

Promoting sustainable mobility in communities with citizen participation: approaches, perspectives and results of a Living Lab in Germany

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Abstract

The present contribution deals with a practical insight into the design, implementation, and evaluation of different participation formats (on-site, direct mail, online) to participate in a living lab. A total sample of 290 citizens was recruited to promote sustainable mobility (i.e. walking and cycling) and improve urban space quality. Results further address the influence of participation methodology on participants' evaluation, willingness to participate and reported satisfaction with the participation used as well as predictors for participation satisfaction. Although the sample was not representative, the results suggest that citizen participation contributed to a more sustainable mobility awareness and a higher acceptance of the urban transformation.

Keywords

Citizen science; Community action; Participation and science governance

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Introduction

In the course of social and technological megatrends such as climate protection and sustainability [Manderscheid, 2021], demographic change [Buffel, Phillipson & Scharf, 2012] and advancing digitalization [Kramers, Höjer, Lövehagen & Wangel, 2014], almost all areas of daily life are changing. For the design of the city of the future, this means extensive adjustments in urban development as well as the (re)design of inner cities [Wittmayer & Loorbach, 2016; von Wirth, Frantzeskaki & Loorbach, 2020]. Concerning urban mobility, the requirements of climate protection, digitalization, flexibility through networking and automation as well as social inclusion must be translated into new intermodal mobility concepts. The drivers for these developments include efforts to increase energy efficiency, ecological sustainability, traffic safety, and mobility comfort [Rehme, Lindner & Götze, 2015]. However, in order to promote intermodal mobility and active means of transport (such as walking and cycling) in urban mobility, integrated, flexible, user-centered mobility concepts are lacking or not yet fully implemented [Burghard

& Scherrer, 2022; Heinrichs & Oostendorp, 2015; van den Berg, Meurs & Verhoef, 2022]. Thus, citizen participation takes on a critical role in achieving increased innovation [Denhardt & Denhardt, 2015], service improvement [Dunston, Lee, Boud, Brodie & Chiarella, 2009] and democracy [Frederickson, 1996], as well as improving conditions for others, shaping the community's future [Adler & Goggin, 2005] and helping to create more livable neighborhoods [Boyte, 2003].

In recent years, living labs are being discussed as one of the most important forms of citizen participation [Parodi, Ley, Fokdal & Seebacher, 2018]. "Living labs are defined as user-centered, open innovation ecosystems based on systematic user co-creation approach, integrating research and innovation processes in real life communities and settings" [European Network of Living Labs, 2019]. Thus, living labs are facilities at the interface of science and practice and provide a framework to pursue research, practice, and educational goals [Defila & Di Giulio, 2018]. The implementation of a living lab can cover the entire design and creation process of socio-technological innovations: from identifying user needs and prototyping ideas [Bischof et al., 2018] to the evaluation and iterative validation of technical products and artefacts. The duration, scope and nature of user involvement are also variable [Bischof, Freiermuth, Storz, Kurze & Berger, 2020].

Living labs are often located outside of research facilities to create a 'real-life context' [Niitamo, Kulkki, Eriksson & Hribernik, 2006]. In real laboratories, transdisciplinary projects and in particular experiments in a real-life setting and experimentation environment are implemented. These projects are continuously reflected upon in terms of an experimental and reflexive way of working, and their project trajectories are adjusted accordingly [Beecroft, Trenks, Rhodius, Benighaus & Parodi, 2018]. Thus, living labs pursue at least a dual objective: the production of insights and new knowledge (research goals), and the initiation of transformation processes (practice goals) [Defila & Di Giulio, 2018].

Present research

Within the present contribution, we give a practical insight into the implementation and evaluation of a combination of different participation formats (on-site, direct mail and online) to participate in a living lab. Citizens were recruited to participate in an urban transformation process to promote sustainable mobility (i.e. walking and cycling) and urban environmental quality. The aim of the present research was a) to better understand the influence of the participation methodology used, b) to identify variables which might be able to predict citizens' reported satisfaction with the conducted participation (i.e. predictors of participation satisfaction), and c) to investigate the potential of citizen participation. To this end, the following research questions (RQ) were addressed:

- RQ1:** How does the choice of participation methodology (on-site, direct mail and online) influence participants' evaluation, their willingness to participate and their participation satisfaction?
- RQ2:** How can participation satisfaction be increased? Or in other words: Which predictors of participation satisfaction can be identified?
- RQ3:** In what way does citizens' participation improve their awareness of the issue of sustainable mobility and increase its acceptance into the urban transformation process?

Method

The citizen participation reported in this contribution was part of a publicly funded research project to promote sustainable mobility awareness in urban areas (NUMIC — new urban mobility awareness in Chemnitz; <https://chemnitz.de/numic>) conducted in Chemnitz, Germany from 2019 to 2022. Using a citizen science approach, citizens were actively involved in an urban planning process and the subsequent implementation and evaluation of several urban re-designs. For this purpose, an urban neighborhood in the periphery of Chemnitz became an experimental field (i.e. living lab). As the citizens in this neighborhood were scientifically accompanied and interviewed during the whole project time, several interview studies and experiments in a real-life setting were conducted. In the urban area of the living lab, a walking and cycling-friendly route (i.e. model route) was developed and three underused places (i.e. potential areas) were upgraded. The implementation involved various measures, such as new cycle and walking paths, the renovation of the surface of existing paths, new infrastructure to help users of lower speed routes where they cross higher speed routes and related accessory measures (e.g. handholds at traffic lights, benches), signage and markings to raise awareness for cyclists and pedestrians, as well as measures for barrier-free access (e.g. lowered curbs), improvements in the overall urban environmental quality (e.g. well maintained green spaces).

Within the living lab, a combination of participation formats, such as workshops and round tables, and direct mail as well as online polls and voting was used. In several co-creation processes, citizens designed the living lab. They determined where the cycle and walking-friendly route should run, which potential areas should be selected and which measures should be implemented to improve sustainable mobility and urban environmental quality. Citizens were able to submit their ideas and preferences via various workshops on-site at the route and at the potential areas, via direct mail and via our project-related online participation platform <https://numic.city>. The city of Chemnitz checked all ideas for feasibility; then, from a selection of suggestions, citizens could vote on the route, the potential areas and the measures to be implemented. The result was a leisure route in the periphery of Chemnitz that is about 3 km long and contains about 40 infrastructure measures.

3.1 Participants

All citizens from the age of 16 years (through legal aspects in terms of data collection) could participate in the living lab. Invitations to the different participation formats were published via the project homepage, newsletters, the local newspaper and press releases by the project partners. Furthermore, all infrastructure measures were equipped with flyers with a QR code and a link to the participation platform, <https://numic.city>. Interested citizens did not need to register and could simply come to the participations on-site and vote online.

A total sample of 290 participants took part in at least one of the participant formats and corresponding questionnaires. The sample consisted of 102 women and 57 men ranging from 16 to 86 years ($M = 31$ years, $SD = 15.2$). 80 participants reported having a general qualification for university entrance. 57 participants were university educated, and 19 participants reported to have finished secondary school only. One participant reported having a secondary school-leaving certificate,

one was still in school education and one had another qualification. Participants reported an average duration of residence in Chemnitz of 14 years ($SD = 17.8$, $Min = 0$ years, $Max = 77$ years). 131 participants made no statement regarding their sociodemographic characteristics.

This study was carried out in accordance with the American Psychological Association Code of Ethics, as well as recommendations, regulations and consent templates of the Chemnitz University of Technology Ethics Commission. All subjects gave written informed consent.

3.2 Field experiment setting

Within this paper, the results from three citizen participation, taken at three different stages (i.e. points of data collection) were reported. The investigation was conducted as a longitudinal study, starting with the first point of data collection in April 2021 from the first citizen participation (T0), following by a participation in September 2021 (T1) and ending with a final evaluation in July 2022 (T2). Study participants could enroll to the study at any stage.

In the first citizen participation reported the three potential areas along the model route were assessed before their redesign and several design wishes were collected. Figure 1 shows the three potential areas at T0.



Figure 1. Maps and pictures of potential area 1 (left), 2 (middle) and 3 (right) at T0.

This point of data collection constitutes our baseline (T0). This participation took place on-site at one of the potential areas, by direct mail, and online via the participation platform <https://numic.city>. The direct mail was sent to 1000

randomly selected households along the model route. The rate of return was 7.2% ($n = 72$). The citizens received an evaluation form for each of the three potential areas. The evaluation form contained a map of the potential areas, a scale to assess citizens' perceived urban environmental quality and questions for future usage intention and design wishes for each potential area (see Figure 2 for an example).

NUMIC HANS-ZIEGLER-STRASSE

Hans-Ziegler-Strasse curves around the fallow land that will develop into Bürgerpark Gablenz in the long term. The focus here is on the potential for mobility along the street.

Please evaluate this potential area from your current perspective and at the present time. Please indicate to what extent the following statements apply to the potential area.

1 = strongly disagree 2 = disagree
3 = neither nor 4 = agree 5 = strongly agree

This environment is a beautiful place. is a pleasant place for the elderly. is a good place for children.
 is a green place. is a safe place. is a friendly place has a good environmental quality.

In the NUMIC project, a transformation of this area is planned. What would you like to use this area for? Please tick

to rest and relax to do sports the children can play and romp here.
 to meet with family/friends/acquaintances and chat/barbecue/picnic.
 others

What wishes do you have for the design of the potential area?

Where would you locate these measures? Please draw your wishes on the map above. If you have multiple ideas, please make sure they are clearly marked or labeled.

CHEMNITZ STADT DER MODERNE TECHNISCHE UNIVERSITÄT CHEMNITZ

Figure 2. Evaluation form for potential area 2 sent via direct mail at T0.

The same evaluation form was implemented as an online questionnaire, which was accessible via the online participation platform ($n = 32$). For the on-site participation, a design workshop and structured face-to-face interviews were conducted with interested citizens at one of the potential areas ($n = 33$). Again, the same scales and interview questions were used. In contrast to the direct mail and online questionnaire, the citizens in the design workshop were able to implement their wishes and ideas for future use in a plastic way with handicraft materials after the conducted interview (see Figure 3).

The second citizen participation was conducted in September 2021 as a purely on-site format at the potential area from T0, after several redesigns were implemented (T1). Again, a design workshop and structured face-to-face interviews were conducted ($n = 33$). The procedure and setup was identical to T0 to assess further design wishes and ideas, as well as to evaluate the implemented measurements. The final evaluation of all implemented redesigns took place as an online questionnaire in July 2022 (T2) and revealed a sub-sample of $n = 120$.

3.3 Scales and measurements

Perceived urban environmental quality. To estimate participants' evaluation of the three potential areas, perceived urban environmental quality of these environments was assessed at T0 on a seven-item scale according to Keul, Brunner and Spitzer [2014]. Items were rated on a five-point Likert scale from 1 = "strongly disagree" to 5 = "strongly agree". Item examples were "This environment is a nice place." and "This environment is a safe place" (see Figure 2). Cronbach's alpha varied between .75 and .87 and can be classified as acceptable to good.

Willingness to participate. Participants' willingness to engage in citizen participation was assessed at T0 and T1 on three single items: I would participate in "analogue participation opportunities on-site or in my neighborhood", "digital participation opportunities on <https://numic.city>" and "postal participation opportunities via direct mail", which were answered on a seven-point rating scale from 1 = "strongly disagree" to 7 = "strongly agree".

Participation satisfaction. To assess participants' satisfaction with the different participation formats, three single items answered at T0 and T1 on a seven-point rating scale from 1 = "strongly dissatisfied" to 7 = "strongly satisfied" were used. The items were: "I am [...] with "analogue participation opportunities on-site or in my neighborhood", "digital participation opportunities on <https://numic.city>" and "postal participation opportunities via direct mail".

Participation acceptance. The acceptance of the conducted citizen participation was assessed at T1 with the two subscales "perceived ease of use" (PEOU) and "perceived usefulness" (PU) from the Technology Acceptance Model [TAM Davis, 1989]. Each subscale contains two items and was assessed on a seven-point rating scale from 1 = "strongly disagree" to 7 = "strongly agree". Examples were "NUMIC citizen participation is easy to use" (PEOU) and "NUMIC citizen participation has helped me to contribute actively to neighborhood development in Chemnitz" (PU). Cronbach's alpha can be classified as acceptable to good ($\alpha_{PEOU} = .70$, $\alpha_{PU} = .81$).

Sustainable mobility awareness. Participants' mobility awareness was assessed at T2 on a five-item scale, answered on a seven-point Likert scale from 1 = "strongly disagree" to 7 = "strongly agree", for example, "Because of values that are important to me, I feel obliged to use the car as little as possible". Cronbach's alpha can be classified as good ($\alpha = .88$).

Acceptance with the urban transformation process. As one indicator of acceptance, the TAM-subscale perceived usefulness [Davis, 1989] with the urban transformation process was used at T2. Acceptance was assessed on a two-item scale answered on a seven-point Likert scale from 1 = "strongly disagree" to 7 = "strongly agree", for example, "The urban infrastructure re-designs have helped me to get from A to B in Chemnitz safely and more quickly". Cronbach's alpha can be classified as good ($\alpha = .81$).



Figure 3. Impressions from the design workshop (on-site participation) at T0.

Table 1 contains an overview of the participation formats used and assessed variables.

3.4 Data analysis

The structured face-to-face interview (on-site), printed evaluation form (direct mail) and questionnaire (online) at T0 and T1 were similarly structured. Except for perceived urban environmental quality (only at T0) and participation acceptance (only at T1), the identical scales and open-ended questions were used. For the open-ended question regarding the design wishes on-site, all answers were recorded and transcribed. The returned evaluation forms were digitized. Thus, all data were statistically analyzed.

To investigate differences between the three participation formats (RQ1) we conducted univariate Analysis Of Variance (ANOVA). Pre-conditions for normally distributed data and equality of variances were checked. A significance level of $p < .05$ and one-tailed post hoc-tests were used with the Games-Howell-correction for multiple comparisons.

For predictions related to participation satisfaction (RQ2) and sustainable mobility awareness, as well as perceived usefulness of the urban transformation process (RQ3), we used linear regression analysis. Predictors of participation satisfaction

are determined by participants' participation acceptance, how familiar participants were with the three participation formats and participants' willingness to participate.

Table 1. Conducted participation formats and assessed variables.

Point of data collection	T0 Baseline	T1 Follow-up	T2 Final evaluation
Format	On-site, direct mail, online	On-site	Online
Corresponding kinds of participation	Assessment of potential areas, future usage intentions, design wishes	Assessment of potential areas, future usage intentions, design wishes	Evaluation of participation potential
Scales and measurements	Perceived urban environmental quality, Willingness to participate, Participation satisfaction	Willingness to participate, Participation satisfaction, Participation acceptance	Sustainable mobility awareness, Acceptance with the urban transformation process

Note. T0 = April 2021, T1 = September 2021, T2 = July 2022. Online = online questionnaire via participation platform, direct mail = printed evaluation form, on-site = structured face-to-face interview and design workshop.

Results

4.1 The influence of participation methodology (RQ1)

To address RQ1 (How does the choice of participation methodology (on-site, direct mail and online) influence participants' evaluation, their willingness to participate and their participation satisfaction?) we first compared participants' evaluation (i.e. perceived urban environmental quality) between the three participation formats used at the first point of data collection (T0). As can be seen in Figure 4 there were no significant differences in participants' assessment between the three participation formats ($F_{potential\ area\ 1}(2, 62) = .26, p = .770, \eta^2 = .01$; $F_{potential\ area\ 2}(2, 62) = 1.91, p = .157, \eta^2 = .06$; $F_{potential\ area\ 3}(2, 57) = .05, p = .955, \eta^2 = .00$). There were also no significant differences in participants' future usage intentions, as well as design wishes for the three potential areas (see questions Figure 2) between the three participation formats.

Furthermore, the willingness to participate did not significantly differ between the formats ($F(1.6, 51.2) = 1.50, p = .234, \eta^2 = .05$). The descriptive statistics are presented in Figure 5 on the left side. However, there were significant differences in participants' satisfaction with the different participation formats ($F(1.9, 60.0) = 7.57, p = .001, \eta^2 = .19$), see Figure 5 on the right side. Participants reported the highest satisfaction with the participation opportunities on-site, followed by participation opportunities via direct mail ($p = .011$). Participants reported the lowest level of satisfaction with regard to the digital or online participation opportunities ($p = .003$).

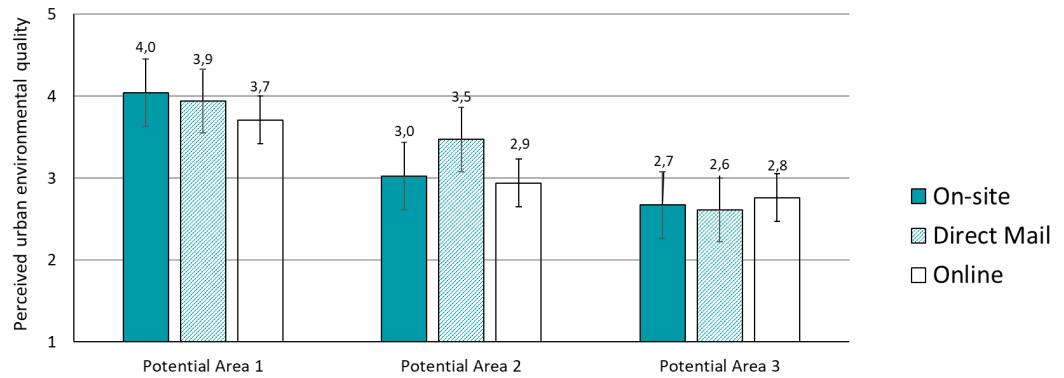


Figure 4. Participants' evaluation of the perceived urban environmental quality between the three participation formats (on-site, direct mail and online) at T0. *Note.* Items were rated on a five-point Likert scale from 1 = "strongly disagree" to 5 = "strongly agree".

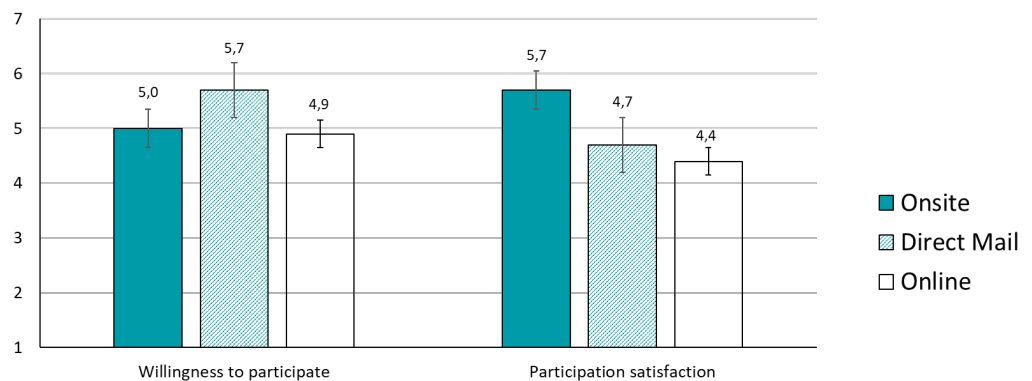


Figure 5. Participants' willingness to participate and participation satisfaction between the three participation formats (on-site, direct mail and online) at T0. *Note.* Willingness to participate was rated on a seven-point Likert scale from 1 = "strongly disagree" to 7 = "strongly agree", participation satisfaction was rated on a seven-point Likert scale from 1 = "strongly dissatisfied" to 7 = "strongly satisfied".

4.2 Predictors of participation satisfaction (RQ2)

To identify predictors of participation satisfaction and to answer RQ2, we conducted linear regression analysis. Table 2 contains the predictors of participation satisfaction. The strongest predictor was identified as being the perceived ease of use, followed by perceived usefulness and participants' knowledge regarding the citizen participation. The participation methodology used was not able to significantly predict participation satisfaction.

4.3 Evaluation of citizen participation (RQ3)

To estimate the impact of citizen participation and to answer RQ3 (In what way does citizens' participation improve their awareness of the issue of sustainable mobility and increase its acceptance into the urban transformation process?), we asked participants for their retrospective evaluation at T2.

Table 2. Predictors of participation satisfaction.

Predictor	<i>b</i>	<i>SE</i>	<i>T</i>	<i>p</i>	<i>adjusted R²</i>
PEOU	.60	.19	4.1	<.001	.33
PU	.48	1.9	3.0	.005	.21
Knowledge	.38	.21	2.3	.030	.17
Methodology					
on-site	.08	.12	.44	.667	.03
direct mail	.28	.10	1.63	.114	.05
online	-.12	.08	-.68	.504	.02

Note. *N* = 33. PEOU = perceived ease of use, PU = perceived usefulness, knowledge was assessed as how familiar participants were with the three participation formats from 1 = “not at all” to 4 = “very familiar”, as methodology participants’ willingness to participate was used. All variables were assessed at T1.

The majority of the participants reported at T2 that they had had an active involvement (i.e. information about the participation possibilities and/or filling out online questionnaire) in the different participation activities. Table 3 shows the descriptive statistics.

Table 3. Participants’ retrospective reported participation activities at T2.

Participation activities	Frequency	<i>M (SD)</i>	<i>Min</i>	<i>Max</i>
Inform about the participation opportunities	89.7%	2.59 (.98)	1	5
Participate in online questionnaires	55.2%	1.97 (1.12)	1	5
Participate in voting (i.e. model route)	48.3%	1.79 (1.05)	1	5
Comment in online platform posts	27.6%	1.41 (.78)	1	4
Take part in an on-site design workshop	20.7%	1.45 (.99)	1	4
Submit own ideas and wishes	20.7%	1.45 (.95)	1	4

Note. *N* = 120. Activities were assessed from 1 = “never” to 5 = “constantly”. The frequency express aggregated participation from 2 = “once” to 5 “constantly”.

91% of the participants evaluated the participation as useful and good. 88% of the participants reported that the participation enabled them to contribute their wishes and ideas for the urban transformation process, and 48% of the participants reported that citizen participation increased their awareness of sustainable mobility.

In addition, regression analyses underlie the importance of the citizen participation. The average frequency of citizen participation in NUMIC (from 1 = “never” to 5 = “constantly”) significantly predicted participants’ reported sustainable mobility awareness ($F(1, 106) = 7.41, p = .008; R^2 = .07; adjusted R^2 = .06$) and their perceived usefulness of the urban transformation process ($F(1, 106) = 6.03, p = .016; R^2 = .05; adjusted R^2 = .05$). Thus, citizens with a higher level of participation have developed a more sustainable mobility awareness and a higher level of acceptance of the urban transformation process.

5.1 *Summary of results*

Within this paper, a practical insight into the implementation and evaluation of a 12-month-long living lab using a combination of different participation formats was given. The results revealed that the participation methodology used did not influence the participants' evaluation and willingness to participate. However, there were significant differences in the participant's satisfaction with the participation formats that were used.

For increasing participation satisfaction, we were able to identify the perceived ease of use, the perceived usefulness and participants' knowledge regarding the citizen participation as important predictors. The participation methodology employed was not able to significantly predict participation satisfaction.

In general, participants evaluated the citizen participation with which they engaged as being useful for submitting their ideas and promoting their active contribution to urban transformation. Participants stated that the citizen participation had increased their awareness of sustainable mobility.

5.2 *Implications*

The present contribution shows in an evident manner how the scientific implementation and evaluation of a living lab can succeed. Several results from a naturalistic field trial with strong external validity were presented. However, the practical framework conditions and the long-term preparatory work and cooperation between different authorities, departments, units, but also various other stakeholders should be taken into account, as these required a certain investment of time and financial and personal resources.

Due to the combination of different participation formats, we were able to overcome the challenges of the Coronavirus pandemic (i.e., lockdowns, and bans on contact). In this context, particular importance should be attached to the online participation formats. The limitations that result from the Covid distance and hygiene regulations can be eliminated, as well as the need to obtain permission from the public order office for an on-site participation. Furthermore, online participation is less dependent on weather conditions, which may lower the hurdles. On the other hand, personal contact is missing online and data protection requirements still have to be observed just as much.

Thus, we experienced the different formats as a meaningful complement to each other. Based on our results, we can recommend using a mix of methods addressing different groups of citizens with different preferences. In addition, independent of the methodology used, the access to take part in any kind of participation form should be made as easy as possible for the citizens. Furthermore, advertising via various marketing channels as well as transparent communication are the most important factors to raise awareness and knowledge.

5.3 *Limitations and future research*

Some methodological limitations have to be considered when interpreting our results to make broader claims. First, the samples were not representative of the

general population. Interested citizens were more likely to be young, educated, and practice sustainable and multi-modal mobility. On the other hand, this also had the advantage that these citizens could almost be considered to be already experts on walking and cycling mobility in Chemnitz. They knew the problem spots, had great ideas and suggestions for solutions, and shared them with us with great commitment.

Second, the continuous enrolment of the study participants adds noise to the data. The weather, the passing of time, different participation contexts (i.e., model route or potential area) and random events that might have occurred over the course of the living lab are very difficult to control for statistically, and cannot be discounted as possible sources of the effects that we found.

Third, due to data protection regulations, we were not able to collect the demographic variables for all participants.

Fourthly, when using online participation formats, such as online questionnaires or voting, possible confounding variables should be considered. For instance, interviewers are here not being able to control the survey situation or to ask additional questions when they realized participants did not understand the content, as well as participants could be distracted from second tasks.

Finally, no statement can be made about the relationship between the assessed variables of participants' evaluation, willingness to participate, satisfaction with the conducted participation formats and participants' actual behavior. The links between satisfaction and behavior could be investigated in future research as well as the potential influence of participants' demographic and individual characteristics (e.g. age, previous participatory experience, sense of community, etc.).

To conclude, several publications emphasized the difficulty of reaching and motivating not only already affine groups in Living Lab projects. This is not only a relevant field in relation to Living Labs but science communication in general, which needs to be tested in theory as well as in practice. In the sense of good research and practice in citizen participation processes, more focus should be placed on the target group and possibilities of inclusion in the future, especially in the first part of the project - not only in the sense of research but also in the sense of a participation process in which those potentially affected can also participate.

5.4 Conclusion

Within this study, results of the implementation and evaluation of a living lab to involve citizens in an urban transformation process were presented. The participation formats conducted addressed interested citizens who were able to contribute their needs, requirements and suggestions in order to improve the urban space quality in the living lab. From the beginning, citizens were actively involved by participating in a meaningful manner. Based on the citizen-orientated approach, the results revealed that citizen participation was a powerful mechanism for positively influencing citizens' acceptance, satisfaction and behavioral intentions.

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