

# Towards Locative Systems for, and by, Children: A Cognitive Map Study of Children's Perceptions and Design Suggestions

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## ABSTRACT

This pictorial summarizes a qualitative study of children's perceptions of mobility through their own cognitive map drawings of the journey from home to school. We engaged 27 sixth-grade students (11 to 12 year-old) from Lisbon, Portugal, and analyze their drawings extracting 12 different design recommendations. We use these recommendations to provide design suggestions in terms of i) existing functionalities of mapping applications (that can be re-used); ii) improvements for existing map and wayfinding systems; iii) children's original design suggestions. The qualitative study reported here provides contributions that could help promote sustainable mobility for children in particular, with regards to innovation but also autonomy and supervision by caregivers.

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C&C '19, June 23–26, 2019, San Diego, CA, USA  
© 2019 Association for Computing Machinery.  
ACM ISBN 978-1-4503-5917-7/19/06...\$15.00  
<https://doi.org/10.1145/3325480.3326568>

## Introduction

Maps are one of the most utilized mobile applications. Yet they are designed and created by, and for, adults. To address this gap, in this study we capture children's perceptions of mobility and wayfinding by asking them to visually recall their daily journeys from home to school via cognitive maps, which are further enhanced by other qualitative data (questionnaires, written narratives, and interviews). Although the definition of a cognitive map is not consensual, due to its extensive multi-disciplinary use [20, 23, 30], we build on the work of Spencer et al. [31] relating to children in the physical environment: "(...) cognitive maps are not isolated and contextless entities: they are formed during purposive activity in the everyday world of the child, and, in as much as they encode the resources, valued friends, memories, and aspirations as well as factual information about geographical layout and routes (...) "[31].

Following the Participatory Design (PD) approach of Iversen, Smith and Dindler [19], we present children as "protagonists," as the main actors in driving the design and reflecting on technology and its role in their everyday life [19]. With this in mind, we analyzed the dataset generated by 27 students (11 and 12 year-old) recruited from a private school in Lisbon. In this pictorial we report on a subset of drawings from 13 children, which provided the widest variety of design suggestions for a new type of children's locative system targeting their interests, uses, and perspectives.

We highlight the output of specific children (as identified by pseudonyms and with ● for boys and ● for girls) and the themes that emerged from the thematic analysis of their design suggestions. We do so by showing their cognitive maps, and by quoting directly the children regarding: i) their own explanations about their 'maps' extracted from their written narratives or interviews; ii) their suggestions and reflections on the use of mapping apps and our design goal of developing a navigation app for people their age. We conclude the pictorial by discussing their suggestions against the backdrop of the existing and most popular mapping app, "Google Maps", and also by reflecting on our methods and data analysis.



The children's design recommendations are marked by this icon

## Research Context and Motivations

Many cities worldwide are examining novel ways to promote sustainable mobility in general [17] and specifically among children [14]. Promoting public transport, car and bike sharing, and free passes for children [6], are among the approaches used. Many of these depend on mobile device usage [22] and location services. We saw this current context as an opportunity to understand how technology can contribute to foster sustainable and independent mobility [11, 26], among children, lessening car dependence while giving caregivers confidence to allow their children to move by themselves.

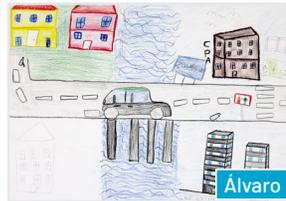
# Overview Of All Cognitive Maps

The top 10 recurrent elements in the cognitive maps were:

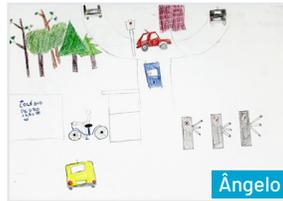
- paths-street-roads (n=23),
- their residence (n=22),
- highrises (n=21),
- flora-tree-flowers (n=20),
- cars (n=18),
- roundabouts (n=18),
- shops/cafes/supermarkets (n=14),
- traffic lights (n=13),
- the Vasco da Gama Bridge (n=11),
- Crosswalk (n=9).



[childrensworld.m-iti.org/lisboa-cognitive-maps](http://childrensworld.m-iti.org/lisboa-cognitive-maps)



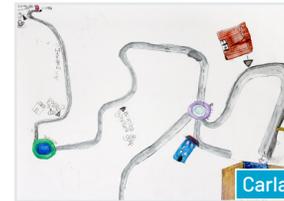
Alvaro



Ângelo



Antônio



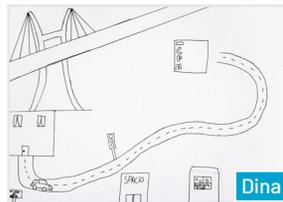
Carla



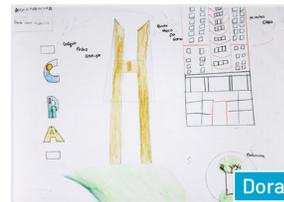
Carlos



Carolina



Dina



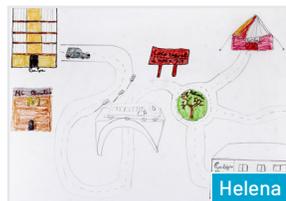
Dora



Francisco



Gustavo



Helena



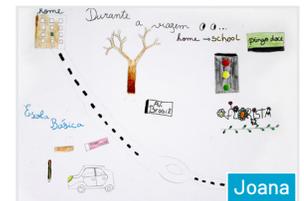
Hugo



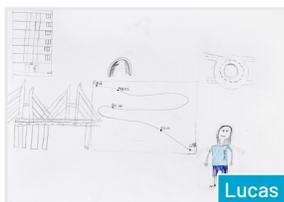
Inês



Isabel



Joana



Lucas



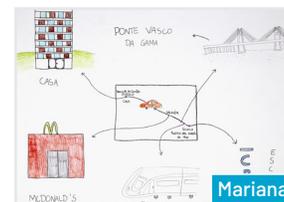
Manuela



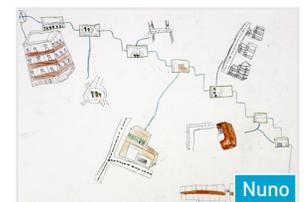
Marcelo



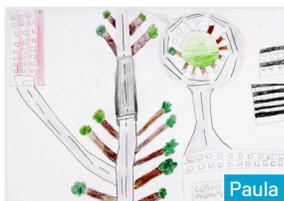
Maria João



Mariana



Nuno



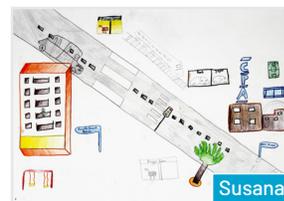
Paula



Paulo



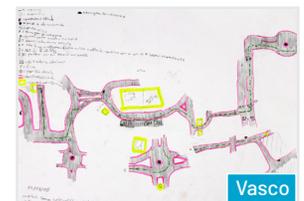
Rafael



Susana



Vanessa



Vasco

Ângelo



**Sustainable Mobility**

**Why did you draw a bike?**

*Because nowadays, there are more and more bicycles, for example. There are at the doorstep of the school those [called] Gira [public sharing bikes], and I think it is a means of transport that will be used more and more, because of pollution. They [cars] are already less and less bought, and the bicycle, as it does not pollute, I think it will be more used. And also, I think that more bike lanes are being built, at least on the way here [school]. Lately there has been construction there, near to the roundabout because they are building a new bike lane...*

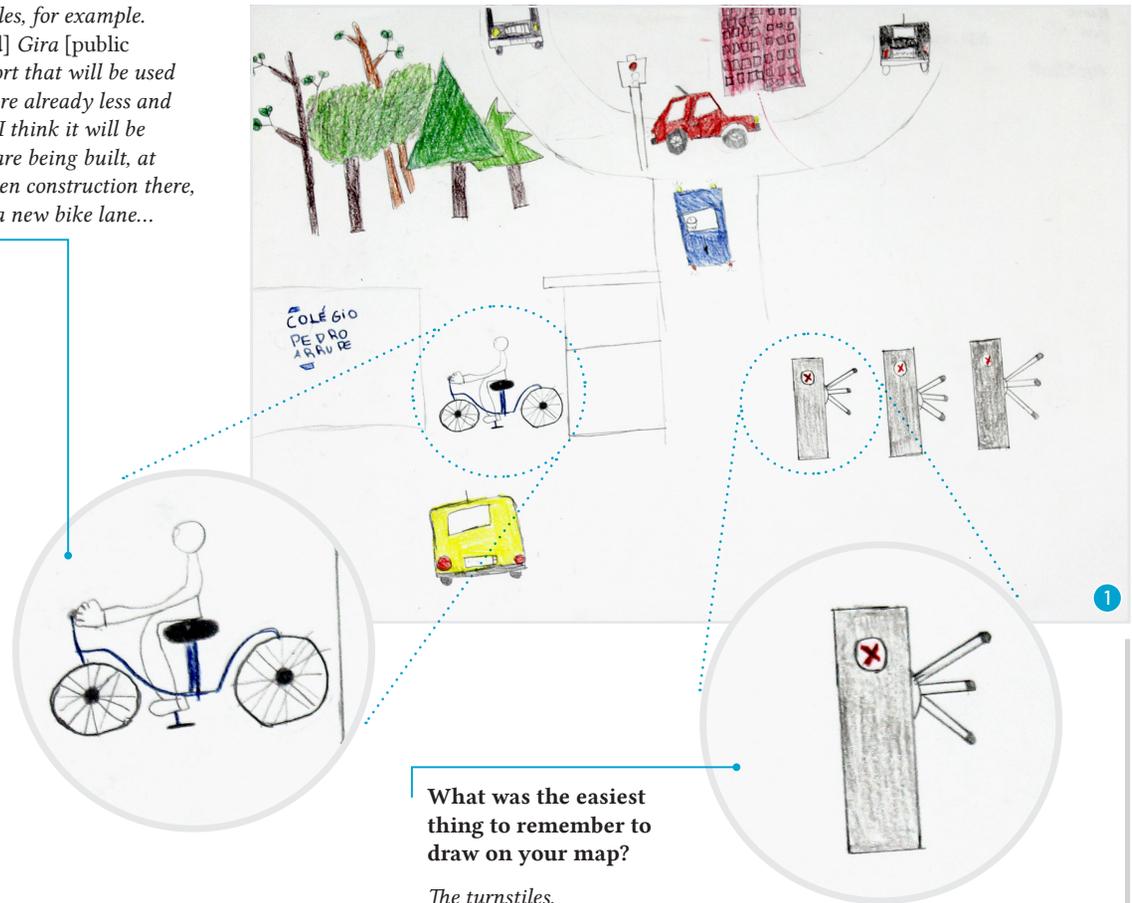
**Research Context**

In our study, children reported that their parents would let them go to school on their own, in the 7th grade, at age 13, commensurate with Australian studies on children's independent mobility [34]. Moreover, the majority of children in this study started using navigation apps such as Google Maps or Waze at the age of nine. Interestingly, when asked what use they make of the mobile maps, the children answered: i) helping their parents with navigation; ii) to see satellite images.

Two thirds of the children in our study (18 out of 27) drew cars, two drew a bus, and only one drew a bike, and one drew the metro. In fact, just seven out of 24 reported owning a public transportation pass (which is free up to the age of 12) [6]. However, when questioned about their preferred means of transportation to school some children answered bicycle (n=6 for only bike, and n=4 for bike combined with other transport). This contrasts with the vast majority of children (20 out of 27) who are driven to school by their caregivers. When asked about their perceptions of public transport several children answered negatively because of waiting times, delays, and crowdedness.

**How do you describe your map?**

*I would say these are the trees nearby a park in my house, this is a roundabout also a little further ahead, a bit close to the bike lane that I told you about. Here is the entrance to the school where I pass every day, and here are also at the entrance, the turnstile.*



**What was the easiest thing to remember to draw on your map?**

*The turnstiles.*

## António



**Autonomy**



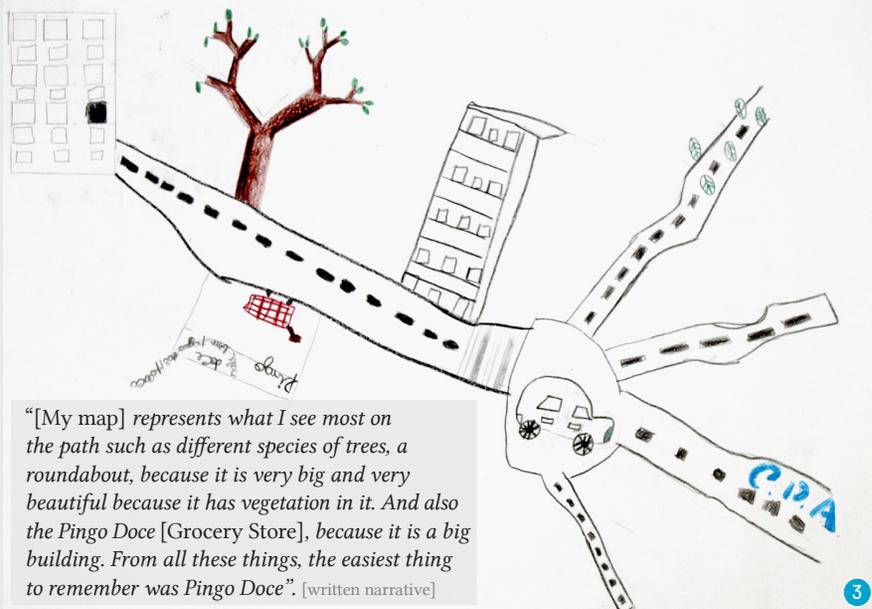
**Gamification**

**Why are you thinking about going to school by bus?**

*“Because I wanted to walk more alone, (...), like, stay here longer in school with my friends, but then I would go home, and I could always come by bike to school, and then go home, to Olivais, of course, I could stay here a little longer at school, and then I would go home soon.”*

*I think, (...) it could be like, the application could enable the user to have points if s/he catch things like pokemons type of thing and this way, people could collect those things and learn about the city.*

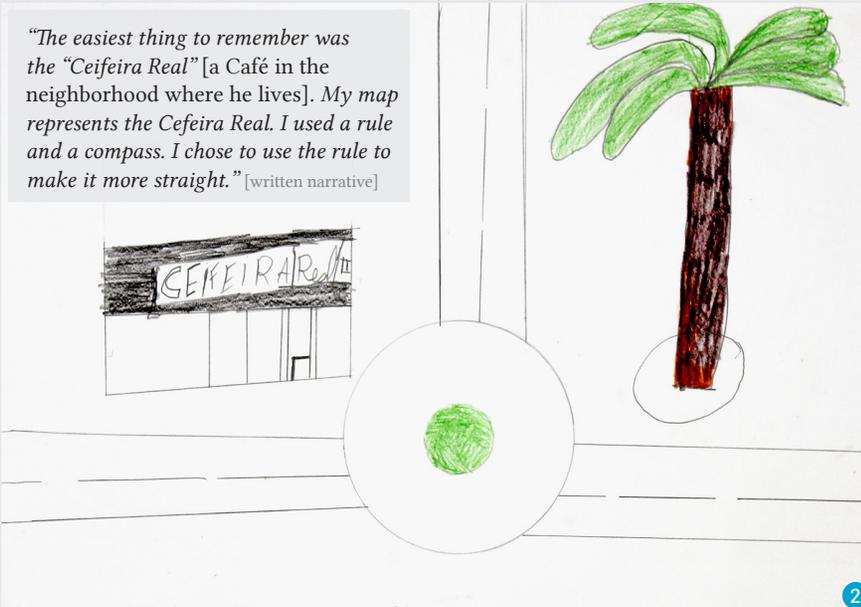




*“[My map] represents what I see most on the path such as different species of trees, a roundabout, because it is very big and very beautiful because it has vegetation in it. And also the Pingo Doce [Grocery Store], because it is a big building. From all these things, the easiest thing to remember was Pingo Doce”.* [written narrative]



*“The easiest thing to remember was the “Ceifeira Real” [a Café in the neighborhood where he lives]. My map represents the Cefeira Real. I used a rule and a compass. I chose to use the rule to make it more straight.”* [written narrative]





## Maria João



**Autonomy**



**Safety**

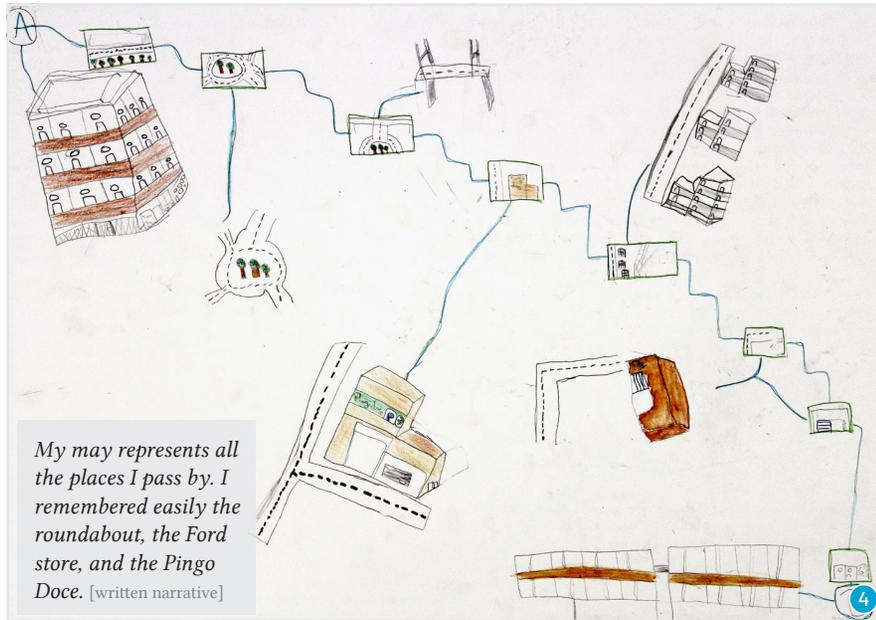
**What do you think of this idea of creating an application for children?**

*I think it's a very good idea [creating a wayfinding app for children] because, as I've said before, it's important that we gain more autonomy and that we can come [to school] alone safely, and that our parents can see where we are in a safe way.*

*[the app should] warn that... first that there is more than one way to get where we want and then tell us which is the safest area for us to go, and maybe faster.*







My map represents all the places I pass by. I remembered easily the roundabout, the Ford store, and the Pingo Doce. [written narrative]

Paula

 Location Sharing & Tracking

 Social Opportunities

**What do you think about this idea of having an app that helps you to move around?**

So I think it's nice, because imagine that we instead of dealing with our parents' concern, "Oh, what time do you come back? Bla bla bla, "they can see us [on the app] and tell us that we're okay and that we do not have to be worried about that ... Oh, where the hell are they? What are they doing? Who are they with?"

**You suggested in the questionnaire, to know when we're close "to a friend," why do you think this is important?**

[I said] so, because I come back from school and I always see a friend's house, and there may be several houses of my friends or acquaintances there, and I wanted to, I'm curious to know, so it was nice to see where they live, how they are, if they are close to a beautiful landscape.

Nuno

 Location Sharing & Tracking

 Optimization

**I saw it here in your questionnaire, that you suggested 'Family Tracking', where did you learn that?**

I was once in a place and I heard about it, and then I went to find it. And I liked ...

**And now that you already know what it is, what do you think of it?**

I think it's a good idea, it's for parents to know where the kids are and to be more rested.

**I would like to have an app that I could call any car. It would not be like Uber. I want to call my car, or my mother's, in this case [without the need to call or talk] Then, they would come close to where I am.**



My map represents what I won't never forget. I included the river because it makes me happy seeing it from a distance, but I did not include the traffic lights because they just make me waste time.

Rafael



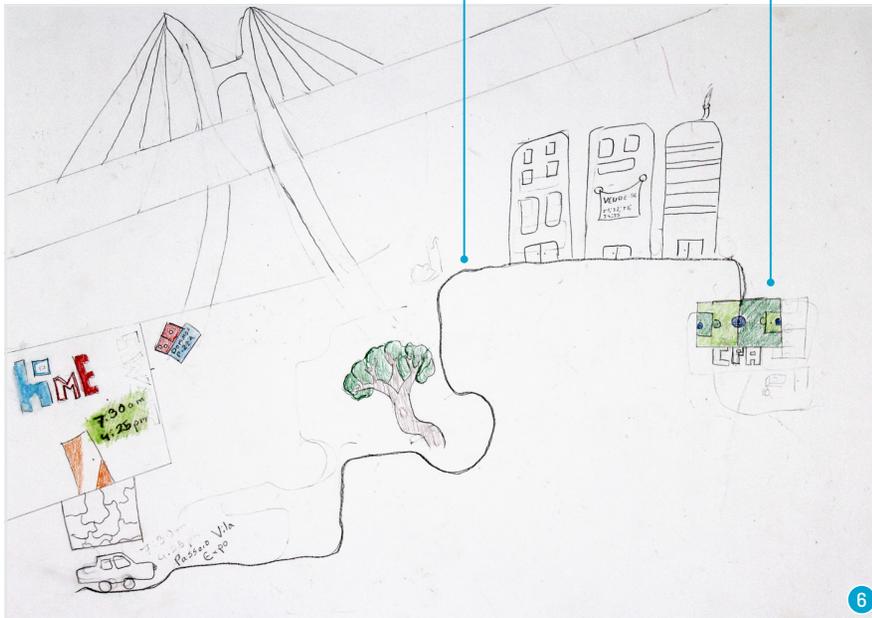
**Autonomy**

*If I had this application, I could go to many more places alone without my parents worrying so much.*

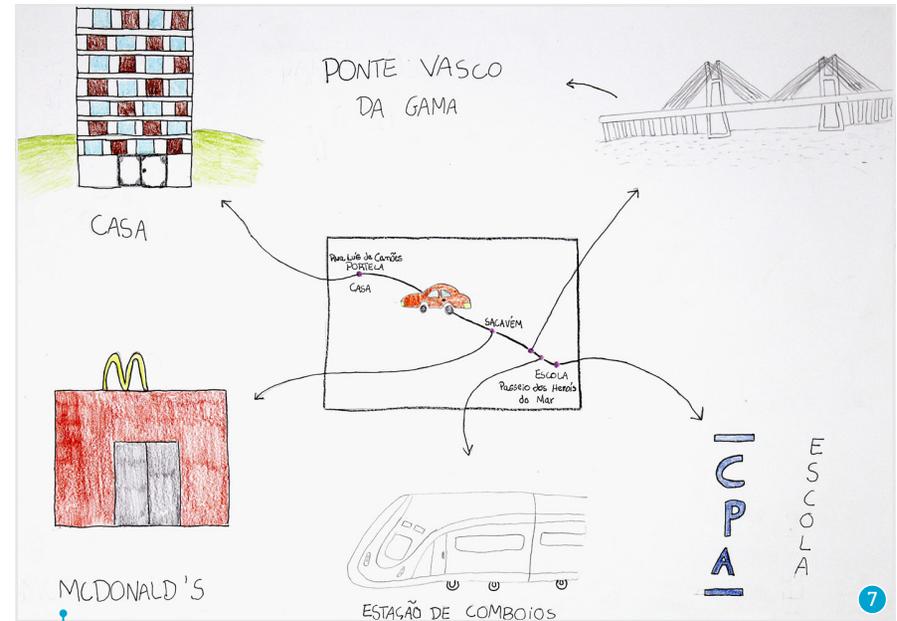


*I like this path because I travel by almost the entire trip to school along the river (...)*  
[written narrative]

*My map represents a soccer field, where I train with my team.*  
[written narrative]



6



7

Mariana



**Location Sharing and Tracking**



**E-ticket**

*The most important elements of my map are the school and my house. The easiest things to remember were the Vasco da Gama Bridge and the Rail Station of Sacavém.*

**In the questionnaire, you wrote that you would like to see the whereabouts of your friends and family and vice-versa. What is your opinion about this ability to track and to be tracked?**

*(...) my mother wants to see where I walk sometimes, so she asks me, but only if I accept that she can see me [referring to WhatsApp location sharing]. I accept, she can see...*

*We could use the phone to pay the bus ticket or metro (...). Yes, that would work, because [otherwise] we can lose our [transport] tickets...*



Carlos



Customization

For example, one thing I like about Waze is that we can choose the transport [the icon that appears on the screen] (...) if it is a Formula 1 car, if it is a motorcycle...



And what about your map, why did you do it like that?  
Because I did the things that most call my attention during the trip from school to home.

Vanessa



Gamification

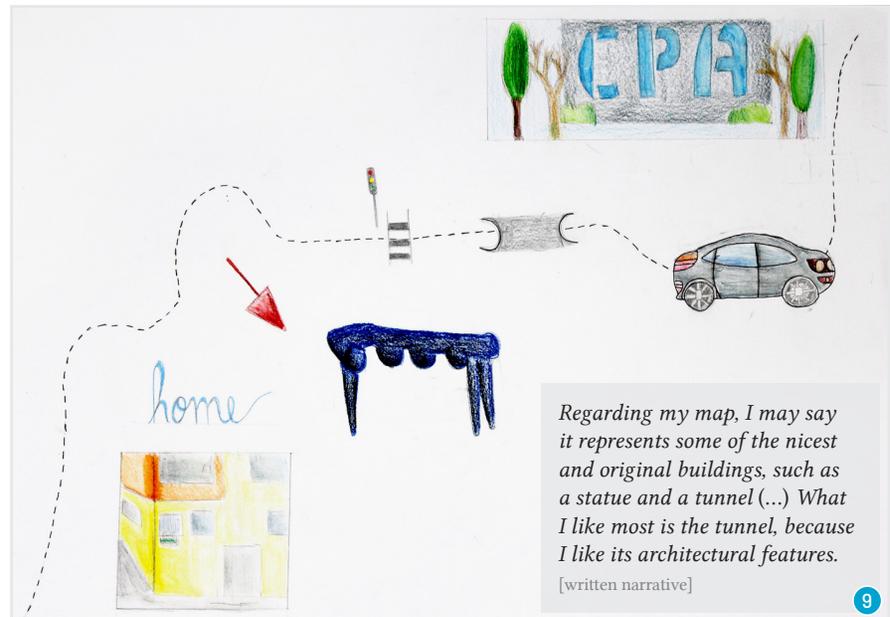


Scale

[The app] could notify us about monuments as we walk back home. And we could gain medals if we walk a lot. We could also gain coins if we go to certain places. The coins could help us to have an avatar instead of that that annoying dot that we have.

(...) I do not know. it could even be a way to personalize with our face. An avatar of a person / character, or so.

I would like my map to get the message that sometimes the biggest buildings are not always the nicest. (...) Because sometimes the smaller things seem nicer, as this tunnel here is nothing special, but I really like it.



Regarding my map, I may say it represents some of the nicest and original buildings, such as a statue and a tunnel (...) What I like most is the tunnel, because I like its architectural features.

[written narrative]

9

Álvaro



Recommendation of Places

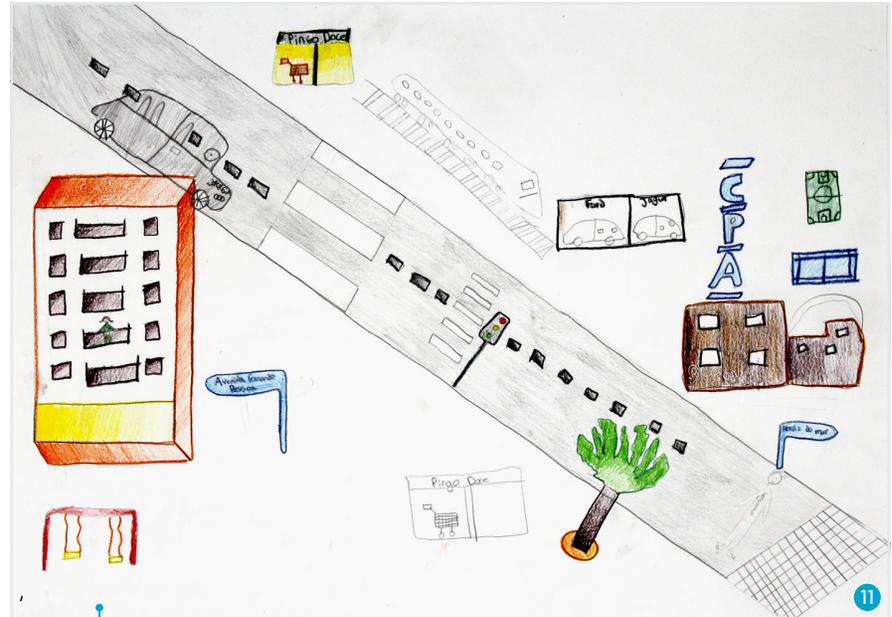
We write the location where we want to go and appear the best way [to get there] and the stores, the stores that we like, and that's more or less ready. And before that we could write what we liked and then (...) We kind of do what we like and it indicates the best places where we can find it.



My map represents a long path (...) I decided to include an ad of the ZooMarine [an aqua park] because I pass by it and I look at it. [written narrative]



10



11

On my map I included the following elements: my house, trees, Pingo Doce, a playground, train, Stand Ford, Stand Jaguar, other Pingo Doce [close to the school], my school. [written narrative]

Susana

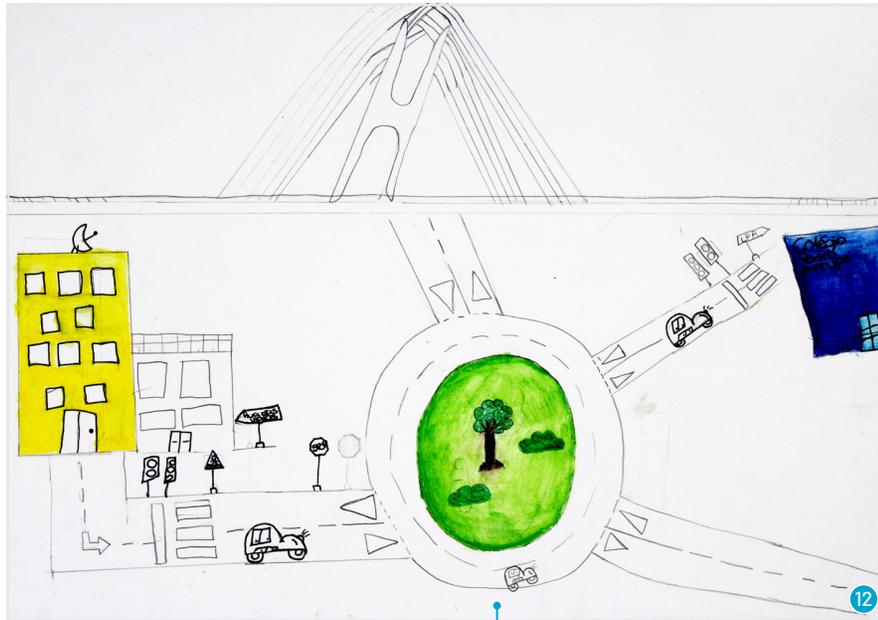


Learning gains

(...) when I go home from school, I do not ... I do not look at things very much, but then when I did this work [for the research project], I got a better idea of what's going on around the house.

Research Context

Although this is not a design suggestion, we consider it important to include the “learning gains” from this research project, because this is a relevant dimension of the “child as a protagonist” approach in PD. The goal of our project is not only to design a technology with children in schools. Following Iversen, et al. [19], this project encompasses learning goals, fostering reflections about technology use, and instilling new habits, such as sustainable ways of mobility.



12

Manuela



Easiness/Accessibility

*I pass by a roundabout, then I see the Vasco da Gama bridge, a little further I pass by Pingo Doce and then I pass by a Café called “Ceifeira Real(...) My map represents the parts of my path that I most enjoy on the journey from home to school. [written narrative]*

*It could be a little more accessible for children, because in Google Maps you need to know the street and so, and for children, it was easier if you [the system] provide it...*



Easiness/Accessibility



Inês

**What is your opinion about the idea of designing an application for children like Google Maps, to help children to move around?**

*“I think it would be easier, and maybe it would be less confusing than Google Maps, and maybe, as we thought it was for children, we might be better oriented, because Google Maps is for all the people, and therefore has many streets there, and sometimes even the color, even the map confuses me a little...”*

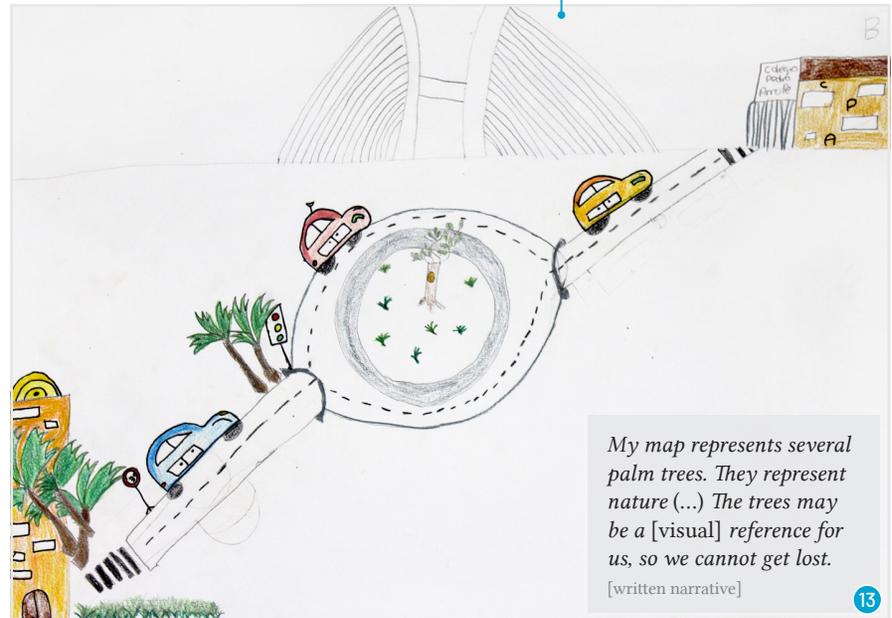


**Why did you include these specific elements in your map?**

*Because this is also what I see most while coming to school, it's the roundabouts, the cars and the bridge [Vasco da Gama], and then I get to school.*

**You said it takes five minutes to get to school from your house, right?**

*Yes.*



13

*My map represents several palm trees. They represent nature (...) The trees may be a [visual] reference for us, so we cannot get lost. [written narrative]*

## The building blocks of children's design ideas

### Existing Functions (can be reused)



**Location Sharing & Tracking** As emphasized by three of the children, sharing the real-time location with parents can be a strong tool to improve child mobility, keeping the parents constantly up-to-date of the child's whereabouts [1, 3]. This functionality, already implemented in WhatsApp, has been made available on Google Maps as well, where it is also possible to share the estimated arrival time and/or public transit information.



**Social opportunity** Children expressed the importance of seeing location details of friends' houses on the digital map. This is already possible on Google Maps, where you can look for names of contacts directly on the map and visualize the location on the map (if shared by the other person). Another two functions can be combined to obtain a similar result: it could be possible to define the preferred place using the "Your Places" function and/or sharing a list of places using the "Share List."



**Recommendation of Places** One child clearly expressed an interest in having a recommendation system for places based on personal interests. Google Maps provides the "For You" function designed to be an updated source of inspiration tailored to the user's preferences. The idea behind the service can be summarized as follows: the more the user utilizes this function, the more the system learns about the user's preferences and provides recommendations (keeping into account the proximity of the places).

### What Can Be Improved



**Optimization** A child mentioned that he/she would like to ask for a car-lift from caregivers just by sharing his/her actual location and pressing a "Call Car-Lift" button, optimizing the service request. This function could be implemented exploiting Uber APIs, augmenting the service including other "providers," such as parents (exploiting the "Location Sharing" feature).



**Customization** A child liked the idea proposed by Waze that allows them to customize and select a preferred icon for the navigation marker. Recently, Google Maps also included this function in the version for iPhone. A wayfinding application for children should take advantage of this mechanic to personalize the navigation marker on the basis of the child preferences and the mode of transportation.



**Easiness/Accessibility** Google Maps provides several services but it seems that some functions are not easily accessible, or clear, to children. This illustrates the need to improve the easiness of the map interface. For example, it is possible to search for places using the name of a person (instead of the address), but the Google Maps interface doesn't provide this information clearly.



**e-Ticket** A child would like to use the smartphone as a ticket, which is already possible and called a mobile ticket [9]. This feature relies heavily on the public transportation ICT infrastructure (it requires specific reader devices on the bus or at the entry points). A collaboration with the local public transport company could be strategic to provide this service and to enhance it exploring gamification mechanisms to foster sustainable and independent mobility among children, while ensuring their safety.

### Novel Children Suggestions



**Gamification** Gamification in locative systems is not new *per se* [10, 16, 27, 33]. What is new is how children would like to explore gamification in different ways, such as gaining coins/points to be used to customize an avatar, or catching virtual, 3D elements while exploring the city (inspired by the Pokémon Go app [29]).



**Safety** While Google Maps provides the fastest route (or the two fastest routes, if in walking mode) to reach a destination, it does not currently provide the option of the safest route for young children. This is due to different technical motivations: first of all, there are different definitions of a safe route (for example, a route with sidewalk, with night lights, without criminality [13], etc.); second, it is difficult to collect objective and trustworthy data so as to label a path as safe, which will vary for different kinds of citizens [28]. Providing paths for children is a potentially interesting feature that needs to be considered.



**Scale** One child said she would like her cognitive map to convey the message that small things matter. This idea could be applied to the design of a locative system for children, in which scale is personal and contextual. A landmark such as a small tunnel may help children in terms of navigation and therefore may be highlighted on a digital map. Or, the system should allow the child to add it. Well-known wayfinding systems do not provide a similar feature.

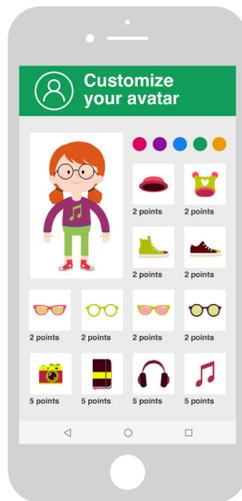
## Children's Original Design Suggestions in Detail

### Gamification + Customization

Gamification strategies could be integrated in a different way to engage the child in using the app and make their experience more enjoyable. For example, a child suggested the use of an avatar. Avatars are very interesting since they could be used also as navigator marker when the child is walking, helping the child to be oriented on the map: the position of the avatar (right, left, front or back) suggests the direction.



The avatar could be used as a navigator marker to help the child to orient themselves and follow the path in the right direction.



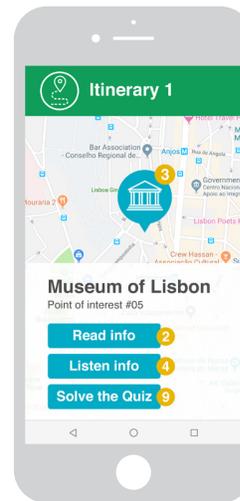
Using points gained by using the application, it would be possible to buy gadgets to customize the avatar.

### Gamification + Safety

Gamification could be exploited to provide safe paths. In particular, it could be envisioned as a function that allows for the inclusion of trust itineraries that can be enjoyed by the child while learning something new related to the city and its culture, having the further benefit of gaining points. In this way, the child could enhance her/his independence precisely by following safe paths.



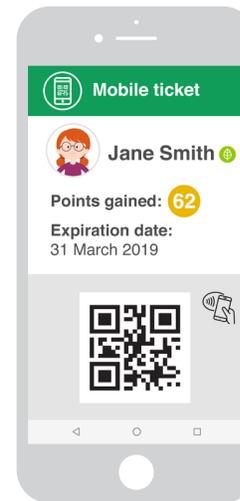
The app might present a safe itinerary that could be followed to collect different cultural points of interest in the city.



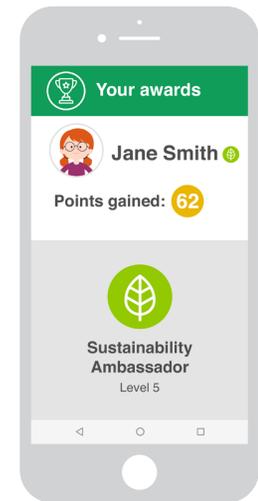
When the child reaches a point of interest, s/he can learn something new about its history and gain points.

### Gamification + e-Ticket

The e-Ticket could be used to gain points as well. In fact, the e-Ticket is linked with the use of public transportation, important to foster sustainable mobility [14] and children's independent mobility [11, 26].



The details about the e-ticket could be easily explored in the app, as well as the number of points gained.



Collecting points could also allow children to obtain badges [16] that state their level of involvement in using the app, encouraging a more independent and sustainable mobility.

## The Relevance Of Creating Locative Systems For Children

The scientific pursuit of understanding children's relationships with (non-digital) maps or wayfinding, or the relations between children and place, goes back to the 1970s [2, 4, 12, 18]. Barbara Bartz wrote about the designing of maps for children, as she believed "children as map users don't behave exactly like adults" [2]. Her argument is justified by Jean Piaget's work [24] on the development of cognition during the years from birth to adolescence. Bartz is not alone in her use of Piaget's theory in explaining the need to understand how children specifically understand wayfinding, landmarks, and the environment, based on developmental stages and age [see 12, 25, 36]. By drawing on these previous studies and their theoretical background, we argue that, nowadays, it is important to invest in the creation of locative systems for children to address their specific needs as mobile phone users, and also those of their caregivers. Such systems should include mobile mapping and wayfinding concerns but also notions of sense of place and placemaking, aiming the fostering of independent [11, 26] and sustainable mobility [14]. Location and locative systems have been widely discussed [15, 23, 37], but in the context of children, there remains a gap.

For the purpose of filling that gap, our data collection was based on a number of methods. First, all elements present in the drawings were counted and coded on a spreadsheet. Second, a profile of each child was created in a Google Doc, which we used to crosscheck the results of the questionnaire, the written narrative (their own explanation about their cognitive maps), and the thematic coding of the drawings. Third, based on these profiles interview questions were scripted for each child in order to probe interesting and unclear issues (e.g., only one child drew a bike; another child wrote "family tracking" as a suggestion for the app in the questionnaire) that emerged during the first stages of data analysis. Fourth, after conducting the structured interviews, we open-coded the interview transcripts in the qualitative data analysis software "NVivo" [5].

For the purposes of this pictorial, we focused mainly on the most relevant design recommendations extracted from the questionnaire and these were enhanced by the interviews in three main regards: 1) children's past experiences with locative and wayfinding systems (e.g., Pokémon Go, Waze, Google Maps); 2) what they think about designing

a wayfinding app and what features they would like to have in such system; 3) what could be improved in such a system, if designed by children, for children. The comments inserted in this pictorial were selected with all these factors in mind, but were also based on the crosschecking of the quantitative analysis of drawings (coding exemplified on page 2) and questionnaire results (e.g., sustainable mobility derived mainly from the particularities of the drawings' analysis, cross-checked with interviews) following triangulation techniques.

Finally, we conducted a thematic analysis [5] of the design recommendations specifically looking for the generation of design knowledge [32]. In order to establish what was original or unique in the children's design suggestions, the last stage of our data analysis was to compare the children's ideas (already coded, i.e., 'autonomy', 'location sharing and tracking') with the existing functionalities available in the application of Google Maps. We did this by scrutinizing the functionalities of Google Maps resulting from creating an account and trying out the children's suggestions.

## Concluding Remarks

This pictorial summarized our research results looking at how children perceive urban mobility through their own lenses, as depicted in drawings of their cognitive maps. Our goal was to collect evidence to inform the design of child-targeted locative systems, including wayfinding and mobile maps. For that matter, this pictorial took the approach of creative visual methods, which are deemed by several scholars as a way to "draw attention to how participants see and frame their social and cultural environments" [7]. The drawing of sketches, or cognitive maps, is also a widely-used method to access how children perceive space or grasp spatial relations in the home-school path [21, 35].

While this approach, influenced by Participatory Design strategies, enabled us to understand better how these children perceive their local environment, and also to extract their

impressions about mobility as well as design suggestions for a child-targeted, locative system, we are aware of the limitations and challenges of this study. First, this work addresses a small group of participants and regards the specific geography and socioeconomic status of a private school in Lisbon, capital of Portugal. Furthermore, cognitive maps are challenging to analyze. Downs and Stea characterize them as "complex, highly selective, abstract, generalised representations in various forms" [8]. We tried to address these methodological challenges in data analysis by engaging children with their own path from home to school, or their "maps," through the writing of narratives and, later on, through individual interviews. Our choice to display the results via pseudonyms was to visually emphasize the relevance of the 'child as protagonist' approach [19], highlighting not only design

suggestions but also the learning benefits of this research project as carried out in a classroom with the assistance of teachers in the formal study of 'Visual and Technological Education' (for the creation of cognitive maps) and 'Portuguese Language' (for the creation of written narratives about their cognitive maps representing their home-school path).

In future studies, we intend to involve parents and caregivers in the process of Participatory Design research in schools and other contexts related to children's attendance, by showing them the children's suggestions and asking for their perspectives, design suggestions, and concerns.

To meet the ethical concerns that arise in PD research involving children, informed consent for conducting the research was gained from the school principal and teachers.

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