Citizen science and the potential for mobility policy – Introducing the Bike Barometer

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ABSTRACT

In this paper, we report on a citizen science pilot project involving adolescents who digitize and assess their daily home-to-school routes in different school neighborhoods in Flanders (Belgium). As part of this pilot project, a web-based platform, called the “Bike Barometer” (“Fietsbarometer” in Dutch) was developed. We introduce the tool in this paper and summarize the insights gained from the pilot. From the official launch of the platform in March until the end of the pilot in June 2020, 1,256 adolescents from 31 schools digitized 5657 km of roads, of which 3,750 km were evaluated for cycling friendliness and safety. The added value and potential of citizen science in general and the platform in particular are illustrated. The results offer detailed (spatial) insights into local safety conditions for Flanders and for specific school neighborhoods. The potential for mobility policy is twofold: (i) the cycling friendliness and traffic flows in school environments can be monitored over time and (ii) the platform has the potential to create local ecosystems of adolescents and teachers (both considered citizen scientists here) and policymakers. Two key pitfalls are identified as well: the need for a critical mass of citizen scientists and a minimum level of commitment required from local policymakers. By illustrating the untapped potential of citizen science, we argue that the intersection between citizen science and local policymaking in the domain of mobility deserves much more attention.

1. Introduction

Mobility, and cycling in particular, is a policy application area where citizen science can play an important role (Haklay, 2015). Citizen science is part of a recent trend in which non-professional scientists volunteer their time for scientific research (Follett et al., 2015). Citizens increase their awareness, knowledge and understanding of a particular field of study (Bonney et al., 2009). Since citizens are experts in their daily travel behavior, their input can improve the understanding of travel behavior and build consensus around these high-priority issues. Consequently, policymakers can take more informed decisions about budget allocation (Wu et al., 2018). Scientists and science in general profit from data collection with much greater spatial and temporal resolution (Cohn, 2008; Bonney et al., 2014; Ziolkowski, 2020). Citizen science also leads to societal impact, for example when community-driven research questions are solved (Bonney et al., 2014) or citizen science improves decision-making through democratic and evidence-based policies (Sieber, 2006; Craglia and Cranell, 2014; Haklay, 2015).

Myriads of policies encourage cycling as an active and sustainable transport mode, associated with public health benefits (Heinen et al., 2011; Caster and Witlox, 2022). Although cycling as a functional mode of transport is on the rise in several European countries, investments in cycling infrastructure lag behind. Policymakers usually determine their investment strategy based on official statistics of the road network, such as traffic information and available incident data from police records, hospitalizations or insurance claims (Winters & Branion-Calles, 2017; Wu et al., 2018). Nonetheless, crashes, and especially bike crashes, often remain under-reported because minor injuries and near-collisions are not registered (Perster et al., 2017b; Winters & Branion-Calles, 2017). However, perceived safety at the street level has been postulated as an
important determinant for active commuting (Huertas-Delgado et al., 2018) and as an essential source of information to reduce traffic accidents (Winter et al., 2016; Wu et al., 2018).

Enhancing the travel-related infrastructure has proven to be a clear incentive for people to cycle (Boussauw et al., 2014; Pucher et al., 2011; Majumdar & Mitra, 2018; Frank et al., 2021). Mobility policymakers should be assisted in prioritizing investments in cycling infrastructure. However, they often lack the tools to engage with their citizens (Wu et al., 2018). Policymakers capture bike flow data at best, for example by using traffic sensors that count the number of cyclists at a particular time of the day or by analyzing data from mobile phones (Järv et al., 2014; Heiler et al., 2020). But these sensors are expensive and only provide limited information on the usage of specific cycling infrastructure. Traditional travel surveys and (smartphone app-assisted) travel diaries also face limitations, such as underreporting of trips due to response fatigue in paper-based surveys (Sammer et al., 2018) or device-related underreporting (McCool et al., 2021). There is a need for more user-friendly tools to connect policymakers with citizens providing insights into local cycling behavior and perceptions of cycling infrastructure.

Citizen science initiatives in the domain of mobility, specifically cycling, are scarce (Cragliia and Cranell, 2014; Keseru et al., 2018). A few exceptions are noteworthy: the role that self-generated civic organizations play in mobility decision-making processes has been addressed before (Banister, 2008; Fernandez-Heredia & Fernandez-Sanchez, 2020). And there are a number of technology-led citizen participation projects on cycling: Gonzalez-Ibanez et al. (2015) designed a web observatory that automatically displays visualizations and indicators of safety-related events as perceived by cyclists. The information is provided in real-time and is based on social networking services. Nelson et al. (2015) developed the citizen science platform BikeMaps.org, where citizens can register near misses or collisions involving bikes. In doing so, they aim to complement traditional data sources of bicycle incidents. Although the platform is global in scope, most collisions or near-misses are reported in Northern America. The study of Wu et al. (2018) uses citizen input to train and evaluate prediction methods. Citizens are asked to rate their cycling experience level and 20 cycling videos through a crowdsourced platform.

We nonetheless argue that the intersection between citizen science and local policymaking in the domain of mobility deserves much more attention. We do so by exploring the untapped potential of the Bike Barometer (BB) platform for local policymakers (“Fietsbarometer” in Dutch – can be accessed via https://fietsbarometer.ugent.be). The BB offers a novel approach to existing ways of monitoring routine travel behavior of important and vulnerable cyclists, namely adolescents between the ages of 14 and 18. The BB was developed by a research team at Ghent University (Belgium) as part of a citizen science initiative, funded by the Flemish government, and captures the home-to-school routes of adolescents. Home-to-school cycling during peak hours is one of several
recurrent uses of local cycling infrastructure. Collecting data through tools such as the BB not only allows for advancing scientific research but can also prove to be an adequate tool to monitor local cycling behavior and cycling friendliness of the environment. If many adolescents of a school participate, the outcome of participation is an insightful map and analysis of cycling and cycling friendliness in the vicinity of schools. Moreover, in case of participation by multiple schools in one village or city, the insights and analyses may cover a larger area and even an entire region, which is highly valuable for policymaking.

In this article, we outline the functionalities of the BB platform and summarize the insights we gained from the BB pilot project. Based on an exploratory analysis of the data at the regional level (Flanders) and a comparison of the data collected in a city and a town, we evaluate the pilot project in terms of its potential for policymakers. In the discussion section, we also elaborate on the aspects of the data that are usually not considered when policies are designed.

2. Introducing the Bike Barometer and the pilot

2.1. The Bike Barometer platform

The BB is explicitly education-oriented, providing formal curricular material for geography classes and teacher development workshops. The structured classroom environment is complemented by a virtual learning space (GIS-environment). This way, teachers are supported in attaining their educational end competences concerning ‘introducing GIS’. The course materials consist of three parts, that each fit one teaching session in the school curriculum. The teachers were asked to dedicate two to three geography lectures to the BB in the last two grades of secondary school. Working via teachers as citizen science ambassadors ensures good access to the real citizen scientists, i.e. their pupils.

We collect personal data in the BB platform¹ (i.e. age, gender, and information about the neighborhood they live in), which obliges informed consents of the participants and of their parents, given that these participants are minors. The study was approved by the Ethics Committee of Ghent University Hospital (B670201940648), and data management occurs in line with the FAIR principles (GO FAIR, 2021). Aggregated data of all participating schools are findable on the homepage of the BB platform, where information is provided on how to access the data. Point and segment data are linked to OpenStreetMap (OSM) data, making them interoperable with other applications related to OSM data. Finally, the available data are enriched with multiple attributes to allow for reuse of the data.

After registering, teachers get access to a ‘teacher space’ where all relevant course materials and video tutorials on how to work with the BB can be found. A specific dashboard allows the teachers to register their school, create classes, and generate logins for their pupils.

Adolescents can open their ‘personal space’ in the BB with the login-code provided by their teacher. Apart from filling out a number of survey questions (e.g. about socio-demographics, most used transport mode to school, wearing safety equipment), two specific tasks are important: the first task involves digitizing their home-to-school trip in a structured manner, regardless of the transport mode used. The second task comprises evaluating the cycling friendliness of different parts of their route.

Adolescents first digitize their trip by clicking at the intersection closest to their home on the map, and select the road segments they follow on their way from home to school, as illustrated in Fig. 1. It is important to note that all adolescents in a class are asked to participate, even if they do not cycle to school. All modes of transport can be

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¹ Free and unrestricted access to the collected data is only possible if the identity of participants remains protected. The research team (i) explicitly asks (informed) consent to adolescents and their parents before participation and for reuse; (ii) chooses not to collect routes from the very start of the trajectory, but from a point nearby; and (iii) publishes aggregated data for reuse.
selected, because all adolescents need to learn GIS skills and the input from non-cyclists is important since they may not commute by bike because of safety issues and poor cycling friendliness of their potential route.

The second task for adolescents is to evaluate points and segments along their route in terms of cycling safety (scores range from 0 (unsafe) to 10 (safe), as shown in Fig. 2. To limit response fatigue of adolescents living a long distance from school, only the last 5 km of their route to school is evaluated, as well as at least two points/intersections. In the final survey, adolescents can motivate why they gave high or low scores to certain segments and points (e.g. too busy, high speed of other road users, poor visibility). Although adolescents can digitize their route selecting other transport modes than the bike, in this step we emphasize that non-cyclists need to focus on cycling safety, and not on traffic safety for their specific transport mode.

In lecture session 2, adolescents visualize and analyze the class data in a web-GIS, included in the BB-platform. The input from an entire class is automatically merged, and aggregated data are shown in a GIS environment. The web-GIS not only shows points and segments digitized by the adolescents, but also contains additional layers (e.g. on bike accidents/fatalities, average traffic speed, air quality, etc.). During this process, adolescents develop GIS competences, for example by learning how to work with GIS-layers, how to filter data in attribute tables, or how to properly visualize their data.

Lecture session 3 confronts a more in-depth analysis of adolescents’ own input with relevant policy documents in their city. An automatically generated report on the cycling safety of their school neighborhood is discussed and adolescents formulate suggestions to improve the cycling safety in the vicinity of their school.

2.2. The Bike Barometer pilot

We conducted a pilot project from March to June 2020 in Flanders (Belgium). Note that this region is flat and highly urbanized, and has local and regional policies encouraging cycling, compared to other regions in Europe (Vandenbulcke et al., 2009). The BB platform was available to all secondary schools in Flanders that were willing to integrate it in their geography courses. We recruited geography teachers as ‘ambassadors’ of the project and asked them to use the platform in their classes with adolescents aged 14–18. The research team at Ghent University provided support to teachers to optimize data collection.

The BB was officially launched in March 2020 in Flanders. In order to optimize the BB for future use and to analyze a first set of data from the BB, a pilot study ran from March to mid-June 2020.

In order to recruit the citizen science ambassadors, namely geography teachers, we ensured some media attention and set up a small communication campaign in collaboration with the geography teachers’ association (ailing, newsletter articles). Geography teachers were invited to attend a free teach-the-teacher workshop on the BB. As an additional motivation, teachers were also informed that they would receive the results of the BB for their school in printed form (on a poster, banner, or cardboard plate, upon their choice).

Six teach-the-teacher workshops took place throughout Flanders in February 2020. A total of 71 teachers attended these workshops. The teach-the-teacher workshops lasted two hours, introduced the objective of the BB pilot and explained the different elements of the course material and BB platform.

The official launch of the BB was in March 2020, and the success of the pilot might have been positively and negatively affected by the spread of COVID-19 and the official measures taken by the regional government to prevent the spread of the virus. In mid-March, Flanders went in lockdown, meaning all schools had to close. This clearly affected the plans of many of the participating teachers. Some had clear guidelines to strictly address the most essential learning competences through online teaching, which implied they had to sacrifice time at the expense of the BB. However, new teachers also enrolled because the BB allowed for remote participation and was therefore considered by teachers as a good tool for online education.

Eighteen of 71 teachers (25%) who attended the teach-the-teacher workshops, participated in the pilot2. It was not necessary for geography teachers to attend a workshop, especially since the BB website also included descriptive instructional videos. Seventeen teachers who had not attended a workshop also participated in the pilot. The main barriers for participation that we identified from a brief evaluation survey (June 2020, n = 14), appeared to be that (i) it took at least two to three course hours to fully participate, which is a considerable amount of time in a typical semester and (ii) signed informed consent forms from both the adolescent and his/her parent/guardian were needed to be in compliance with GDPR, which meant an additional administrative hassle. Most teachers (10 of 14 who responded) limited their participation to the first

Fig. 3. The trip distance of adolescents’ most frequent trip to school varies for each type of main transport mode (Source: Authors).
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Adolescents indicated one or more reasons why they chose their particular route to school. Most adolescents prefer to take the shortest route. (Source: Authors).

3. Descriptive statistics of the pilot

3.1. Characteristics of platform users and their home-to-school trips

Between March 1st and June 17th 2020, 1,256 adolescents from 116 classes in 31 different schools participated in the BB pilot. Higher numbers were targeted for the full rollout of the BB in the next school years by promoting the BB through social media and partner organizations.

The motivation and effort of the adolescents that participated were high: although participants were asked to evaluate at least two points along their route, many respondents chose to score significantly more points (average = 11 points per route). This is also reflected in the time needed to complete session 1: on average, participants spent 41 min on the data collection. 228 adolescents did not fully respond to all survey questions or made mistakes when filling in the platform. We chose to omit these from the exploratory analyses below. This resulted in responses from 1028 adolescents, who together digitized 5,657 km of roads in Flanders. Because only the last 5 km of a route are evaluated, the total distance of roads that are assigned safety scores is 3,749 km.

The adolescents were on average 17 years old, as the sessions were mostly integrated into courses of the 5th and 6th grade of secondary school, and 54% were girls. Cycling was the dominant transport mode (53%), followed by travel by bus (19%) and by car (16%). Fewer trips were made by foot (6%), by train (4%), by moped (2%) and other transport modes (<1%). As shown in Fig. 3, train trips were on average the longest (17.0 km) and trips on foot the shortest (1.0 km). The mean distance of cycling trips was 4.9 km. Overall, the average distance of adolescents’ most frequent trip from home to school was 6.7 km and lasted 22 min. Adolescents left home for school between 6:44 AM and 8:25 AM, and arrived between 7:10 AM and 8:40 AM at school. It is remarkable that 45% of the adolescents reported wearing a headset while cycling. On the other hand, 59% of the cycling adolescents were accompanied by one or more persons, such as friends, siblings, or an adult. To protect themselves in traffic, 21% of the adolescents reported wearing some type of safety equipment, such as a high vis vest, high vis cover or armband, and 11% wore a bicycle helmet.

On the BB platform, adolescents were asked to indicate one or more reasons why they chose their particular route to school. Fig. 4 displays these with the percentage of adolescents for whom the reasons play a role. The most important aspect that determines adolescents’ route choice was travel distance: 60% preferred to take the shortest route to school. Other determining aspects were company along the route (25%), safety (21%) and limited traffic (20%).

Besides giving general information on themselves and their route, the adolescents had to digitize and assess how safe they perceived individual roads and intersections on their home-to-school trip, while additionally, indicating the type of cycling infrastructure on each road segment. The cycling safety assessment resulted in an average safety score of 5.6/10 (SD = 1.5) per route. Intersections obtained an average score of 4.7/10 (SD = 2.0), and road segments received an average score of 6.0 / 10 (SD = 1.6). It is noteworthy that cyclists covered the most distance along roads without cycling infrastructure. Next, roads with separated and non-separated bike lanes were most used. Another striking result was the large use of bike paths without cars, which was even larger than the use of bike streets (streets where cyclists have priority and are allowed to use the full width of the street). When comparing different types of cycling infrastructure, statistical tests revealed that bike paths without cars, separated bike lanes and bike streets received higher safety scores, while non-separated bike lanes and roads without cycling infrastructure received lower safety scores.

For a selection of intersections and roads, adolescents could indicate 3 3 3

**Fig. 4.** Adolescents indicated one or more reasons why they chose their particular route to school. Most adolescents prefer to take the shortest route.

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3 A Kruskal-Wallis test (H = 862959, p < 2.2 * 10^-16) showed that respondents comprised different ranges of safety scores to different types of cycling infrastructure. Mann-Whitney-U post hoc tests revealed that the differences where significant for all combinations of cycling infrastructure types, except for the combination of bike streets and other infrastructure types (Appendix - Table 1).
Fig. 5. Main transport modes used by adolescents from Mechelen and Groot-Bijgaarden for their home-to-school commute (a). Home-to-school distance covered on roads with or without cycling infrastructure by all adolescents, regardless of travel mode, in Mechelen and in Groot-Bijgaarden (b).

Fig. 6. This local map of Mechelen shows the aggregated cycling safety scores along the road segments and intersections assessed via the BB (Source: Authors).
why they gave a particular score by selecting one or more of the following reasons: good or low traffic volume, traffic speed, road condition, lighting, space, view, traffic signs, traffic rules and hindrance. Statistical analyses of these data showed that road segments and intersections with good lighting, good condition and good views received higher safety scores, while roads and intersections with a high traffic volume and high traffic speed were perceived as less safe. For intersections, hindrance was an additional reason for unsafety.

3.2. Looking into the data of a city and a town

The BB pilot provides not only regional findings for Flanders, but also more specific local data of the cities or towns where the schools are located. To illustrate this in this section, we present the results of two case studies, namely the city of Mechelen and the town of Groot-Bijgaarden. Mechelen (population of about 86,000) is one of the larger cities in Flanders and is located in the province of Antwerp. 63 adolescents from two schools in Mechelen participated in the BB pilot. Together they digitalized 262 km and evaluated 196 km of roads. Groot-Bijgaarden (population of about 8,400) is a small town that is part of the municipality of Dilbeek and is located in the province of Flemish Brabant. It is part of the agglomeration of Brussels and is highly urbanized. 65 adolescents from 1 school participated in Groot-Bijgaarden, digitizing and evaluating 487 km and 260 km of roads respectively.

Adolescents in Groot-Bijgaarden also assessed the roads and intersections as less safe for cycling than in Mechelen. However, for road segments, there was more variation in the scores in Mechelen than in Groot-Bijgaarden. Maps showing the aggregated assessments of the roads and intersections in Mechelen (Fig. 6) and Groot-Bijgaarden (Fig. 7) provide a good picture of which roads and intersections require prior attention. Low safety scores indicate that adolescents perceive these roads or intersections as unsafe for cycling, while high scores indicate that adolescents feel safe at those locations. The latter Fig. 5a shows which transport modes were mainly used by the participating adolescents. In Mechelen, the bike was the most dominant transport mode. Almost 80% of the adolescents took the bike to go to school. Walking to school was the next most dominant mode, followed by commuting by bus or by train. In Groot-Bijgaarden, there was more variation in the use of transport modes (Fig. 5a). The car was used most often, followed by the bus, and active transport modes (cycling and walking). A possible explanation for this is the difference in distance to school between trips of adolescents in Groot-Bijgaarden and those in Mechelen: the average distance to school was 7.5 km (SD = 5.7 km) in Groot-Bijgaarden, while in Mechelen this was only 4.2 km (SD = 3.1 km). Fig. 5b visualizes the distribution of distances covered on roads with different types of cycling infrastructure. More than half of the roads used in Groot-Bijgaarden did not have a bike path. The opposite was true in Mechelen, where more than 70% of the roads traveled by the adolescents were accommodated with some form of cycling infrastructure. Note that the differences in modal split might influence these results, as non-cyclists might take roads that are less cycling friendly.

4 Kruskal-Wallis tests (H = 3637.9, p < 2.2 * 10^{-16} for road segments, H = 466.82, p < 2.2 * 10^{-16} for intersections) indicated the presence of significant differences in safety scores between the different reasons. The Mann-Whitney-U tests (Appendix – Table 2 & Table 3) showed that the differences were significant for most combinations of reasons.

5 Unequal variances t-test with t(2836) = 20.66, p = 1.68 * 10^{-88} for segments, and t(630) = 7.47, p = 2.60 * 10^{-13} for intersections.
can be interpreted as good examples of how a safe cycling environment can be organized.

Linking these results with the local circumstances and infrastructure yields new insights into how roads and intersections are perceived by the public. For instance, roads that receive the highest cycling safety scores in Mechelen are bike paths without cars along waterways and the bike highway from Antwerp to Mechelen. The stated reasons for safety along these roads emphasize the importance of good road conditions, according to the adolescents. Also, safe and unsafe intersections can be easily detected from the BB-data map. Clicking on a specific intersection in the BB platform displays the reasons adolescents gave for a particular safety score. For example, high traffic volume or limited visibility may explain a low safety score.

4. Discussion

The present paper describes the process of engaging adolescents in citizen science research on cycling safety, and reports on some descriptive statistics from a pilot across 31 schools in Flanders. Apart from general benefits of involving the public in science, we argue that the BB platform has untapped potential for policymakers. We reflect on the pilot, identify a number of limitations and address ways to overcome them.

Even though the COVID-19 pandemic led to a lockdown in Flanders at the start of the pilot, the participation of respondents still surpassed expectations. Our sample and travel behavior findings are consistent with other findings in Flanders, such as the general Flemish cross-sectional survey on travel behavior (OVG) (Declercq et al., 2018). For example, according to the OVG, the average distance of home-to-school travel by bicycle is 3.4 km, while the average distance of cycling trips reported via the BB was 4.9 km (SD = 3.3 km). Also, Mertens et al. (2016) reported similar outcomes on adolescents’ preferences when cycling; the separation of bike paths, the importance of short routes and travelling together are important determining factors for young cyclists.

The cycling DNA report of Fietsberaad (2021) demonstrated that the importance of the latter has even increased in recent years: 6 out of 10 Flemish cyclists want to be able to cycle safely in pairs on a bike path.

4.1. The added value of the BB pilot

The BB has the potential to become a user-friendly tool that creates local ecosystems of adolescents, teachers, and policymakers, while still being scalable which is interesting for research. For example, the BB pilot triggered a number of additional initiatives. It led to the development of the action program ‘Jonge Wegweters’ of a partner organization Bataljong, in which adolescents discuss their concerns about local cycling safety issues with policymakers. Next, the BB was integrated in a teaching module for the first grade of secondary schools by another partner organization, namely RVO Society. Moreover, some municipalities requested the BB data from schools in their territory to conduct custom analyses, and several municipal representatives expressed their interest in a similar tool where citizens in general could provide input. This resulted in the development of a similar platform aimed at data collection by all types of user groups. The Province of East Flanders currently co-finance the development of local cycling maps based on this platform. The BB platform is innovative in this way, illustrated by the need for such tools in urban planning as discussed by Craglia and Cranell (2014) and Wu et al. (2018). It complies with the suggestion of Bonney et al. (2014) to exploit the ‘local’ eyes on the road and enhance local collaborations through citizen science projects.

The main added value of the BB lies in the extensive geospatial information that is collected, as shown in the case studies of Mechelen and Groot-Bijgaarden. Not only does the preserved data of the BB allow for general analyses of travel mode choice and route preferences in a school neighborhood, but the ‘wisdom of the crowd’ can inform policymakers on particular road sections that demand prior attention. Moreover, data collection requires only limited effort, while being highly cost-effective. This is possible thanks to the online web platform available to all secondary schools in Flanders, the importance of which is discussed by Bonney et al. (2014). The BB results in insights into local traffic flows of adolescents traveling to school, because not only spatial but also temporal data of home-to-school routes, such as time of departure and arrival, are included. These data are directly linked to OSM data, which creates a great potential for further data integration.

The large data input provides the opportunity to perform in-depth analyses of different aspects of cycling safety. For example, more in-depth knowledge of why a segment or intersection received a lower score is obtained (see Section 3.3). Moreover, while it is possible to deduce cycling friendliness from predetermined objectives parameters (for example, bicycle lane width), it is now possible to compare these objective insights with more subjective feelings of cycling safety at the street level. As cycling incidents are strongly underestimated in available objective data sources, Winters and Branion-Calles (2017) reported the need for innovations in cycling safety monitoring. In addition, unlike most studies, subjective data is collected at the level of individual intersections and road segments.

Another advantage of the BB is the focus on local problems and successes as perceived by adolescents. Not only negative, but also positive perceptions are collected for roads and intersections. This is important information for policymakers to get confirmation about their efforts to improve cycling safety. Maps of the BB outcomes quickly show which locations are valued. The specific cycling safety scores and reasons for these scores allow insight into specific problems or successes. Moreover, the perceptions of non-cyclists about cycling safety are collected as well. This can provide new insights into how subjective cycling safety plays a role in not choosing the bicycle in home-to-school traffic.

The BB can act as a tool where subjective travel safety can be monitored over time. This results in longitudinal datasets, which facilitate, for example, the evaluation of the effect of local infrastructural changes near secondary schools. Besides the assets for policymakers, it is clear that the data generated by the adolescents can advance scientific work in a number of ways. For example, the relationship between subjective and objective safety can be investigated, and characteristics of safe and unsafe roads and intersections can be analyzed.

Finally, the BB has benefits for society at large. Adolescents can get a voice in mobility policy, when their concerns about cycling safety in their town or city are shared with local governments. Moreover, although generalizing the results to the broader population in Flanders is not the aim of the BB, the survey outcomes can be informative on a regional scale, as discussed in Section 4.1. General assessments of cycling infrastructure types improve our understanding of which types are preferred by young cyclists, illustrated in Section 3.1.

4.2. Potential pitfalls and limitations

To fully exploit the strengths of the BB, two conditions must be met. Firstly, high participation rates in a local environment are required to secure dense cycling networks before significant insights can be extracted for policymakers, and hence before the output can be
meaningfully translated into policy. As a result, communication and outreach activities must be adequately addressed in advance (Ferster et al., 2017a). This leads to the second condition, comprising a minimum level of commitment from policymakers.

To further support the active participation of local policymakers, it makes sense to involve them from the very beginning. Adolescents have the possibility to give open-ended responses during session 1, and to make suggestions for changes or solutions to problematic roads and intersections in session 3. However, their analyses and recommendations must reach local policymakers. If only their collected data on where they feel unsafe is shared, as has been the case in some municipalities (section 4.2), the impact remains limited. Therefore, we recommend teachers to provide practical support for adolescents to take further steps, and we suggest further integration of adolescents in the formulation of mobility policies, for example, through co-creation sessions. This strategy was not used in the BB pilot but could invoke the transition to what King et al. (2019) refer to as citizen science “by the people”.

Newman et al. (2010) suggest the implementation of a platform for project managers, in addition to that for citizen scientists. A dedicated web space for policymakers, including a short tutorial, could further encourage their involvement. As mentioned in Section 4.2, our research team is working on an extension of the BB in this regard, that will include interactive visuals and reports of the output for an entire city, and automated deduction of policy implications. In the process, realistic, community-relevant solutions might be designed and developed in co-creation. The BB platform will be adapted for use beyond adolescents in order to involve the entire population of road users.

Currently, adolescents only digitalize and evaluate their route from home to school, and not the return journey. The direction in which an intersection or road is approached, may lead to different safety perceptions. We decided to limit the digitalization effort for adolescents to one class hour to avoid response fatigue. Again, the condition of a critical mass that is needed to participate in a local environment applies. If multiple schools in a city participate with a large number of adolescents, these spatial limitations will be overcome.

4.3. Situation and further research

The BB has been fully operational for all secondary schools in Flanders since September 2020. Several schools have already participated for the second time. This reflects the satisfaction of the citizen ambassadors, and illustrates the interest of monitoring the cycling safety over the years.

The BB data contain substantial amounts of information which will be exploited in several scientific studies. The link between subjective cycling safety and objective indicators will be further studied. Wegman et al. (2012) argued that well-designed bicycle facilities such as physically separated networks reduce risks for cyclists and therefore have a net positive impact on the entire road safety, with the BB data allowing these findings to be compared to the perceptions of cyclists. Because the BB results include both spatial and temporal data of cycling routes, clusters of cycling adolescents can be detected in space and time. Given the increasing importance of cyclists cycling with others (Fietsberaad, 2021), current cycling infrastructure should be considered in relation to the localization of these clusters. Besides these scientific studies, local policymakers in mobility will consider BB results when drafting new mobility plans, as a result of the action program ‘Jonge Wegweters’.

5. Conclusion

In this paper, we argue that citizen science can provide clear benefits for policymakers, as well as citizens and scientists, by presenting the BB, an online platform where adolescents digitize and evaluate their home-to-school route in terms of cycling safety. First, such initiatives can give citizens a voice in mobility policy when local ecosystems are created between them and policymakers, while policymakers obtain a large amount of input with little effort and few resources. Analyses of this input deliver in-depth information about, in the case of the BB, perception of safety in cycling, which can be monitored over time. For scientists, the BB results in a huge dataset, which can serve as the input of many in-depth studies of subjective cycling safety over a large region. Prerequisites are the participation of a large crowd to obtain dense data within an area, and the minimal engagement of local policymakers for promotion and communication of the project.

As of today, the BB is still operational in Flanders for at least three years, providing us with longitudinal data. Additional outreach activities will be organized to promote the BB to our target groups. The data collected will be translated into readable information for local policymakers, and seasonal variations in the data will be examined. In the meantime, the BB is being explored for international purposes, and is being expanded to enable additional user groups to contribute to their local policies, and to extend the scope to all types of destinations.

CRediT authorship contribution statement

Tom Storme: Conceptualization, Validation, Investigation, Writing – original draft, Project administration. Sien Benoit: Methodology, Formal analysis, Investigation, Visualization, Data curation, Writing – original draft. Nico Van de Weghe: Writing – review & editing, Funding acquisition. Lieve Mertens: Writing – review & editing. Delfien Van Dyck: Writing – review & editing. Ruben Brondeel: Writing – review & editing. Frank Witlox: Writing – review & editing. Frank Witlox: Funding acquisition. Luc Zwartejes: Writing – review & editing. Greet Cardon: Supervision, Conceptualization, Writing – original draft, Funding acquisition.

Appendix A

Table 1

<table>
<thead>
<tr>
<th>Type 1</th>
<th>Type 2</th>
<th>W</th>
<th>p (fdr-corrected)</th>
<th>H₁</th>
</tr>
</thead>
<tbody>
<tr>
<td>no cycling infrastructure</td>
<td>non-separated bike lane</td>
<td>6.11E + 11</td>
<td>&lt;2.2E-16</td>
<td>less than 0</td>
</tr>
<tr>
<td>no cycling infrastructure</td>
<td>separated bike lane</td>
<td>2.97E + 11</td>
<td>&lt;2.2E-16</td>
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<tr>
<td>no cycling infrastructure</td>
<td>bike path without cars</td>
<td>6.47E + 10</td>
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<td>bike street</td>
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<td>separated bike lane</td>
<td>2.51E + 11</td>
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Table 2

Results of the significant Mann-Whitney-U post hoc tests comparing adolescents’ safety scores of segments for different assigned reasons.

<table>
<thead>
<tr>
<th>Reason 1</th>
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<th>p (fdr-corrected)</th>
<th>H₁</th>
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<td>hindrance</td>
<td>traffic rules</td>
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References


