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ESTA: Educating Adolescents in Sustainable Travel Urban Behavior through Mobile Applications Using Motivational Features †

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Abstract: This paper proposes the use of motivational features in mobile applications to support adolescents' education in sustainable travel urban behavior, so that they become more mindful of their environmental impact. To this effect, existing persuasive strategies are adopted, implemented, and integrated into six simulated screens of a prospective mobile application named ESTA, designed for this purpose through a user-centered design process. These screens are then assessed by secondary education pupils, the outcome of which is analyzed and presented in detail. The analysis takes into consideration the possibility for the daily use of ESTA in order for the adolescents to foster an eco-friendly and healthy transit attitude and make more sustainable mobility choices that will follow them throughout their life. The potential effectiveness of ESTA is demonstrated via two use cases: the "Daily Commuting" case is addressed towards adolescents who want to move within their area of residence or neighborhood following their daily routine and activities, while the "Weekend Entertainment" is addressed towards adolescents who want to move using the available public transport modes, encouraging them to adopt greener weekend travel habits.

Keywords: educational technology; mobile application; persuasive technology; sustainable urban mobility; user-centered design

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1. Introduction

Mobility is "the ability to move easily from one place to another" [1]. More specifically, the independent mobility of children is typically defined as the freedom to travel around the neighborhood or city without adult supervision [2,3]. This independent mobility often includes non-motorized activities like walking and cycling [4]. In the extensive literature on the wellbeing of children, a significant part has been dedicated on numerous health and environmental benefits of independent mobility [5–8]. It has been well-documented that this mobility levels may substantially influence children's physical, social, cognitive and emotional development [9,10]. For instance, according to [11,12], the physical development of children is closely associated with their freedom of movement, while they are not accompanied by adults. In terms of cognitive development, independent mobility helps children learn to map and to navigate within their neighborhood [13], while from an emotional point of view, it allows them to build social relationships beyond their immediate family and connect them with the natural environment [14,15]. Moreover, independent mobility has also been shown to be associated with a stronger sense of community, and reduced fear of crime and feelings of loneliness during adolescence [16]. However, many parents restrict the movement of their children around the local neighborhood due to safety concerns. Numerous studies have shown that the restrictions on the independent mobility

of children are mostly connected to their parents' anxiety about road safety, their parents' perception that their neighborhood is not safe for children as well as to the available reports on the likely presence of strangers and social dangers [6,17–19].

Nowadays, children have a more confined independent mobility range than children of previous generations [6], and there is some evidence that boys experience greater independent mobility than girls [18,20]. The relevant research has also indicated that girls have a different form of independent mobility than boys, which is based more on the use of public transport, visiting people and places across larger distances and doing more things in the company of friends [21,22]. Nevertheless, the most significant and determinant factor for children to navigate the street network and neighborhood environment alone safely is their age [5–7]; independent travel increases as children get older [23]. The degree of the independent mobility of children varies worldwide with significant restrictions placed across all the ages between 7 and 15 [4,6,12,16,24]. Restrictions are more apparent for children under 11. However, children over 11 years old are also restricted in nearly all the countries in what they are allowed to do, while they are approaching the transition to adulthood [15,25–27].

Besides, it has been shown that walking or, in general, an active lifestyle in childhood can influence their physical activity and eco-friendly transport decisions over a lifetime [4,28]. The cultivation of children's environmental awareness could clearly provide long-term benefits [21,26]. Children who are educated to be aware of sustainability will probably grow up to become more sustainability-conscious adults. In addition, providing education to children towards this direction, apart from encouraging them to adopt a more sustainable behavior, also creates a domino effect so they may primarily influence their parents and relatives and encourage other adults towards sustainable choices in their daily activities [29]. Today's children are tomorrow's adult transport users and, therefore, multimodal travel behavior must be promoted and adopted at a very early age.

The popularity of smart mobile devices (tablets and smartphones) among children and their use from an early age is growing exponentially around the world [30–32], as children grow up alongside technology that changes at lightning speed. As mobile technology can facilitate "anytime and anywhere" learning, it has the potential to support the education of children and encourage their choices towards greener habits [30]. Many studies [33–37] have been conducted on assessing the use and effects of smartphones, especially for learning purposes and for supporting formal, informal and autonomous learner engagement. It is apparent that these digital devices, along with the accompanying applications, can create exciting and compelling, highly customized and personalized environments for learning and education in every age [32,38]. These environments can integrate motivational techniques which can be applied as learning aid instruments, acting directly or indirectly in the direction of engaging students and promoting eco-friendly travel outcomes beyond the four walls of the classroom [39,40]. These outcomes involve more sustainable multimodal transport choices and habits by children within their region, including walking, cycling and public transport.

Common persuasive strategies implemented for this purely educational purpose are goals setting, provision of incentives or rewards, self-monitoring, sharing information and gaming. Prior research implies that students are more likely to be susceptible to reward offers, followed by social competition, social comparison, and social learning [40–43]. The relevant results suggest that the three social influence strategies mentioned above can be employed in educational software to influence students to achieve a positive goal in their learning [44,45]. Moreover, people learn by imitation. The use of live models that are incredibly effective in influencing the attitudes and behavior of others [46,47] should be considered a powerful tool in education. If students see positive consequences from a particular type of behavior, they are more likely to repeat that behavior themselves. For example, children are more motivated to adopt an eco-friendly attitude if they see others around them, also adopting this attitude. However, a children's response to the same

stimulus can vary enormously in different settings. A variety of influencing elements may be perceived well by some children, but they may be ignored or rejected by others [48].

Towards this direction, for supporting the education of adolescents in sustainable travel urban behavior, our research proposes the use of a mobile application, named ESTA (Educating adolescents in Sustainable Travel urban behavior through mobile Applications). ESTA uses motivational features and has an educational orientation. The functionality of the six simulation ESTA's screens presented and assessed by a group of pupils. The analysis of the outcome is presented, and the possibility for the use of the application on a regular basis is explored.

The rest of the paper is organized as follows: Section 2 presents related work on the domain of educating pupils in adopting a sustainable travel urban behavior using motivational features and the persuasive strategies used. The user-centered approach for the design and evaluation of ESTA implemented in two stages is given in Section 3. The methodology and the analysis of the data obtained from the assessment, along with the description of two use cases as a result of the daily use of ESTA by pupils are then described in Section 4. A discussion on the main findings follows in Section 5, and the work finishes with conclusions, limitations of the study and future steps in Section 6.

2. Related Work and Persuasive Strategies Used

Nowadays, there exist several measures to increase the healthy behaviors of children like walking and cycling: physical measures (e.g., safer routes with footpaths on most streets and low traffic speeds, school crossing patrols with an adult stopping the traffic for enabling children to cross the road safely), improvement in the schools' infrastructure (e.g., providing secure cycle parking and lockers), school trips and awareness campaigns including posters and leaflets [49,50]. Furthermore, promoting daily routine activities, such as active commuting to school [51], is seen as a strategy for tackling obesity and other chronic diseases as well as an opportunity to increase physical activity and fitness [52]. The existing literature implies that children and young people who cycle and walk less are more likely to become overweight and unhealthy [11,14,53]. Another study suggests that the wellbeing of children can be affected by many factors, including amongst others, perceived road safety, active travel and independent mobility [5,24]. A systematic review of the association of independent mobility with physical activity, sedentary behavior, and weight status identified a consistent positive association between independent mobility and physical activity [14,54].

For the promotion of independent mobility, new mobile technologies should be incorporated, as various studies have reported an increased parental feeling of safety when children took a mobile phone roaming in the neighborhood independently [55]. Through a mobile phone, the parents can quickly get in contact with their children at any instance or directly observe their children through global positioning system tracking [56]. Although the mobile phone use is positively associated with sedentary behavior [57], the mobile phone ownership has no negative effect on independent mobility [4]. At the same time, a few projects, educational games and mobile applications have been developed in the field of education, aiming to facilitate the independent mobility and help pupils—adolescents be aware about moving safely on the roads, use alternative transport modes, as well as learn about the advantages of using sustainable transport (Table 1).

So far, the education of children concerning traveling and mobility from their parents, is still too often only related to learning traffic rules or road safety training, i.e., how to cross the road. For this reason, there is a need to develop a mobile educational application, using motivational techniques adapted to pupils—adolescents, for establishing a sustainable travel behavior. To this effect, the design of the mobile application components should take into consideration the fundamental motivational aspects that involve various innate psychological needs of the adolescents, such as autonomy, competence, and relatedness, and social needs such as achievement, affiliation, intimacy, leadership, and followership, mainly learned in the school [58].

Table 1. Tools for educating pupils—adolescents in sustainable travel urban behavior.

Tools	Short Description	Web Page
ACTIVE—HEALTHY to Kindergarten and School (Project)	A program for active and healthy mobility management for Vienna's kindergartens and schools: educating children on how to behave in the transport system, improving their travel safety, and strengthening their skills in using different modes of transport in an autonomous way.	http://young-mobility.at/en/active-healthy/
Active Mobility—Healthy Travelling 2019–2022 (Project)	A project that encourages Active Mobility, including walking, cycling and use of public transport, resulting in environmental, economic and social benefits.	https://aktive-mobilitaet.at/
B-TRACK-B Family cycling for energy efficiency in urban leisure travel (Project)	"Bike the track/ track the bike" promotes the use of bicycles by families with children aged 9–15 for their leisure (urban) trips in 7 European cities. The action intends to engage indicatively 100 families per site in an innovative track-the-bike "lottery" to motivate them to shift from car to bike use.	https://ec.europa.eu/energy/intelligent/projects/en/projects/b-track-b
CONNECT (Project)	CONNECT encourages children and their parents, as well as young people, to use more sustainable transport modes when travelling to and from school.	https://ec.europa.eu/energy/intelligent/projects/en/projects/connect
Do the Right Mix (Project)	This project provides useful material, including effective and funny cartoon videos, to explain how to move in an eco-friendly way using all the different means of transport available.	http://dotherightmix.eu/
Youth for Public Transport (Y4PT) (Project)	Y4PT's aim is to promote the active participation of young people on transport and mobility issues at all levels and settings by promoting the integrated use of public transport with other means of transport, to achieve a greater well-being and a better quality of life of all people around the world.	http://www.y4pt.org/
Beat the Street (Educational Game)	Beat the Street is an educational game that turns towns into giant games. The participants can earn points, win prizes and discover more about their area by walking, running and cycling.	https://www.beatthestreet.me/
Kids Go Green (Educational Game)	Kids Go Green is an educational game that involves the school, the children and their families in an adventure around the world and promotes a more sustainable mobility.	https://kidsgogreen.eu/en/
Traffic Snake Game Network (TSG NETWORK) (Educational Game)	TSG established an effective EU-wide and long-term support network to replicate, transfer and expand the uptake of the Traffic Snake Game as a successful p tool for changing the travel behaviour of primary school children (age 6–12) and of their parents.	https://www.trafficsnakegame.eu/
SETA app (Mobile application)	Seta for school tracks the movements of students and helps the school get free perks. Seta is a project funded by the European Union.	http://setamobility.weebly.com/seta-app.html

The desired behavioral change is achieved by bridging the gap of the appropriate implementation of the behavioral change techniques combined with established theoretical constructs from behavior theories such as the theory of planned behavior [59,60], and the transtheoretical therapy model [61]. According to the theory of planned behavior, behavior is based on the intention, which in turn is based on three determinants: the attitude toward the behavior, the subjective norm and the perceived behavioral control.

The intention to adopt a certain behavior (e.g., walking to school) can be reasonably predicted from these three psychological constructs [62]. However, the theory of planned behavior conceptualizes behavior only as a product of these psychological constructs. It assumes that all the other attributes (including household socio-demographics and the built environment) operate through the constructs of this theory [50]. This particular hypothesis is a potential limitation of this theory in terms of its application to the travel behavior research, e.g., examining the direct effects of the built environment on travel such as availability and proximity of destinations, land-use diversity and density and street connectivity. The transtheoretical therapy model claims that a behavioral change may be accomplished through a series of stages rather than by a single or sudden event through which individuals progress toward a desired kind of behavior. It has been confirmed that the interventions which support the various processes defined in the transtheoretical therapy model may achieve a change in the travel behavior (for example, a significant reduction of the car use and an increase of use of active modes) [63–66]. However, they provide a rather limited knowledge of how these interventions—which support single actions—affect the transition process from one stage of the transtheoretical therapy model to the next [67].

The goal of a travel behavioral change towards a more sustainable may be achieved by using appropriate persuasive strategies. Each persuasive strategy may significantly contribute to the continuous enhancement and effectiveness of a transit mobile application's "green" purpose and educational nature. Therefore, the designers should take into consideration the importance of appropriately choosing and implementing influence techniques to prevent unintended interactions [68] and to carefully choose the most suitable extrinsic rewards applied in every use case to achieve the eco-friendly application's goal. Towards this direction, the existing literature mentions that reinforcement via rewards is most effective when it occurs immediately after the desired behavior is performed [46,69,70]. For this reason, it is essential to provide a pleasant stimulus as soon as possible after the desired behavior is performed, thus making it more likely that this desirable travel behavior will reoccur. This perspective combines the social learning theory [46] with the behavioral learning theory [70] about extrinsic positive or negative influences on behavior. The behavioral learning theory notes that external reinforcement shapes learning. At the same time, the social learning theory acknowledges that learning is not always a result of external reinforcement and suggests that internal psychological processes are also an influence on behavior. However, one limitation of this aspect is that the social learning theory cannot explain how people make procedural decisions or deal with the various types of potential rewards and goals. This inability occurs as there are individual differences in human learning, variations in learning styles and the influence of personality on education [71,72]. Furthermore, the social learning theory ignores that as people move through life, their behavioral patterns could change drastically with little change in their environment. To overcome these drawbacks, the following different motivational features and persuasive strategies have been investigated more extensively and have been used in our work:

- Realistic challenges and goals with positive visual feedback about adolescents' performance, [43,73], i.e., "green" e-mails, mainly sent during the day or occasionally in the evening (last motivational thought of the day) with information that may include daily weather forecasts about the transport mode that could be used (e.g., bicycle or walking on a sunny day instead of taking the bus); entertaining elements; short videos; virtual tours using different modes (multimodal) within a single trip.
- Self-monitoring and reminders, through the tracking of the adolescents' travel behavior and by providing a review of the achieved goals [43,74] along with a travelling history.
- Social reinforcement and normative influence, through sharing information, network comparison, cooperation to achieve a specific common goal and online competitions among community school or schoolmates [48,75,76].

- Gaming, for contributing to the reduction of the "waiting and travel time" perception of the adolescents and for stimulating them playfully and amusingly to walk, cycle and use public transport more intensely [77,78] by earning points or rewards and by learning more on the topic of sustainability [79].
- Recognition, via virtual (badges or podiums for places 1, 2 and 3) or monetary (green credits or points which will be used for discounts under some conditions) rewards, to provide a sense of accomplishment in the adolescents and to motivate them to participate actively and continuously [80–82].
- Cooperation, when the classmates need to cooperate to achieve or adopt a particular target behavior, i.e., walking every day to or from school [83,84].
- Influence on the emotion, (e.g., pride, hope, guilt) via messages, images, symbols, sounds and voice-based avatars [85].
- Cause-and-effect simulation, by providing graphical representations or awareness-raising images about the impact of mode choices on the environment [80,86].

The expected result of implementing a combination of these persuasive strategies during the mobile application's daily use becomes even more profound when each strategy is implemented separately. It has been shown that the combination of multiple strategies may lead to temporally increased compliance [80,81,84]. However, the relevant long-term results have consistently demonstrated a rather negligible effect [68]. The utilization of the above-mentioned motivational strategies and their integration in a mobile educational application has as a primary goal the adolescents' motivation to use daily and, finally, to adopt sustainable transport choices.

3. Designing ESTA Using Motivational Features—Stage 1

Within the framework of the mobile application design, a user-centered methodology has been followed in order to fully explore the needs and desires of the adolescents, as well as the intended uses and expectations about the mobile application. The significant advantage of our approach emerges from the adolescents' involvement during the design (stage 1) and the evaluation (stage 2) of the prospective mobile application. This participation, therefore, may lead to the development of a product that is more effective, efficient and suitable for its intended purpose in the learning environment in which it will be used. This action provides a sense of ownership for the final product (it is my application) that often results in a higher user satisfaction and in a smoother integration of the mobile application into the adolescents' daily routine [87,88].

In the first stage, the user habits, travel attitudes and user requirements were investigated with the means of a questionnaire survey conducted on pupils (in order to take part on this survey each pupil's parent had to sign a parental consent form). The questions used were open-ended and close-ended (multiple-choice, matrix, and rating scale). The first section of the questionnaire included questions related to the users' demographics information. The second section included questions related to the users' daily travel habits, the use of the smartphone and its applications and the intention to obtain a more sustainable travel behavior via a mobile application. The 46 pupils (24 boys and 22 girls) who accepted to take part in the study were mostly first- and second-year pupils (age range 15–18) of a public senior high school (Lyceum) in the area of Attica, Greece. The survey was performed in the spring of 2020.

The pupils surveyed conduct an average of 4.17 routes per day, while the most common is four routes per day (37.8%). This can be easily explained by the fact that on a regular basis all pupils travel to and from school (5–10 and 10–15 min are the most common durations) and most of them to foreign language classes or tutorial centers (less than 5 min is the most common duration). Other trips include going to sports or outdoor play and visiting friends with 10–15 min most common duration and arts (mostly music and painting) or interest—hobbies (e.g., chess) with a 5–10 min common duration. More than six (6) trips per day are fairly uncommon. The primary transport mode is walking or cycling (80%), with metro or tram (15.6%) and bus (4.4%) coming next. All of the pupils

are smartphone or tablet owners. Table 2 shows the applications that the pupils use the most; social networking, messaging and entertainment are in the top three while travelling and maps are at the end of the list as the majority of the pupils move within their familiar neighborhood, or their school's transport is dominated by the use of automotive transport, whether by private vehicle, public transportation, or school bus.

Table 2. Mobile applications that pupils use the most.

Categories of Mobile Applications	Percentage (%)
Social networking	82.2
Messaging	71.1
Entertainment (music, dance, etc.)	57.8
Searching tools	42.2
Gaming	35.6
Sport, health and fitness	33.3
News	20
Weather forecasting	17.8
Travelling and maps	13.3

Table 3 presents the features that pupils like to have in a mobile travel application in order to use it on a daily basis. We observe that earning points or rewards (i.e., recognition) set up a powerful incentive for the daily use of ESTA alongside with playing eco-games (i.e., gaming). Moreover, sharing or posting travel information and their itineraries with other users (i.e., social reinforcement, normative influence and cooperation) seems to be an essential part of the overall teenage socializing. Being a part of a peer group is significant during adolescence, offering to its members the opportunity to develop various social skills like empathy, sharing and leadership. For this reason, it is more likely that reporting positive experiences and green travel choices may influence other pupils and users to foster the same behavior [44].

Table 3. Features that pupils like to have in a mobile travel application in order to use it daily.

Mobile Application Features	Percentage (%)
Set a journey planner	68.9
Collect points or get rewards, i.e., free public transportation tickets	64.4
Set reminders—get notifications about a scheduled trip	44.4
Play eco-games	42.2
Share or post real-time information about traffic, disruptive events and transport choices	41.7
Share or post your itineraries with other users	40.1
Learn more on the topic of sustainability with relevant information, i.e., calories burned, carbon footprint calculation	31.1
Suggest travel options to other users	20
Give feedback on travel options provided	15.6

The majority of the pupils (71.1% answered "yes", and 22.2% answered "maybe") are interested in or are prepared to change their behavior just for the sake of the environment. Figure 1 shows their intention to use a mobile application in order to obtain a more sustainable travel behavior. This answer reflects the mobile application's potential positive contribution to educating pupils to become more mindful of their environmental impact and choose more "green" travel options. Furthermore, it underlines the prospect to develop a mobile application adapted to the expectations and the needs of adolescents in this area. The privacy and the personal data protection upon the use of ESTA concerned considerably (41.4%) or sufficiently (39.6%) the pupils, with the main problems, mentioned being: the mobile application must collect only those data that are strictly necessary to perform the lawful functionalities as identified and planned (79.3%); the users must be able to choose which data they want to share with others or with third party services (72.1%); the

application must be hack-proof (60.4%), and the personal data needs to be protected when stored through effective encryption (51.4%).

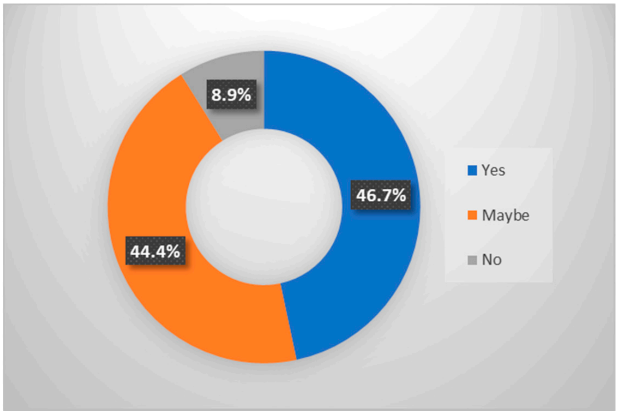


Figure 1. Pupils' intention to use a mobile application in order to obtain a more sustainable travel behavior.

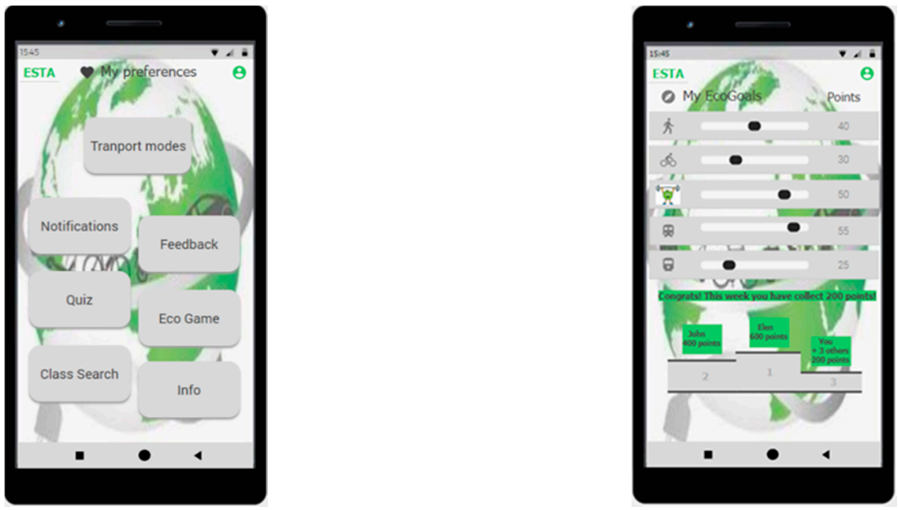
4. Designing ESTA Using Motivational Features—Stage 2

In the second stage, we designed a prospective travel mobile application named ESTA to collect data connected to the subjective perceptions, the intention to use and the level of satisfaction across pupils. This application was mainly based on the pupils' responses (Table 3), and it integrated the previously mentioned motivational features. The primary purpose of ESTA was to support the pupils' education and raise their awareness in order to become more mindful of their environmental impact, as well as to adopt a sustainable travel urban behavior progressively.

For this reason, a second questionnaire survey was conducted on six simulation screens (Figures 2–4) along with two use scenarios. The questions used were open-ended and close-ended (multiple-choice, rating scale and Likert scale). The first section of the questionnaire regarding the assessment of the aforementioned simulation screens, aimed to record the users' intention of using ESTA on a daily basis, to extract information related to the functional aspects of the interface's interaction and, finally, to identify potential usability issues. The second section included the two use cases as an essential part of our user-centered design process. The provided feedback allowed us to explore additional ways to enhance the users' interactions and to broaden our goals for the daily application's use (for example, the possibility of real-time exchange information service between the users, such as seat availability on a crowded metro, or the cleanliness of the bus).

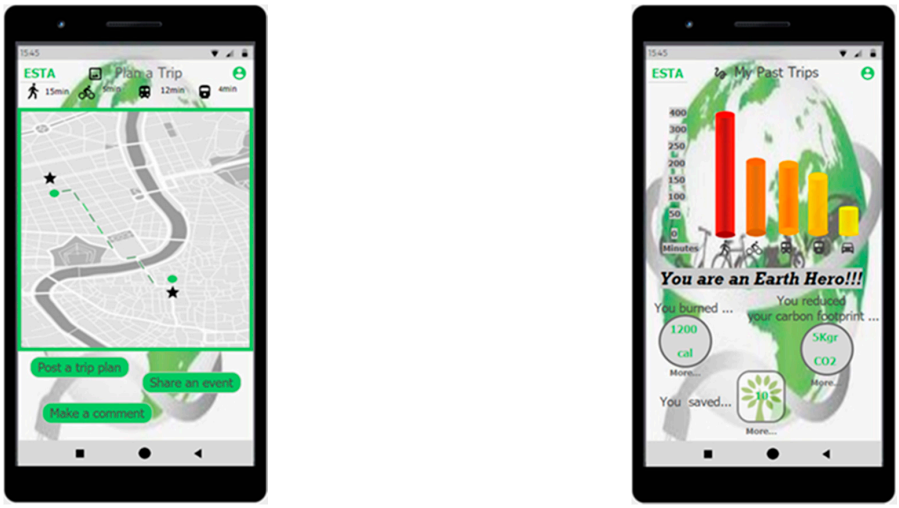
(**a**) (**b**)

Figure 2. (**a**) Welcome Screen integrating social reinforcement and recognition; (**b**) Home Screen integrating options for personalization, challenges and goal setting, recognition and cause-and-effect simulation.



(**a**) (**b**)

Figure 3. (**a**) My Preferences Screen integrating options for gaming, social reinforcement and normative influence and cooperation; (**b**) My EcoGoals Screen integrating social network, recognition, influence on the emotion and self-monitoring and reminders.



(**a**) (**b**)

Figure 4. (**a**) Plan a trip Screen integrating social reinforcement, normative influence and cooperation; (**b**) My Past Trips Screen integrating self-monitoring and reminders weekly reflection, suggestion recognition, goal setting, influence on the emotion and cause-and-effect simulation.

4.1. ESTA's Simulation Screens

From the "Welcome Screen" (Figure 2a), the pupil can be attracted by a promotional message about the rewards that she could earn for herself and for her school by using ESTA. By clicking on the "Get Started" button, the pupil can create an account using a name and a password and optionally her school or the pupil can sign-in her account. From the "Home Screen" (Figure 2b), the pupil can set her travel preferences and eco goals, make a trip plan request and review her past trips. In addition, the pupil can see the total number of points collected. The pupil by clicking on the "Check rewards" button can overview the corresponding to these points rewards (e.g., free talk time or mobile data, special discounts

on public transport tickets, free tablets or gadgets for her school, free rides with municipal bicycle).

In the "My Preferences Screen" (Figure 3a), the pupil can review the modes of transport (public, private, and shared) with the location of stations and maps, set her travel preferences, choose whether she wants to get notifications about upcoming trips, give feedback on travel suggestions, learn more on the topic of sustainability with relevant information, calories burned, carbon footprint calculation, search schoolmates and, finally, play online games or take online quizzes for earning more points. In the "My EcoGoals Screen" (Figure 3b), the pupil can set new eco goals using the slider bar in a particular time period. The pupil can also review the points or rewards she has collected. These rewards are placed on a visualized podium among other users.

The "Plan a Trip Screen" (Figure 4a) provides sustainable route recommendations and live step-by-step directions for choosing the best route from one place to another according to the pupil's criteria and preferences and the possibility to socialize by sharing with friends' mobility relevant messages and spreading the application use among her schoolmates. "My Past Trips Screen" (Figure 4b) allows the pupil to save previous trips history and to review the real past trips using graphical representations showing how much she used the different modes of transport over a time-period, with information about calories burned, carbon footprint mitigation, and trees saved. She is also praised for the excellent work that she has done. Furthermore, the pupil can learn about eco-mobility options and the consequences of sustainable transport choices regarding fitness and personal health by clicking on the grey circles. By this way, the pupil can monitor her travel behavior and her progress towards improving her transport habits over time.

4.2. Use Cases

The potential of ESTA was demonstrated to the pupils via two use cases. For this purpose, two different actors have been created and the corresponding to these actors scenarios. The subject of these scenarios was to complete a story about the ideal daily pupil's experience, thus providing us information on how the actor interacts with the system. The first use case "Daily Commuting" is addressed towards pupils who want to move within their area of residence or neighborhood following their daily routine and activities. The second one, named "Weekend Entertainment", is addressed towards pupils who want to move using the public transport modes and are being encouraged towards greener weekend travel habits.

4.2.1. Use Case "Daily Commuting"

Maria on her way to school on foot (it usually takes 10 minutes) receives a notification from her smartphone suggesting a new route which takes three minutes of extra time, in order to walk a little more for improving her physical activity. At the same time, she can see that 10 of her classmates have chosen the same route with an overall satisfaction level of 9 to 10, and now they can all participate in a quiz for earning "green" points for their school. At the school break, she can play an eco-game and set more eco goals for the rest of the week as she wants to be the hero of her class and get free metro tickets. After the end of the lessons, she receives a confirmation notification about the bus itinerary for going to her chess class. If she chooses bicycling as an alternative route, she could take the first podium. During the time spent waiting for the bus, she is sociable and interacts with friends trying to save one more tree at the community game "Save A Tree!". Before going to sleep, Maria adds a reminder for the next day school trip; the application will notify her when to leave in the morning and will also inform her about the weather conditions so that she can do some extra exercise in case of a sunny day.

4.2.2. Use Case "Weekend Entertainment"

On a Saturday morning, John is informed about his weekly progress with a graphical representation and a review of points he has earned in parallel with a suggestion for more

eco-friendly ways to spend them, i.e., special discounts for an e-bicycle sale. Furthermore, as it is the weekend, he can try walking with his classmates for about an hour, listening to a podcast for saving the Amazonian forest; he shares this event with his classmates then and takes part in an online competition in order to win a tablet for his school. In the afternoon, he searches for destinations to go out (non-touristic spots, a view of suggestions and favorites places from friends and family, expert tips, as well as consumer reviews), itineraries, and suggestions of the desirable means of transportation. When he is about to leave the cafeteria, he receives a notification to confirm his current location, the permission to save the route and the total distance he did in order to have the calories burned and the carbon dioxide he saved calculated. Before going to sleep, John can watch a short video with virtual tours using different modes (multimodal) within his neighborhood.

4.3. Outcomes

Figure 5 shows the overall satisfaction rating scale—from 1 (very low) to 5 (very high)—concerning the user-friendly application design and the position of on-screen messages of ESTA's screens.

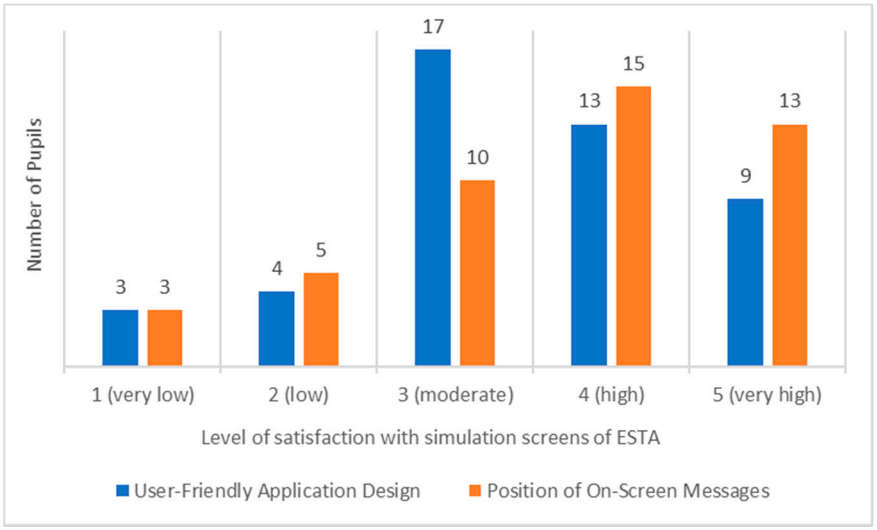


Figure 5. ESTA's simulation screens overall satisfaction rating scale concerning the user interface design and the position of on-screen messages.

According to their suggestions, the pupils would like to see the following features in an upcoming update: an initial drop-down menu instead of an options list; more bright colors with the blue one having the most preferences; a "vivid" background with different environmental awareness pictures in every screen; people or animals in the current background's vehicles; more clever inspirational slogans; a bright new original font with bold letters; a mascot-cartoon on the go as a virtual assistant; cooperation with celebrities or influencers who would motivate the pupils through video notifications and maybe even challenge users among themselves; replacement of some text with icons for improving interface usability; maximum one or two actions in every screen; enforcement of a user-level application security policies including an ensure secure network access, an isolate application information, a robust authentication mechanism and data confidentiality.

Table 4 shows the overall evaluation of pupils on accepting, understanding, being motivated, and their intention to use the ESTA application.

Table 4. Overall evaluation of ESTA.

Variables	Measurement Features Details	Percentage (%)
Acceptance	The content appeared in ESTA is appropriate for a pupil	89.6
	The use of ESTA is relevant to the pupils' needs for the adoption of sustainable travel behavior	82
	ESTA works the way I would want it to work	76.9
Understanding	I found ESTA easy to use	98.1
	The language used in ESTA is easily understood	95.7
	ESTA has functionality that is easy to understand	86.4
	I can use ESTA without written instructions	76.9
Motivation	I am highly motivated to use ESTA	61.2
Intention to use	I think that I would use ESTA frequently	58.7

Based on the responses of Table 4 and the feedback provided, the pupils expressed the need for a mobile application with personalized interface in order to: be motivated for more eco-friendly transportation and physical activity like walking or cycling daily; help the environment; have better quality in their daily journeys more healthily and sustainably; obtain a long-term environmental consciousness; have access in real-time route information and journey planner; gain ecological knowledge and awareness; have more options on how to move; promote a "greener" transport attitude; get rewards, i.e., free mobile data or talk time; save time on their transits.

The majority of the pupils (58.9% answered "yes", and 30% answered "maybe") would recommend ESTA to a friend, and 68% of them are looking forward to its implementation in order to use it as is, among other answers, "it encourages the pupils to move in a way that benefits both the environment and themselves", "it is a smart idea", "it is very easy to use", "it gives me a chance to win prizes" and "it is in Greek".

5. Findings—Discussion

In this section, we summarize the main findings according to the pupils' responses and suggestions during the process of the design and assessment of ESTA.

Pupils preferred the usage of high-contrast colors in the user interface. The contrast provided against the background enhances the pupil's visibility, while on the action, which is very important for them. In addition, the pupils are being attracted from many bright colors (e.g., green, blue) and they are willing to easily detect the call-to-action buttons or any other important content.

Besides, not all pupils are triggered by environmental concerns. Some pupils may not be very interested in or eager to establish a sustainable travel behavior just for the sake of the environment. Changing the pupils' transport habits towards greener options or maintaining their existing eco orientation ones, may be achieved by providing them with suggestions that fulfil in their transport needs and expectations (e.g., walking, cycling) or their criteria for making transport choices (e.g., journey time). When people incorporate transportation habits that rely more on the use of public transportation and the physical walking into their daily routines, they can repeatedly take some actions without paying too much attention.

Pupils also pointed out that it is better to use an avatar as a triggering agent for supporting the eco-friendly attitude. Motivating pupils to use ESTA can be promoted by a daily encouragement via an avatar (character, pet, or cartoon) [69] in an attractive and easy-to-handle user interface. This avatar may potentially be in a "physically" active mode (e.g., cycling, dancing or walking) and facilitate the pupils in setting realistic challenges or goals.

Moreover, pupils asked for real rewards instead of virtual ones. To create an effective, rewarding system and for this system to be integrated into the mobile application remains a challenge. This study pointed out that the pupils requested the deployment of a rewarding

system which is not just "virtual" (e.g., points or badges) but instead provides specific advantages of urban mobility offer in real life (e.g., discounts on public transport tickets, free vouchers for shopping, free mobile data or phone calls). The benefit attached to this aspect was also considered necessary for the engagement of the pupils in the eco-game within the mobile application, aiming to inform them about the environment and win at the same time.

Pupils also highlighted that sharing or posting mobility travel data only when it is safe. They are usually willing to share or post other relevant real-time information about traffic, disruptive events and transport choices. This kind of sharing or posting though should also include an option to the use of anonymity (31.1%) or to limit data sharing within a pupil's network of family and close friends (11.1%) or both (57.8%).

Regarding the educational eco-game development, the pupils suggested to create educational games related to the environment for playing with their classmates. They also expressed a preference for games that do not need to be downloaded and installed in the smartphone but can be accessed directly from ESTA.

Finally, the pupils should have confidence and feel comfortable using ESTA. They should be aware that the application is accessible in a smooth and easy-to-use manner with a high quality of traveling information. They should also be mindful that they can have a personal account and can adapt the user interface of ESTA to their preferences.

The primary outcomes of the ESTA's screens evaluation and the pupils' comments show that the idea of a mobile travel application that works effectively and rewards the users for their environmentally friendly behavior appears to be welcome and very promising. Furthermore, starting education from the early years for the adoption of ecological consciousness and awareness should be an issue that our society ought to consider very seriously. Besides, the personal data protection and use only for the mobile applications primary purpose along with the option of anonymity and limitation of data sharing within an own pupil network must be a mandatory functional feature.

6. Conclusions Limitations and Future Steps

This work presents the primary outcomes from a user-centered design process we followed in order to better understand the adolescents' requirements, expectations and intention to use a prospective traveling mobile application named ESTA. ESTA provides a novel combination of motivational features based on the pupils' needs and could be used to support and continue their education for adopting a sustainable travel urban behavior progressively. The research indicates that although our sample pupils own a smartphone or tablet, they rarely use mobile travel applications. However, the pupils have a positive attitude and intend to use ESTA. Setting a journey planner, collecting points or getting rewards and playing eco-games are the most popular features that a mobile application should have alongside with a bright colored background and an avatar-helper. All these features may increase the pupils' environmental consciousness and enhance their ecological knowledge and awareness. Nonetheless, these results must be interpreted with caution as the primary limitation to their generalization is the relatively small sample.

Future steps should be devoted to the development of a beta version of ESTA, taking into account the findings mentioned above. This beta version should then be assessed in a larger pupils' population to identify potential or foreseeable consequences resulting from the application's misuse. Special attention should be paid to situations where computer-mediated persuasion takes place without the user being aware of it. This persuasion may occur when people who create, distribute, or adopt the technology are the ones who have the intention to affect the user's attitudes or behavior through computers, e.g., discussion forums, e-mail, instant messages, blogs, or social networks [85]. Furthermore, the design of ESTA should consider first how the system responds according to the applied persuasive strategies, e.g., immediate feedback provision after the desired travelling change occurs. It should also consider how the system responds to either normal or any unexpected situation, e.g., limited internet access, or first-mile/last-mile challenges. Finally, the system should

be automatically updated to content changes according to last-minute changing mobility patterns, or to potential bugs in order to avoid unsustainable behaviors, e.g., problematic smartphone use.

We strongly believe that such a mobile application could engage and influence the pupils to foster an eco-friendly and healthy transit attitude making more sustainable mobility choices that will follow them throughout their life.

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