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E-Scooter as Environmentally Friendly Last Mile Option? Insights on Spatial and Infrastructural Implications for Urban Areas based on the Example of Vienna

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1 ABSTRACT

We recently face an e-scooter hype in Europe. More and more e-scooter sharing offers are provided in cities and towns which are marketed as a last mile option. At the same time, a greater extent of private households has their own equipment. This trend is two-fold as e-scooter offers not only provide benefits (e.g. in terms of accessibility) but also pose certain risks (e.g. in terms of road safety).

To find out about spatial and technical implications and to assess the potential of e-scooters for urban areas, we used a 'triangulation' research strategy using different sources. Based on the insights from a trend and target group analysis and focus groups with users and non-users we conducted 1-week tests with persons using e-scooters on everyday routes (N=51), a survey of users and non-users (N=128) and course exercises carried out with pupils (N=94) in the city of Vienna in Austria.

Against widespread assumptions that e-scooters can use existing infrastructure, we found that the preconditions are not necessarily suitable for e-scooters. Infrastructure elements would have to be adapted to enable a safe use of e-scooters. It was revealed that e-scooter usage should be recommended for the last mile in suburban areas and not the city center as the density and infrastructure (e.g. cubblestone) do not correspond to preconditions essential for a safe e-scooter usage. In addition to that, we found that labeling e-scooters as an environmentally friendly option is the subject of controversial debate.

Keywords: e-scooter, urban areas, infrastructure implications, spatial implications, Vienna

2 PROBLEM STATEMENT

At present, the e-scooter is an indispensable part of the cityscape of many European cities. There has been a e-scooter hype, which has led to an increasing number of suppliers of this trend vehicle. This includes on the one hand sales to private individuals and on the other hand free floating sharing offers in urban areas. No less than eight suppliers have to struggle for acceptance on the market in Vienna (Gruber/Wiederwald 2019); in Germany seven suppliers offer their services in different cities (t3n 2019). The deployment does not stop at smaller city scales or regions with challenging weather conditions (e.g. Nordic countries). In Norway, e-scooter sharing suppliers entered the market in early 2019 providing services in cities such as Trondheim, Oslo or Helsinki (Lime 2019) under the guise of the green transportation trend. Even though a year-round use of rental systems is not planned, the harsh climate itself is a challenge for the material and the safe use on the roads and cycling paths.

The popularity of e-scooters is due to its relatively easy handling, low physical activity required and flexible everyday use. The new means of transport is promoted as an ideal addition to the existing transport network. It is marketed as an environmentally friendly alternative to motorized individual transport or at least as a supplement for the first and last mile in urban areas (Zarif et al. 2019). Therefore, the said potential of e-scooters unfolds above all in the combination with other transport modes, as a first or/and last mile option for short distances and opportunity for the road users' extension of range.

We know from the past that new trend vehicles are regularly entering the market, which are promoted and advertised differently by retailers. Individual vehicles are strongly accepted by consumers, create a long-term establishment and become everyday means of transport (e.g. inline skates, micro-scooters), others have disappeared from the market after a few sales seasons. It is clear by now, that e-scooters not only offer opportunities for road users. There are manifold problems attached to the implementation of the vehicle in the overall transport system. Lack of parking space, problems with handling, lack of a legal basis and excessive speeds are only some of the factors that contribute to the displeasure of the city administration (Hunstable 2019). Furthermore, it remains unclear whether e-scooters will actually be used as a supplement

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in the transport system or whether they replace footpaths, cycle paths and public transport. The marketing as environmentally friendly must be critically questioned. Not least because of the production of the vehicles and power consumption which receive little or no attention.

3 METHODOLOGY

The complexity of the effects of e-scooters requires further research. To assess the potential of e-scooters for urban areas, we need to find out about spatial and technical implications. First insights could be gained from a trend and target group analysis and focus groups with users and non-users. Based on this knowledge, we used the 'triangulation' research strategy proposed by Robert K. Yin (2003, 2009) using different sources to capture different aspects of the topic. 1-week tests with subjects using e-scooters on everyday routes (N=51), a survey of users and non-users (N=128) and course exercises carried out in a school (N=94) were performed for the city of Vienna in Austria (see Fig. 1).

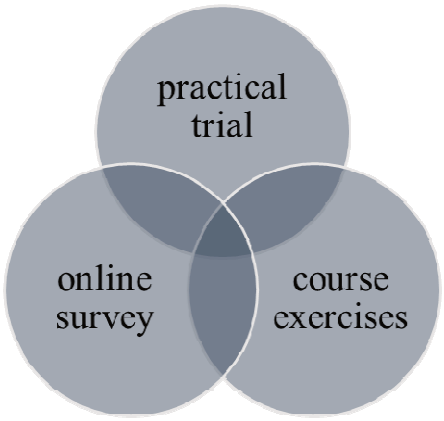

Fig. 1: Triangulation approach covering different aspects.

The approach described provides insights on the usage of e-scooters in terms of spatial ranges and preferred applications, suitability as a last mile option and technical implications (vehicle itself as well as the infrastructure).

3.1 Practical trial

The practical trial took place from September to June 2019 (including a winter break) with no spatial restriction but a focus on the Vienna region. 60 persons participated in the 1-week tests using e-scooters on everyday routes which resulted in complete data sets for 51 participants. The data collection was performed via a Smartphone App called 'SmartSurvey' which collects all the spatial information and offers additional features such as the localization of problem areas, route evaluations, type of infrastructure used as well as requests and proposals.

3.2 Online survey

To obtain a general picture of the population's opinion, an online survey was conducted from May to July 2019. A total of 147 people took part in the survey, which resulted in 128 fully completed questionnaires that were used for an evaluation. In the survey, a broad public was asked about their attitude towards small electric vehicles, their previous experiences and the resulting requirements. Users, non-users and occasional users were interviewed in order to survey the different aspects of road use and to allow different perspectives on this mode of transport. In order to obtain a general opinion, the survey has been advertised via social media, the event 'Radgipfel' in the city of Graz as well as the channels of the LOI partners.

3.3 Course exercises

The course exercise took place on two days in June 2019 in the secondary school "De La Salle" in the north-east of Vienna. Three parcours were designed and placed on an even surface outdoors on the school ground (see Fig. 2):

- straight driving (10 m length; 60/40/20 cm lane width)
- slalom (20 m length, distance between the little hats: 4/3/2 m)

- target braking (speed at least 20 km/h, stop after 4 m, the target area is 1 m long, the front wheel has to stop in this area)

Fig. 2: Examples of the three course exercises: „straight driving“, “slalom” and “target braking”.

The aim of the various tests was to assess the handling of e-scooters in relation to age, gender and previous experience for adolescents. Since it was a closed area, accidents with other road users could be excluded. Furthermore, all tests were explained to the children in detail and special attention was paid to their safety. Their participation was only possible with the consent of the legal guardian and with safety equipment like helmets.

4 RESULTS

The main focus of the study is to investigate the potential of e-scooters as a last mile option for urban areas. Insights on spatial and infrastructural implications were gained using the ‘triangulation’ research strategy described in chapter 3, namely the practical trial, the online survey and course exercises.

4.1 Practical trial

The evaluation included 533 paths and 398 trips which reveal that a combination with public transportation was performed in 53 trips and on 94 paths (see Table 1). A trip implies at least one, more likely several paths.

Category	Trips	Paths
e-scooter	180	200
e-scooter & public transport	53	94
e-scooter & motorized individual transport	2	4
e-scooter & motorized individual transport & public transport	4	6
undefined	159	229
sum with undefined	398	533
sum without undefined	239	304

Table 1: Distribution of trips and paths.

The analysis of the data shows that the participants who drove the 200 e-scooter paths had an average speed of 9.5 km/h during the trial and covered an average distance of almost 2.7 km. Compaired to the second categorie “e-scooter & public transport” were participants drove much shorter distances. If an e-scooter was used in combination with public transport, the average distance of the e-scooter paths were only 1.6 km long while the average of the driven speed is 3 km/h higher. (see Fig. 3).

63% of the respondents stated that their routes had changed as a result of using the e-scooter. 18 respondents (33%) stated that their travel time was shortened by using the e-scooter, while four respondents stated that their travel time was extended. The e-scooter most often replaces cycle and footpaths and in almost 19% of cases it also replaces the use of the private car.

The majority of the test persons (70%) had no experience with e-scooters before the test week. Only 11% said they use e-scooters regularly. About two thirds of all respondents (67%) had a very good or rather good

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overall impression of e-scooters after the test week. 9% of the respondents rated the experience as "rather bad" or "poor". 78% of the respondents stated that they consider e-scooters suitable for everyday use.

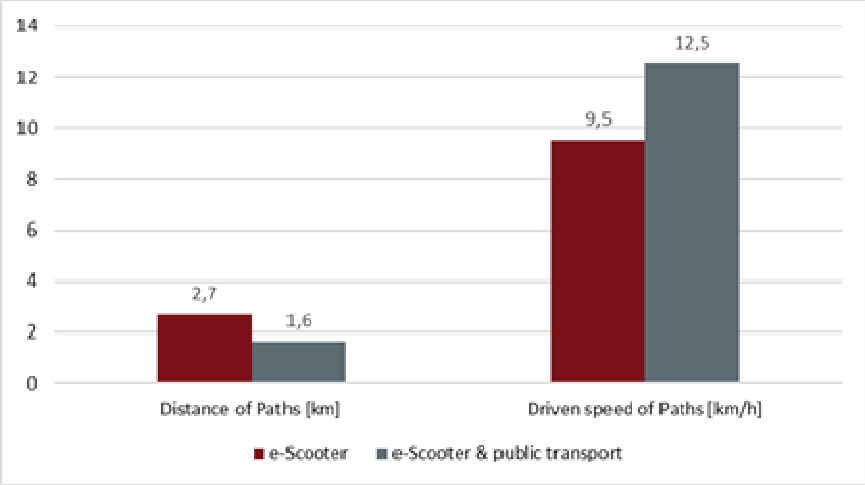

Fig. 3: Distance and speed per category.

With 65%, the majority of problems reported are infrastructure-related. Missing or insufficient infrastructure is classified as serious in only three of 41 cases (7%). In contrast, damage to or defects in existing infrastructure or problems with the vehicle are much more often (14% and 17%) rated as serious. The high speed, as well as damage to the surface of the carriageway or tracks etc. are often classified as a high safety risk. Requests mentioned by the respondents for infrastructure improvement measures mainly concern the surface of the road. On the one hand, this includes the repair of road damage, on the other hand, the avoidance of edges or tram tracks in the direction of travel along cycle routes. It should also be avoided to equip cycling infrastructure with uneven flooring (e.g. paving).

Time saving, flexible use and the possibility to combine with public transport are the three most frequently mentioned advantages of e-scooters. The lack of secure storage opportunities and the weight of the e-scooters were mentioned as the most common disadvantages.

During the practical trial 174 problem areas, including safety relevant issues with the e-scooter itself, were tracked by participants (see Fig. 4).

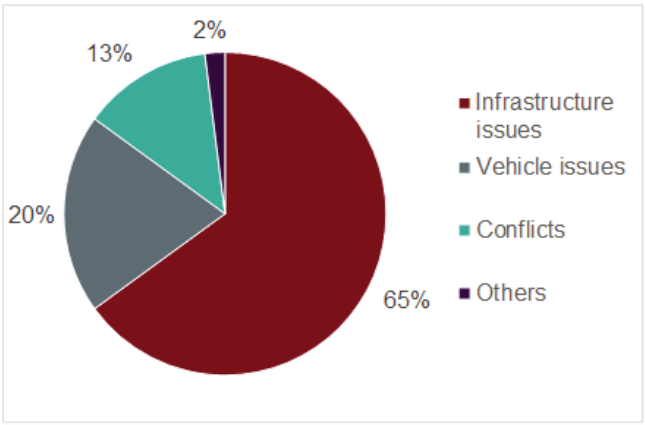

Fig. 4: Problem areas per category.

65% of the problem areas concern infrastructure, of which the majority are missing or insufficient cycling facilities. Reported problems with the e-scooter itself are the second largest category with 20%. Participants mentioned issues with the breaks of e-scooters, as well as the size and weight of the vehicles especially when travelling on public transport. A frequently mentioned problem is giving handsignals. Conflicts with other road users are in third place (13%). Almost two-thirds of them occurred between e-scooter drivers and pedestrians, but none took place on a sidewalk. Conflicts between scooters and motor vehicles have mainly occurred in the intersection area during turning operations, as well as at driveways. Throughout the practical test, no conflict was found between cyclists and e-scooters, although they use the same infrastructure.

The pressure on the infrastructure for cyclists has increased considerably due to the new group of e-scooter riders. On the one hand, this can result in decreased traffic safety, e.g. increase of conflicts. On the other hand, this is also a chance to gain more space as well as more ressources for this road user groups.

4.2 Online survey

With regards to household equipment, it was found that only a few people have access to small electric vehicles. Scooters are owned by only 34 respondents and e-scooters by nine persons. Other small electric vehicles are only available in households to a very limited extent. According to this, the e-scooters are borrowed from various rental providers, with Lime leading the way (20 entries).

After all, 45% have already tried out a small electric vehicle, of which 81% have already been on the road with an e-scooter. Use on everyday routes is still the exception. Only four people stated that they used an e-scooter every day. In contrast, other small electric vehicles are used significantly less frequently. Nevertheless, the predominant purpose of use for e-scooters was still everyday journeys before leisure time activities.

The majority of those questioned stated that the environmental alliance (public transport, cycling, walking) had been replaced by e-scooter driving. Only twelve respondents replaced a car ride with an e-scooter ride. E-scooters were mainly driven on cycle paths/cycle lanes and the road. Sidewalk/pedestrian pathways were also frequently mentioned and only very rarely other surfaces such as play streets. As expected, the survey participants preferred shorter distances with the e-scooter. At the same time, everyday routes hardly differ from leisure routes. 22% of the survey participants use it for a maximum of five minutes on everyday or leisure paths, another 49% and 42% for five to ten minutes respectively.

37% of all respondents perceive e-scooters as an attractive means of transport. The approval among users of small electric vehicles (n=57) is significantly higher here than among those who have not yet had any experience with small electric vehicles (n=71). Among e-scooter users (n=46), e-scooters are perceived as particularly attractive. Here it is 65% who regard e-scooters as an attractive means of transport.

E-scooters are perceived as a very individual, pleasant, fast means of transport. There is a need to catch up on the safety aspect and integration into everyday life. E-scooters are not seen as a cheap means of transport. The previous experiences among all respondents are mediocre to poor. Only 33% of the 128 respondents stated positive experiences. Here again there is a big difference between people with experience in handling small electric vehicles (n=57) and those without this experience (n=71). Only a quarter of the non-users report more or less good experiences. If only the e-scooter users are considered (n=46), 65% have had consistently positive experiences. The fun factor, time savings, flexibility and combinability with other means of transport have been highlighted as particularly positive. The barrier-free access (booking process, availability in the room, etc.) and the driving experience have been highlighted. Critical remarks have been made about mutual consideration and compliance with laws and regulations.

The reasons for switching to small electric vehicles in general were once again cited as alternatives to other means of transport (80 entries), rapid progress (75 entries), taking passengers on public transport (72 entries) and flexibility (70 entries). Coolness, on the other hand, is a secondary topic and received only 19 entries. There is no reason for as many as five people to switch to small electric vehicles.

The main reasons cited against the changeover were the risk of injury (91 entries) and the lack of safe traffic areas (71 entries), followed by other reasons with less than 60 entries. From the point of view of the users of e-scooters (n=46), these aspects also speak against use, followed by the lack of barriers (23 entries). Other reasons given by the users were high weight, lack of battery capacity, the availability of service points, weather dependency, legal aspects and environmental pollution.

22% of all respondents were already involved in a conflict or accident as road users and 4% as e-scooter drivers. 30 people described the conflict situation in detail, often involving pedestrians. 30% of all respondents also stated that they had already observed an accident or conflict. 35 persons described conflicts/accidents caused by reckless driving and/or the combination e-scooter/pedestrian. In contrast, conflicts on the road are rather sparsely represented.

Problems with e-scooters were already experienced by 17% of all respondents. Present topics were speed dosage while driving (14 entries), problems when turning and with uneven ground (10 entries each). Other problems mentioned were lack of equipment due to a change in the law, defective equipment, no

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homogeneous speeds on cycle paths, not enough power of the rental e-scooter (heavy backpack and gradient) and too slow speed.

More than half of the respondents stated that they were poorly informed about the legal framework of e-scooter use. Only 40% feel sufficiently informed. The legal situation is clearer for users of small electric vehicles (n=57) than for non-users (n=71), two thirds of whom have little knowledge of the legal framework. Among e-scooter users (n=46), more than half of them are largely aware of the legal situation.

When asked about the traffic areas that may be used by e-scooters, cycle path/bike lane received 111 entries, followed by 87 entries of the roadway and 13 entries of sidewalk/pedestrian path. Other areas listed were meeting zones, private ground and approved sidewalks. As a minimum age for unaccompanied use, 44 persons correctly stated 12 years or 10 years with passed bicycle test. If one takes only the 46 users of e-scooters into account, then almost half of them are aware of the minimum age (22 entries).

When asked about the alcohol limit for e-scooter drivers, 58 entries that the 0.5 per mille limit applies and 46 entries 0.8 per mille (actual alcohol limit). After all, there were 15 entries of 0.1 per mille and 14 entries stating that there is no alcohol limit. There are hardly any differences between users of small electric vehicles and non-users answering this question. Among the users of e-scooters (n=46) the level of information was slightly better. 18 entries related to 0.5 and 0.8 per mille and 7 entries to 0.1 per mille. Four e-scooter users assume that there is no alcohol limit.

59% of all respondents see the combination of e-scooters and public transport as an attractive mobility option. This contrasts with 9% who do not like it at all. However, most respondents do not regard the e-scooter as a replacement for a car. Only 44% would assign potential for the e-scooter to replace the car at the first/last mile in the long run. A restriction in the use of e-scooters would be supported by 60%. The regulation of parking areas is particularly present here with 57 nominations, followed by 40 nominations for reducing the existing speed limit. The same tendency can be read for the users of e-scooters. Proposals for other regulations addressed safety aspects, the design of the rental equipment, the regulation of loading responsibility and the areas to be used.

The concluding question about the wishes for the future has been answered extensively by no less than 70 persons. The wishes concerned integration into the transport system, environmental and safety aspects, legal regulations and technical details.

The gender ratio of the interviewees was almost balanced with 45% female persons. All age groups between 14 years and older were represented. 95% stated that they are not restricted in their mobility. The school education of the respondents was above average with 51% holding university degrees. Most of them are employed (69%) and the majority live in households with two persons (45%).

4.3 Course exercises

94 pupils (40% females) took part in the course exercises with a maximum of ten points awarded per course (three attempts per test in order to see their improvement) for comparing the participants and rounds objectively.

After a the welcoming and a general explanation per class giving insights on the project goals, the research questions, the handling of the e-scooter and the tests, the first student was able to start driving.

After performing all exercises, the pupils have been asked about their previous experience with scooters, e-scooters, bicycles and e-bikes, as well as their opinion on e-scooters. After that, they should announce suggestions for improvement to increase safety from their point of view.

The results are evaluated according to age groups and experience with scooters. The course tests show no significant differences in the points achieved between the sexes. Interestingly, the 13- and 16-year-old pupils performed better than their 14- and 15-year-old colleagues (see Fig. 5). A comparison of points between the three courses is not conducive because the criterias for reaching the maximum points were different.

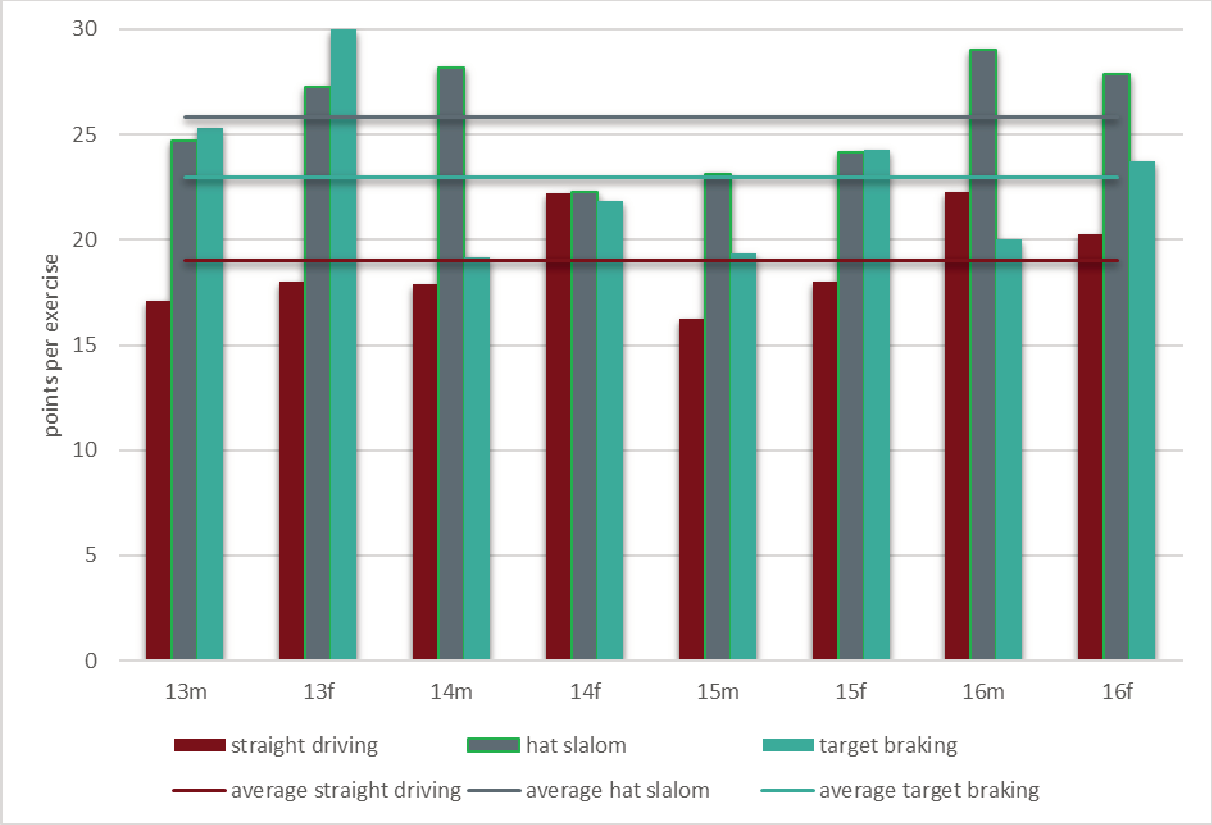

Fig. 5: Points per exercise per age and sex.

The students hardly had any previous experience with electric small vehicles (e-bike and e-scooter), but many of them had experience with normal bicycles and scooters. It was revealed that the experience with e-scooters and normal scooters does not clearly affect the points achieved in the various tests. The students seem to learn how to handle e-scooters very quickly (see Fig. 6).

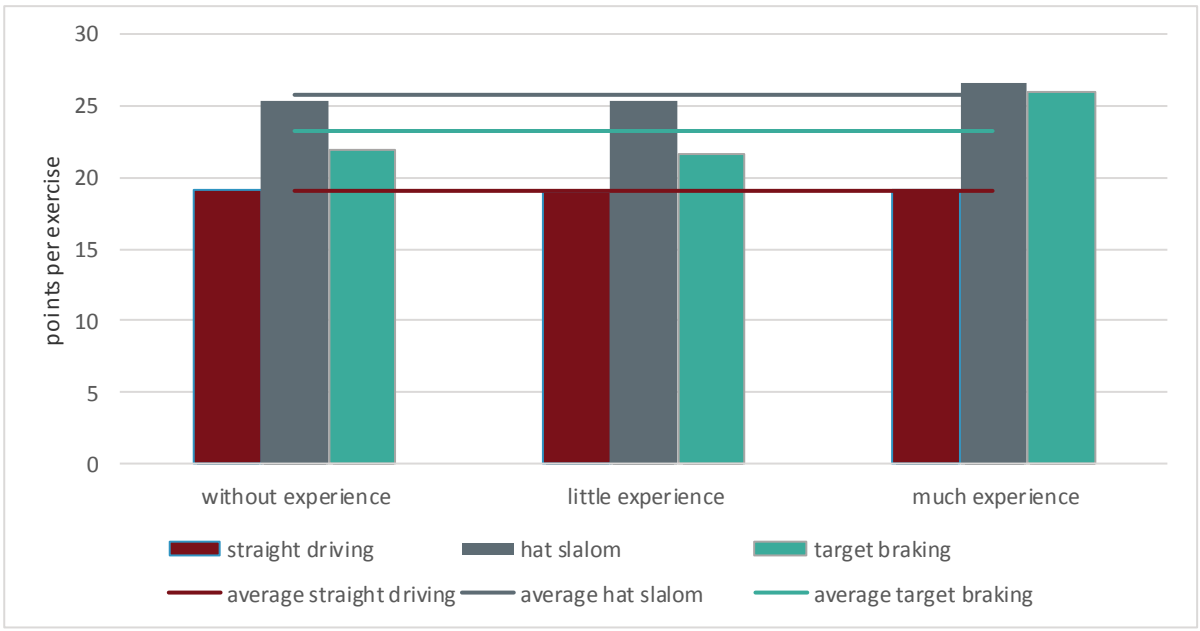

Fig. 6: Points per exercise according to experience with e-scooters.

Only about two-thirds of the total points were achieved in the "straight driving" course. This suggests that keeping a (narrow) track with e-scooters is a challenge. Otherwise the lower value could also be related to the fact that the course was the first to be traversed by the pupils. Slight improvements in the individual tests during the three rounds can be found in "straight driving" and "slalom". During "target braking" the improvement from the first to the third attempt is only visible on average.

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The results of the questionnaire show that young people have a positive attitude towards e-scooters, they say that "it is fun". They are aware that driving e-scooters "requires practice" and feel safe riding e-scooters on separate cycle paths, wearing a helmet and after receiving training on the handling of the devices.

5 CONCLUSION

E-scooters are trend vehicles flooding the European market for a few years now. They have proven to be not just a flash in the pan as sales of private vehicles are still high and sharing providers are conquering more and more new cities. So far, they have been treated like bicycles or conventional scooters which means that they share the same urban space. However, they differ considerably in terms of speed and weight. A closer look is necessary to find out which requirements are really needed in urban areas and how suitable they are as an environmentally friendly last mile option.

A more detailed analysis shows that the use of e-scooters in their current form poses several challenges at different levels. Handling the equipment presents difficulties, as do shared areas with other road users and uneven surfaces especially in combination with bad weather conditions. Furthermore, the inner city is a difficult area to use them. On the one hand, decorative surface structures are often used that are not compatible with the small wheel diameters, and on the other hand, these streets are often narrow and very busy areas.

In addition to the infrastructural and organisational (space distribution) challenges, there are major uncertainties regarding the legal aspects. Not everyone is aware of applicable legal regulations. This lack of knowledge can have an impact on traffic safety.

Another striking detail of e-scooter usage is the environmental aspect meaning the perception of the e-scooter as an environmentally friendly alternative for short distances, the promotion of the e-scooters as ‘green transportation trend’ and the users' assessment to that effect. Unexpectedly, many survey respondents pointed out that e-scooters are not environmentally friendly for stating several reasons (e.g. manufacturing, battery, comparison with active mobility).

Measures would have to be taken in different areas (infrastructural, legal, etc.) to promote the positive aspect of use for the last mile focussing on the group of motorized individual transport users. In addition, it becomes clear that it is a much more promising approach to use it as a feeder to public transport stations in poorly developed urban areas than, for example, in a pedestrian-friendly city center.

6 ACKNOWLEDGEMENTS

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