Smart Pedestrian Crossing - An EPS@ISEP 2020 Project

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Abstract. This paper reports the development of WalkSafe, a Smart Pedestrian Crossing solution, by a multinational and multidisciplinary team of students during the spring semester of 2020. The team was enrolled in the European Project Semester (EPS), a project-based capstone programme offered by Instituto Superior de Engenharia do Porto (ISEP). Motivated by the idea to reduce the number of pedestrians hit by cars at road crossings, and associated injuries and deaths, the team surveyed pedestrian behaviour to conclude that people often ignore pedestrian crossings. Thus, this project intended to motivate people to use pedestrian crossings, increasing the safety of both pedestrians and drivers. The proposed solution can be implemented on any pedestrian crossing and involves up to three components: (*i*) a box to be fixed on each side of pedestrian crossings with a radio-frequency identification reader as well as Bluetooth and Wi-Fi interfaces; (*ii*) a smartphone mobile app; and (*iii*) a personal bracelet for children and elderly, with a passive radio-frequency identification tag.

Keywords: Engineering education · Collaborative learning · European Project Semester · Smart cities · Intelligent mobility

1 Introduction

The European Project Semester (EPS) is a one-semester capstone project/internship programme offered to engineering, product design and business undergraduates [1] by 19 European engineering schools (the EPS Providers), corresponding to 30 European Credit Transfer Units (ECTU). EPS aims to prepare

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future engineers to think and act globally, by adopting project-based learning and teamwork methodologies, fostering the development of complementary skills, addressing sustainability and multiculturalism, while having a pervasive concern with sustainable development within EPS projects [4].

The syllabus of EPS course implemented at the School of Engineering of the Porto Polytechnic (ISEP) - EPS@ISEP - comprises Project (20 ECTU), Project Management and Team Work (2 ECTU), Marketing and Communication (2 ECTU), Foreign Language and Culture (2 ECTU), Energy and Sustainable Development (2 ECTU) plus Ethics and Deontology (2 ECTU). Apart Foreign Language and Culture, the 2 ECTU modules are project support seminars oriented towards each team project [8,9].

In the spring semester of 2020, a team composed of six students chose to design and develop a Smart Pedestrian Crossing solution intended to reduce the number of pedestrian crossing accidents. The members were a Brazilian designer student, a Scottish electrical power engineering student, a chemical engineering student from The Netherlands, a Telecommunication and Computer Science student from Poland, a materials engineering student from Germany, and a mechanical engineering and ergonomics student from France.

The students started by performing a state-of-the-art analysis on existing solutions regarding pedestrian crossings all around the world. This study was complemented with a survey to understand the behaviour of people concerning their use of pedestrian crossings. After several brainstorming sessions and many ideas, the decision was to create a system of rewards, convertible into public transport discounts, for the pedestrian crossing user. It was also decided that sustainability should be one of the main features of the system, aiming to have minimal waste materials. Next, motivated by the idea of transforming the prototype into a product, the students identified a market niche and developed the marketing strategy, considering both competitors and stakeholders - it was during this phase that the system brand/name was defined: WalkSafe (Fig. 1).

Fig. 1. Walk-Safe logo

In the sequel, the team addressed the sustainability, ethical and deontological issues related to the project development and manufacturing process, *i.e.*, from the design until the market. Next, they modelled the envisioned system, encompassing a scanner box and a promotional reflective bracelet, in 3D and

chose adequate dimensions and materials. In parallel, the team developed the mobile app to collect and redeem points. Finally, they built a simulation of the system to test and enable the collection of possible results.

This paper, which provides an overview of the learning process followed by the team to accomplish this project, comprises four additional sections: Sect. 2 surveys innovative pedestrian crossing solutions and analyses the related marketing, ethics and sustainability perspectives; Sect. 3 presents the concept, design and architecture, together with the development and simulation of the proposed solution; Sect. 4 discusses the results of the project; and Sect. 5 concludes with a summary of the project and personal outcomes.

2 Background Studies

The background studies, which included a survey on related products together with marketing, sustainability and ethics analyses, allowed the team to derive WalkSafe's requirements.

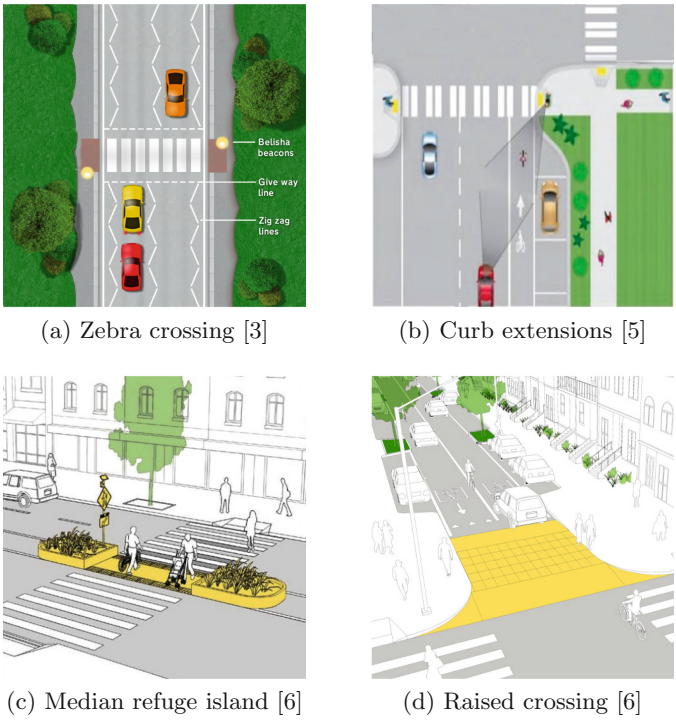
2.1 Related Solutions

Research was done on different types of safe road-crossing options currently in use to decrease the number of accidents occurring when pedestrians cross roads. The solutions found can be divided into three different groups, namely:

Signalised crossings are crosswalks with signs and/or lights to indicate the presence of the crosswalk. Different types of signalised crossings exist, with different types of signalling. The most common ones are the zebra crossing (Fig. 2a), the pelican crossing and the puffin crossing. All of them have beacons, a give way line and road markings. They can also have audible signals and can be provided with traffic lights, buttons or sensors.

Physical Aids help the pedestrian to cross the road faster and safer or make the crosswalk more visible. Often used aids are curb extensions (an extended sidewalk), as depicted on Fig. 2b. Its objective is to slow down drivers, reduce the length of the crossing and increase visibility of pedestrians. Another option is the median refuge islands (Fig. 2c), an "island" in the middle of the road and a safe place for pedestrians between two driving lanes. It takes less time and it makes it easier and safer for the pedestrian to cross the road. A final example is the raised pedestrian crossing (Fig. 2d), which has two main advantages: (*i*) the road surface is raised at the location of pedestrian crossings, slowing down the traffic and (*ii*) increasing the visibility of pedestrians.

Smart crossings are pedestrian crossings which make the crosswalk safer by using smart electrical components. Most of these smart products can be implemented in already existing crosswalks. The polish company "SmartPass" designed a smart box that can be attached at lamp poles near the crosswalk [12]. The SmartPass has motion sensors, extra lighting, LED lights, monitoring cameras, sound signals and an anti-skidding system. When a pedestrian wants to cross the street, the driver gets warned with colour changing LED.



(a) Zebra crossing [3] (b) Curb extensions [5]

(c) Median refuge island [6] (d) Raised crossing [6]

Fig. 2. Types of pedestrian crossings

2.2 Marketing

To determine WalkSafe's positioning in the market, the team carried out a marketing analysis. This allowed the team to develop a dedicated marketing plan for the WalkSafe success. First, the advantages, disadvantages and improvements to increase the safety of the user of conventional crossings were identified. After detailed research into existing solutions and user behaviour, the team concluded that the issue was not so much the crossing itself but the user's motivation to use the crossing. To identify internal and external factors impacting on the product success, the strengths, weaknesses, opportunities and threats (SWOT) analysis was applied alongside with the market research survey on user usage of pedestrian crossings. This helped to identify the market niche and delineate the marketing strategy. To increase user safety and differentiate WalkSafe from competition, the team decided to make people to use crosswalks rather than following existing approaches such as increasing pedestrian visibility or providing drivers with additional information through a variety of lights and sensors. The team's idea to innovate in order to motivate is the main aspect of this product, which allows to stand out from its competitors, Consequently, the goal of WalkSafe is to motivate pedestrians to use crossings by earning discounted public transport tickets.

In summary, the two core ideas and benefits behind WalkSafe are: (*i*) increased user safety, as most road accidents occur in areas where pedestrians don't use the available crossings; and (*ii*) increased air quality, by encouraging locals to walk more and, once they have gained enough credits, get discounts on their city public transports – both ways try to deter people from car use.

As with any new product, promotion is a key aspect to the success of the product. To enhance WalkSafe odds on the market, the team decided to use multiple promotion channels, such as social networks and hard copy posters around the city of Porto.

2.3 Sustainability

Sustainability helps to satisfy the needs of the present without damaging the planet and compromising next generation needs.

To find a sustainable solution for the city of Porto, the team considered the use of eco-friendly solutions and the local environment. Transport is the biggest source of CO_2 in the Europe Union (EU), responsible for the emission of over a quarter of all greenhouse gases [11]. Furthermore, transport is the only sector in which emissions have grown since 1990, contributing in 2015 to the increase in the overall EU emissions. If EU is to achieve the Paris climate goals, it is likely that transport emissions must be reduced by 94 % from 2005 levels. These numbers confirm that it is needed to push the people from cars into public transport. The WalkSafe is contributing to reduce greenhouse gas emissions by motivating the society to increase the use of public transport. In fact, it is aligned with United Nations' Sustainable Development Goal 11: make cities and human settlements inclusive, safe, resilient and sustainable.

2.4 Ethics

Regarding the ethical and deontological concerns considered, four different topics were addressed: engineering ethics, sales and marketing ethics, environmental ethics and liability. Concerning Engineering Ethics, the Code of Conduct for European Chartered Engineers, as issued by the European council of Engineers Chambers (ECEC) [2], was taken into account since this project is based in Europe. In relation to the Sales and Marketing Ethics, the team adhered to the approach sometimes referred to as Conscious Business, or the Economy of Meaning [7]. In what respects Environmental Ethics the team considered the morality of sustainability measures related to the environment while developing WalkSafe. Finally, and regarding Liability, during the development of this project the following European directives were taken into account:

- Machine Directive
- Electromagnetic Compatibility Directive
- Low Voltage Directive
- Radio Equipment Directive
- Restriction of Hazardous Substances in Electrical and Electronic Equipment Directive

2.5 Background Studies Summary

By thinking outside the box and looking at ways to improve sustainability, WalkSafe allows urban areas to become safer whilst, at the same time, promoting the use of public transport systems and, overall, creating a healthier environment. The performed studies have shown that public transport has a more positive impact on the environment compared to the single user car. The core principle behind WalkSafe – offering promotional discounts on public transport to motivate the use of crosswalks – contributes to make communities safer and more sustainable.

3 Proposed Solution

3.1 Concept

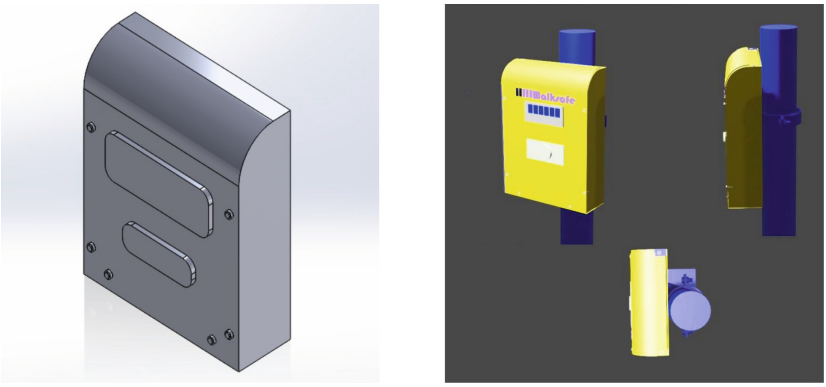
The team's idea was to develop a concept to promote the reduction of the number of pedestrian accidents. A survey was conducted to understand the reasons why people neglect the use of pedestrian crossings. The answers indicated that it was in part due to lack of time and motivation. Therefore, it was decided to concentrate on this last aspect. The survey also showed that a significant part of the respondents used public transports: among 171 respondents, 159 always, often or sometimes use public transports.

This lead to the idea of implementing a reward system for people that use pedestrian crossings. Based on this, the WalkSafe system was conceived as a scanner box. Before crossing the road, people scan their Andante card, their phone with the WalkSafe app or the WalkSafe reflective bracelet. Then, they cross the road and scan it again on the other side. This process accumulates points which, after 100 crossings, grant a free trip on a public transport.

For the app, the user has to create an account. The app informs about the operation of the solution, the number of accumulated points, and provides access to the Andante website for information about public transport in Porto. The reflective bracelet has many roles: a promotional object as well as a collector of points. It is intended for people without smartphone, such as kids and elderly. Moreover, it is easier and faster to use than a card, since it is wearable around the wrist. This bracelet is reflective given that most accidents at pedestrian crossings occur at nigh time. The idea of adding a reflective aspect aims to improve the visibility of the pedestrian at night and, therefore, increase pedestrians safety.

3.2 Design

Three systems were designed: the scanner box, the bracelet and the app. The scanner box must be deployed on both sides of the pedestrian crossing, as shown in Fig. 3a. When a pedestrian presents a compatible personal WalkSafe component to the scanner box, the screen displays the date, hour and accumulated credit points. The box can be attached to any pole (lamp, traffic lights, traffic signal, etc.) near the pedestrian crossing, as depicted on Fig. 3b.



(a) Scanner box (b) Bracket system [10]

Fig. 3. WalkSafe scanner box design

To accumulate points the pedestrian has to present the personal reflective bracelet, illustrated in Fig. 4a, or personal card, the multimodal Andante card in the case of Porto. Both the bracelet and the card have a radio-frequency identification (RFID) tag, which is scanned by the box. Moreover, the bracelet reflects the light so that, at night time, the pedestrian visibility is increased.

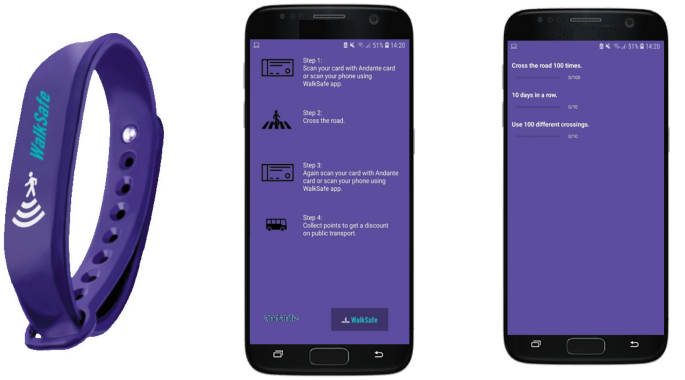
Finally, there is the mobile app. Once installed on the smartphone of the pedestrian (shown on Fig. 4), it displays the accumulated credit points, informs about the WalkSafe solution and provides access to the Andante card website.

3.3 Simulation

This section describes the simulation of the WalkSafe system due to the COVID-19 pandemic. With ISEP facilities closed and team members back to their countries, it was not possible to develop a proof of concept prototype.

3.4 WalkSafe System Architecture

The WalkSafe system architecture is presented in Fig. 5. The system comprises a control unit, included in the scanner module, responsible for reading the inputs (from the Andante card or from the reflective bracelet) and communicating with the database to update the user credit points. For prototyping purposes, this control box was going to be implemented using an Arduino Uno control board.



(a) Bracelet (b) App steps (c) App milestones

Fig. 4. Reflective bracelet and mobile app

3.5 Control

To simulate a virtual Arduino board, the team adopted Tinkercad software. However, since not all required electrical components were available in the software, the team had to use substitutes. Moreover, there was no RFID sensor and, for this reason, a different component was used to represent the output of this sensor. The main purpose of the simulation was to show that the control system authenticates the user based on the ID of the passive element radio-frequency sensor. When the ID is correctly identified, the system adds points to the user's account.

4 Discussion

4.1 Interpretation

The goal of this project was to design a smart pedestrian crossing in order to reduce pedestrian accidents in urban environments. The initial survey indicated that there are several options to make the streets of Porto safer, and it was decided to focus on motivating people to use crosswalks. By creating a mobile app, designing a reflective bracelet and using the existing Andante card, the team believes that WalkSafe ensures that everyone will be able to use it, not only young people but also the elderly.

4.2 Implications

The WalkSafe is an innovative approach for pedestrian crossings. Although there are already smart pedestrian crossings solutions on the market, WalkSafe is an affordable solution that contributes to make cities safer and more sustainable. The reward system was conceived to work closely together with Porto's public

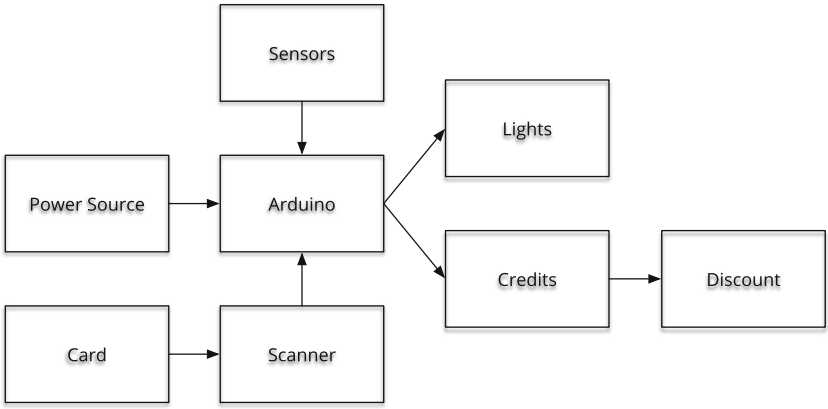


Fig. 5. Control system

transport multimodal card (Andante) as a means to motivate people to use crosswalks. In the end, it is beneficial for both parties: the Andante network gets more clients from WalkSafe and WalkSafe crossings get more pedestrians from the discounts granted on the Andante network.

4.3 Limitations

While the findings of this study show that is is technically feasible to effectively implement RFID based service to promote pedestrian safety, this study does not determine the actual effectiveness of such a service. Particularly, it is unclear whether a system such as WalkSafe would attract enough users in order to have a positive effect on the safety of pedestrians in the city of Porto. Furthermore, the system has some possible limitations, like potential queue-forming in front of scanner boxes that might mitigate the positive effect of the system.

4.4 Recommendations

To overcome these limitations, studies on the effectiveness of the WalkSafe system need to be performed. A suggested first step would be to execute a targeted, representative survey among the population of Porto in order to get an idea of the willingness of pedestrians and other road users to use the WalkSafe system. This could be followed by a small pilot test in different areas of Porto, taking into account the kind of users in these areas (e.g. tourists, commuters, elderly, youth). Once proven effective through the pilot test, the WalkSafe system could be deployed in the whole city.

5 Conclusion

5.1 Project Outcomes

The team involved in this project designed and simulated a complete system composed of a scanner box, a mobile app and a reflective bracelet to improve the safety of pedestrians. However, the goal of EPS@ISEP is more important than building prototypes, is to make students contribute with their distinct visions converge into a common solution. This process is not always easy, since at this educational level the students are not usually used to collaborate with colleagues from different nationalities (implying distinct cultural origins) and from different backgrounds (students from engineering areas tend to think differently from students from business and product design). These tasks are demanding for the students since they are not used to this type of decision process, *i.e.*, they must always reach consensus. However, this approach develops communication, negotiation, and collaboration skills, which are usually lacking in students following more "traditional" paths. This year the degree of difficulty was even greater as students had to work remotely, with all the difficulties inherent to this process.

5.2 Personal Outcomes

Due to the worldwide Covid-19 pandemic outbreak, the team was not able to complete the project in Porto. It succeeded to finish the project remotely but, in their unanimous opinion, they would have preferred to do it in person. This would have allowed the team to discuss project work in a easier way and share good moments together. Regarding the EPS learning experience, the team members shared the following testimonies:

"*The EPS was a really good experience for me because I worked with an international team for the first time. I learnt how to conduct a complete project respecting current issues like the ethics and sustainability questions. Moreover, I met nice people, I discovered other cultures with our discussions, and I improved my English partly thanks to them. Because of Covid-19, the communication and the collaboration were harder, but we succeeded to achieve our objectives.*" – Solenne.

"*Taking part in the European Project Semester was a really good decision. I learned how it is to work with students from all over the world, I improved my English and I made new friendships with nice people. Furthermore, I got a great insight in the Portuguese culture. I am very glad to be part of the EPS.*" – Jens.

"*Taking part in the European Project Semester was a great experience. During this semester I met many wonderful people, I learned about other countries' culture, especially about the Portuguese culture. I improved my English and I think taking part in the EPS was one of the best decisions I've ever made.*" – Jan.

"*Even though it is unfortunate that we were unable to complete our project in person due to the Covid-19 pandemic, I look back to a great European Project Semester. I met and became friends with people from all over the world and briefly got to experience the Portuguese culture. Finishing the project online has been a valuable experience as it helped me work on my online communication skills.*" – David.

"*Working on the European project semester has allowed me to meet many nice people that I hope to keep in contact for the rest of my life. Along with friends, I believe it has improved my teamwork skills, challenging me with situations such as different cultures and backgrounds of other and making me adapt in a way which benefited everyone. With the world perpetually changing I think it's one of the most important things is to be understanding and considerate of others methods and cultures. The EPS exchange has been a fantastic opportunity to explore another country learning about yourself as well as others on the way I would highly recommend it to anyone considering it.*" – Charlie.

"*Working on this project was a wonderful opportunity for me and something that I will definitely take into my professional and personal life. Despite the pandemic's misfortune, I believe that each of us improves our communication skills, empathy, teamwork and much more. As a person from outside Europe, I realised how different and rich our cultures were and I was privileged to get to know them a little more.*" – Bárbara.

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