once in the second week;
- 12 students who received and used the PTP;
- 25 students who received the PTP but never used the recommended sustainable alternative.

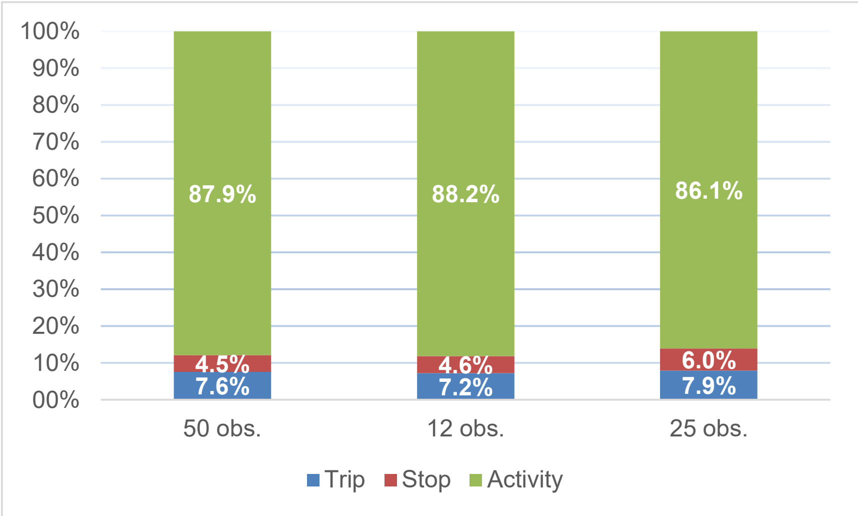

Figure 11. Breakdown of activities (percentage) over 24 h.

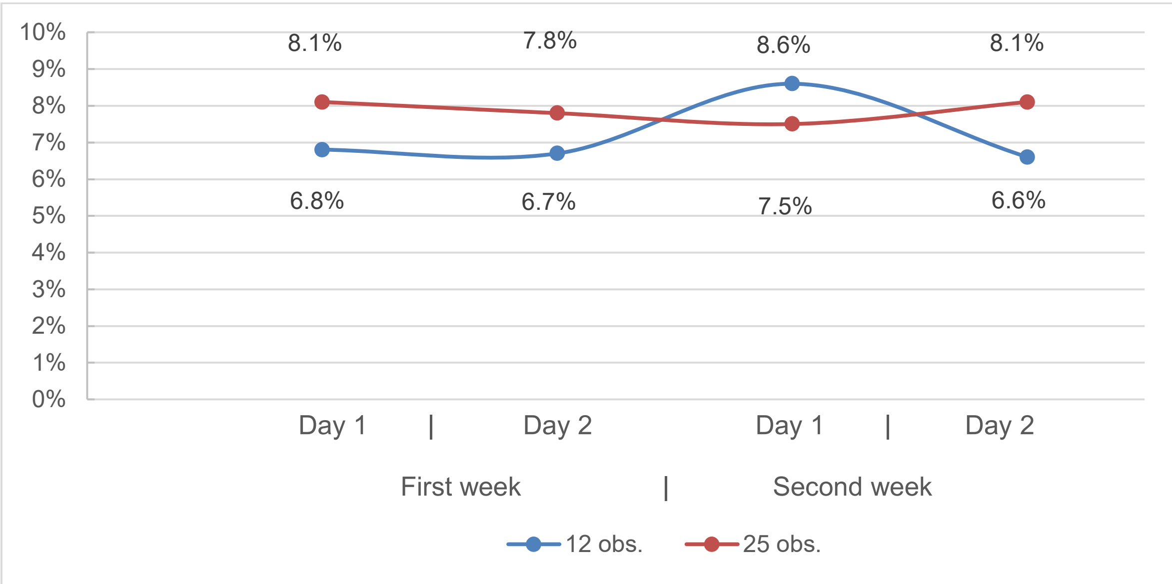

Figure 12. Time spent on trips for students who used the PTP and those who did not.

As can be observed the time spent on stops and trips by those students who followed the suggestion presented in the PTP differs slightly from those who did not. This is shown in detail in Figure 12. In fact, on the first two days (pre- PTP phase) the sub-sample of 25 users who did not use the PTP spent more time than the sub- sample of 12 students on trips and stop activities (between one movement and another). On the first day of the second week, the 12 user sub-sample spent a greater percentage of time in trips than the 25 users (8.6% for 12 *vs.* 7.5% for 25), probably due to the fact that the 12 users who adopted the PTP took more time to make the trips (with the recommended sustainable alternative). But on the last day of the second week the percentage of trips reverted to the average values of the first week (6.6% for 12 *vs.* 8.1% for 25), and consequently the percentage of stops increases to 8%.

These results suggest that:

- the majority of students who used the PTP tried the suggested alternative only one day, probably because, as stated in paragraph 5, travel time using the proposed alternative was longer than by private vehicle;
- stops, namely activities between one trip and another made during the same tour, are hardly practicable when using a sustainable means of transport such as bus or train.

5 DISCUSSION AND CONCLUSIONS

The object of this work was to test the efficacy, in the short time, of a mobile system for promoting sustainable means of transport among university students. Using the IPET platform, a test conducted with 50 students in the city of Rome, indicated that information and persuasion strategies potentially affect behavior change, though the context is characterized by a car-centric culture, where almost all students already own a driving license and a car.

Monitoring students' behavior before and after delivery of the personalized travel plan allowed us to conduct an in-depth analysis of trip and activity patterns. Moreover, the decision to gather data for more than one day made it possible to observe individuals' behavior change as a process, through the choices made by individuals on each day of the survey.

Comparison of the data collected in the first and second weeks showed, for those who received a PTP, an 8.1% shift towards more sustainable transport modes. This is in line with the findings of the few studies reported in the literature that quantify the contribution of personalized programs to behavior change as between 5 and 15%. However, note that 24.3% of students who received the PTP tried the suggested alternative at least once but did not maintain the change in their behavior for the whole second week, mainly because the public transport alternative, in most cases, was not competitive in terms of travel time, with the private vehicle. This fact shows that people could be persuaded to use a more sustainable means of transport but that the sustainable alternative, to be chosen and to be able to compete with private vehicles, must be a valid alternative, not only in terms of carbon footprint, but also in terms of travel time and cost.

The study also investigated whether there were any changes in the cognitive factors after implementation of the VTBC program. We observed a strong positive change especially in the level of awareness regarding CO_2 emissions and calories burnt. However, all the other categories (intentions, attitudes, social norms) were only slightly impacted by the program implementation. This may reflect the fact that the IPET platform is able above all to increase individuals' knowledge of the consequences of their behavior. Further, note that the frequency and the intention to use active mobility, a travel alternative that does not depend on the quality of service such as public transport, increased significantly.

However, this work has a number of limitations that could be addressed in the future. The size of the sample was rather small so caution must be taken in interpreting the results. However, one of the keys to the success of VTBC programs is the high degree of personalization and how the information is conveyed. Implementing these kinds of measures on a large scale can be expensive, therefore is essential, in order to be able to implement effective and efficient measures, to run a pilot test. In literature several VTBC programs studies have a small sample, and this is all the more in the case of pilot test studies. Our study is just a forerunner of future studies involving more people.

Moreover, the presence of a control group would have helped to take into account the self-selection bias in the analysis. These are shortcomings but the overall experience represents an additional contribution to research in the area of soft measures and persuasive technology.

In conclusion, despite its limitations, the findings of this study suggest that *soft* measures, implemented with the aid of technology, could prove a valid tool for university mobility managers for addressing the problems caused by the wide use of private vehicle.

REFERENCES

Ajzen, I. (1991). The theory of planned behavior. *Organizational behavior and human decision processes*, *50*(2), 179-211.

Anable, J. (2005). 'Complacent car addicts' or 'aspiring environmentalists'? Identifying travel behaviour segments using attitude theory. *Transport policy*, 12(1), 65-78.

Aoun, A., Abou-Zeid, M., Kaysi, I., & Myntti, C. (2013). Reducing parking demand and traffic congestion at the American University of Beirut. *Transport Policy*, 25, 52-60.

Arroyo, R., Ruiz, T., Casquero, D., & Mars, L. (2018). Trip characteristics analysis of the effects of a travel behavior change program. *Transportation Research Record,* 2672(47), 146-158.

Baird T. and Zhao J. (2014). 'Nudging' Active Travel: A Framework for Behavioral Interventions Using Mobile Technology. In Transportation Research Board 93rd Annual Meeting, no. 14-4106.

Balsas, C. J. (2003). Sustainable transportation planning on college campuses. *Transport Policy*, 10(1), 35-49.

Bamberg, S. (2006). Is a residential relocation a good opportunity to change people's travel behavior? Results from a theory-driven intervention study. *Environment and behavior*, 38(6), 820-840.

Bamberg, S., Ajzen, I., & Schmidt, P. (2003). Choice of travel mode in the theory of planned behavior: The roles of past behavior, habit, and reasoned action. *Basic and applied social psychology*, 25(3), 175-187.

Bamberg, S., Fujii, S., Friman, M., & Gärling, T. (2011). Behaviour theory and soft transport policy measures. *Transport policy*, 18(1), 228-235.

Barla, P., Lapierre, N., Daziano, R. A., & Herrmann, M. (2012). Reducing Automobile Dependency on Campus: Evaluating the Impact TDM Using Stated Preferences. Cahier de recherche/Working Paper, 3.

Brög, W., Erl, E., Ker, I., Ryle, J., & Wall, R. (2009). Evaluation of voluntary travel behaviour change: Experiences from three continents. *Transport Policy*, 16(6), 281-292.

Brown, B. B., Werner, C. M., & Kim, N. (2003). Personal and contextual factors supporting the switch to transit use: Evaluating a natural transit intervention. Analyses of Social Issues and Public Policy, 3(1), 139-160.

Brown, J., Hess, D. B., & Shoup, D. (2001). Unlimited access. *Transportation*, 28(3), 233- 267.

Cairns, S., Sloman, L., Newson, C., Anable, J., Kirkbride, A., & Goodwin, P. (2008). Smarter choices: assessing the potential to achieve traffic reduction using 'soft measures'. *Transport Reviews*, 28(5), 593-618.

Carrese, S., Cipriani, E., Giacchetti, T., Sottile, E., & Zamberlan, L. (2019, June). Hybrid Choice

Model to analyze electric car sharing demand in a university community. In *2019 6th International Conference on Models and Technologies for Intelligent Transportation Systems (MT-ITS)* (pp. 1-6). IEEE.

Carrese, S., Giacchetti, T., Nigro, M., & Patella, S. M. (2017). An innovative car sharing electric vehicle system: An Italia experience. *Urban Transport XXIII*, 176, 245.

Cialdini, R. B. (2001). The science of persuasion. *Scientific American*, 284(2), 76-81.

Creemers, L., Bellemans, T., Janssens, D., Wets, G., & Cools, M. (2015). Analyzing access, egress, and main transport mode of public transit journeys: evidence from the Flemish national household travel survey.

Cruz, L., Barata, E., Ferreira, J. P., & Freire, F. (2017). Greening transportation and parking at University of Coimbra. *International Journal of Sustainability in Higher Education*, 18(1), 23-38.

De Witte, A., Macharis, C., Lannoy, P., Polain, C., Steenberghen, T., & Van de Walle, S. (2006). The impact of "free" public transport: The case of Brussels. *Transportation Research Part A: Policy and Practice*, 40(8), 671-689.Delmelle, E. M., & Delmelle, E. C. (2012). Exploring spatio-temporal commuting patterns in a university environment. *Transport Policy*, 21, 1-9.

Delmelle, E. M., & Delmelle, E. C. (2012). Exploring spatio-temporal commuting patterns in a university environment. *Transport Policy*, 21, 1-9.

Di Dio, S., Casto, B. L., Micari, F., Rizzo, G., & Vinci, I. (2015). Mobility, data, and behavior: the TrafficO_2 case study. In *Handbook of Research on Social, Economic, and Environmental Sustainability in the Development of Smart Cities* (pp. 382-406). IGI Global.

Di Dio, S., La Gennusa, M., Peri, G., Rizzo, G., & Vinci, I. (2018). Involving people in the building up of smart and sustainable cities: How to influence commuters' behaviors through a mobile app game. *Sustainable Cities and Society*, 42, 325-336.

Erdoğan, S., Cirillo, C., & Tremblay, J. M. (2015). Ridesharing as a green commute alternative: A campus case study. *International Journal of Sustainable Transportation*, 9(5), 377-388.

Fuji, S., & Kitamura, R. (2003). What does a one-month free bus ticket do to habitual drivers. *Transportation*, 30, 81-95.

Fuji, S., & Taniguchi, A. (2006). Determinants of the effectiveness of travel feedback programs—a review of communicative mobility management measures for changing travel behaviour in Japan. *Transport policy*, 13(5), 339-348.

Fujii, S., Bamberg, S., Friman, M., & Gärling, T. (2009). Are effects of travel feedback programs correctly assessed?. *Transportmetrica*, 5(1), 43-57.

Han, D., Yu, J., Beimborn, E., Jin, Z., & Tan, W. (2019). Elements of Successful Universal Student Transit Pass Programs from Planning to Implementation: A Benchmark Study. *Transportation Research Record*, 0361198119834916.

Heath, Y., & Gifford, R. (2002). Extending the theory of planned behavior: Predicting the use of public transportation 1. *Journal of Applied Social Psychology*, 32(10), 2154-2189.

Hsieh, H. S., Kanda, Y., & Fujii, S. (2017). Reducing car use by volitional strategy of action and coping planning enhancement. Transportation research part F: traffic psychology and behaviour, 47, 163-175.

ISFORT. 15° Rapporto sulla mobilità in Italia. ISFORT, www.isfort.it, 2018.

Isler, E., Hoel, L. A., & Fontaine, M. D. (2005). Innovative parking management strategies for Universities: accommodating multiple objectives in a constrained environment. In Annual Meetings of the Transportation Research Board, Washington, DC.

James, B., & Brög, W. (2002, September). TravelSmart-large-scale cost-effective mobility management. Experiences from Perth, Western Australia. In Proceedings of the Institution of Civil

Engineers-Municipal Engineer (Vol. 151, No. 1, pp. 39-48). London: Published for the Institution of Civil Engineers by Thomas Telford Services, c1992-.

Jariyasunant, J., Abou-Zeid, M., Carrel, A., Ekambaram, V., Gaker, D., Sengupta, R., & Walker, J. L. (2015). Quantified traveler: Travel feedback meets the cloud to change behavior. *Journal of Intelligent Transportation Systems*, 19(2), 109-124.

Jylhä A., Nurmi P., Sirén M., Hemminki S., Jacucci G.: MatkaHupi (2013). A Persuasive Mobile Application for Sustainable Mobility. UbiComp'13, Zurich, Switzerland.

Letarte, L., Pouliot, S., & Waygood, E. O. D. (2016). The Impacts of Universal Bus Pass on University Student Travel Behavior (No. 16-1498).

Litman, T. (2003). The Online TDM Encyclopedia: mobility management information gateway. *Transport Policy*, 10(3), 245-249.

Maynard, D., & Newmark, G. L. (2018). Bicycling Among University Campus Residents: A Policy-Oriented Analysis (No. 18-06690).

Meloni, I., Spissu, E., & Bhat, C. (2011). The effect of personal cap-and-trade mileage policies on individual activity-travel patterns: The Activity Locator project. *Transportation Letters*, 3(4), 293-307.

McGuckin, N., & Murakami, E. (1999). Examining trip-chaining behavior: Comparison of travel by men and women. *Transportation Research Record: Journal of the Transportation Research Board*, (1693), 79-85.

Piras, F., Sottile, E., & Meloni, I. (2018). Modal Share Change following Implementation of Travel Demand Management Strategies. *Transportation Research Record*, 2672(8), 731-741.

Rose, G. (2008). Encouraging sustainable campus travel: Self-reported impacts of a university TravelSmart initiative. *Journal of Public Transportation*, 11(1), 5.

Rotaris, L., & Danielis, R. (2014). The impact of transportation demand management policies on commuting to college facilities: A case study at the University of Trieste, Italy. *Transportation Research Part A: Policy and Practice*, 67, 127-140.

Sanjust di Teulada, B. & Meloni, I. (2016). Individual Persuasive Eco-travel Technology, a mobile persuasive application for implementing voluntary travel behaviour change programmes. *IET Intelligent Transport Systems*, 10(4), 237- 243.

Sargisson, R. J. (2018). Do Parking Fees Affect Commuting Choices Of Staff And Students On A University Campus?. *International Journal of Transport Development and Integration*, 2(2), 189-201.

Seethaler, R. K., & Rose, G. (2005). The Use of Persuasion Principles to Promote Travel Behaviour Change. TDM Review, 13(2).

Skarin, F., Olsson, L. E., Friman, M., & Wästlund, E. (2019). Importance of motives, self-efficacy, social support and satisfaction with travel for behavior change during travel intervention programs. Transportation research part F: traffic psychology and behaviour, 62, 451-458.

Spissu, E., Meloni, I., & Sanjust, B. (2011). Behavioral analysis of choice of daily route with data from global positioning system. Transportation research record, 2230(1), 96-103.

Steg, L., & Vlek, C. (2009). Encouraging pro- environmental behaviour: An integrative review and research agenda. *Journal of environmental psychology*, 29(3), 309-317.

Stopher, P., Clifford, E., Swann, N., & Zhang, Y. (2009). Evaluating voluntary travel behaviour change: Suggested guidelines and case studies. Transport Policy, 16(6), 315-324.

Taniguchi, A., Suzuki, H., & Fujii, S. (2007). Mobility Management in Japan: Its Development and Meta-Analysis of Travel FeedbackTravel Feedback Programs. *Transportation Research Record: Journal of the Transportation Research Board*, 2021, 100–109. https://doi.org/10.3141/2021-12.

Taylor, M. A., & Ampt, E. S. (2003). Travelling smarter down under: policies for voluntary travel behaviour change in Australia. *Transport policy*, 10(3), 165-177.

Vale, D. S., Pereira, M., & Viana, C. M. (2018). Different destination, different commuting pattern? Analyzing the influence of the campus location on commuting. *Journal of Transport and Land Use*, 11(1).

Yu, J., & Beimborn, E. (2018). College Student Transit Pass Programs (No. Project J-7, Topic SA-42).

Zhou, J. (2012). An analysis of university employee car-sharers in Los Angeles. *Transportation Research Part D: Transport and Environment*, 17(8), 588-591.