Introducing electric vehicle-based mobility solutions – impact of user expectations to long and short term usage

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Abstract

When introducing innovative technologies, it is crucial that they comply with users’ needs or help fulfilling certain tasks. Hence, knowing users’ needs and expectations allows developing an innovative technology that motivates high usage and acceptance. The paper presents results of a field study investigating the introduction of a mobility service based on electric vehicles with 120 participants. While introducing the service, user needs and expectations were examined using a semi-structured guided telephone interview and two questionnaires. After launching the service, the actual usage of the system by the users is tracked by collecting system data and conducting ongoing questionnaires. Results of the empirical study show that users’ expectations split primarily into two groups. One group perceives the introduced mobility service as a flexible and quick solution to optimize their mobility needs. The second, technology driven group is highly interested in the electric vehicles. System data shows how both groups perform over time to answer questions if usage meets the expectations of both groups and how they influence their overall short and long term acceptance. Results can be integrated in other services/systems to better address users’ needs.

Introduction

Usually people use their private cars with regular combustion engines for short distances. In Germany, the average usage of private cars is about one hour with just one passenger. Furthermore, the average distance driven within urban areas is less than 45 kilometres (Mobilität in Deutschland, 2008). Given these figures and the upcoming scarcity of fossil fuel, the German government demands innovative mobility concepts and changing mobility behaviour. It announced the aim to increase the number of electric vehicles on a large scale by 2020 (Die Bundesregierung, 2009). Electric vehicles use electric power instead of fossil fuels and are able to manage most of the daily transportation tasks within urban areas.

One approach to realize increased usage of electric vehicles is the implementation of mobility-on-demand systems that are characterized by the sequential use of (electric)
cars within a service area by different people. Companies, public institutions and authorities which are divided into more than one location are examples for such systems. The implementation could also be enriched by offering (electric) bicycles or special public transport services to provide the users a multimodal mobility solution. The main challenge of multimodal mobility-on-demand systems, i.e. systems which combine public transportation with rental cars and even bicycles, is user acceptance and adoption. When introducing such innovative technologies, it is crucial that they comply with certain user needs or help fulfilling certain tasks. Beliefs that the innovation can meet those requirements can be described as positive user expectations. Knowing those user needs and expectations allows developing a system that motivates high usage and acceptance.

The paper draws on a real-life multidisciplinary research project with both public and privately owned mobility companies as partners. In our research, we used an explorative mixed-method approach, based on qualitative data analysis triangulated with gathered system data to answer the question if user expectations have an impact to long and short term usage and if so, what implications for a mobility-on-demand systems can then be extracted. Furthermore, we want to answer the question, if expectations are a suitable measure for short- and long-term usage predictions. The research group investigates users’ needs and expectations using a semi-structured guided telephone interview and two questionnaires. In the remainder of this paper, the next chapter presents the research field with a short summary of prior studies and afterwards the results of our recent studies.

The research field and prior studies

The described mobility solution was implemented at a medium sized German university in 2012. The university has four sites and approximately 4000 employees. The average distance between the university sites is about 3.5 km with a maximum distance of 5.1 km. The four university sites are well-connected to the public transportation network (Figure 1). Three university sites can be reached without transferring between public transport modes. All transportation lines run every ten minutes, except Bus B, which runs every twenty minutes.

![Figure 1. Location and accessibility of the sites to public transport](image)

The need for action, i.e. to develop a multimodal mobility-on-demand system resulted out of a pre-survey, which was conducted prior to the research project. Altogether 62 employees participated (21 female and 41 male participants, in age
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from 23 to 59 years). It became apparent that 44% of the employees commute between the locations more than once a day. Furthermore 64% commute at least once a week. The most commonly used vehicle for this action was a privately owned car (82%). But there are other transportation options as well. An interesting point is that 86.9% of all participants are willing to accept a longer trip time to use a carbon dioxide reduced transportation option. In detail 55.7% said that they would invest five or more minutes in transportation if there is a sustainable transportation option. On the basis of these results, relevance and potential of a multimodal mobility concept for short and mid-range distances for the employees of this university was designed and established.

In a representative survey at the start of the project, more detailed information about the current mobility behaviour was gathered in order to define the goals and the technical design of the system. The survey was split into two survey time points - summer and winter. Both surveys were conducted in term time to gather information of the mobility behaviour due to educational obligations. Aspects like the subjective assessment of mobility relevant aspects of their main location (accessibility, availability of parking slots) and overall travelling behaviour between the locations were asked. The employees were also asked their personal reasons for choosing a specific transportation option. Factors mentioned were weather, environmental friendliness, low financial effort, availability of transportation options, accessibility of parking slots and speed.

399 employees took part in the summer survey. The average age was 34 years (SD = 10.6), 61.7% males. In the winter survey 187 (52.8% males) employees with an average age of 34 years (SD = 11.0) participated. Out of a retrospective view, the participants described their daily mobility behaviour of one week. In summer, 525 trips (1.32 per employee), in winter 294 (1.65 per employee) different trips between the university sites were found. About half of the persons questioned (summer: 209 persons [52.4%]; winter: 90 persons [50.6%]) travelled once a week between the sites. The distribution of the chosen transport options, the modal share, concentrates on motorized individual transport (Table 1).

Table 1. Modal share

<table>
<thead>
<tr>
<th>Means of transport</th>
<th>Trips taken</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>summer</td>
<td>winter</td>
</tr>
<tr>
<td>by foot</td>
<td>17</td>
<td>7</td>
</tr>
<tr>
<td>Bicycle</td>
<td>55</td>
<td>13</td>
</tr>
<tr>
<td>Private cars</td>
<td>319</td>
<td>171</td>
</tr>
<tr>
<td>Company cars</td>
<td>11</td>
<td>2</td>
</tr>
<tr>
<td>Public transport</td>
<td>112</td>
<td>94</td>
</tr>
<tr>
<td>Others</td>
<td>11</td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td>525</td>
<td>295</td>
</tr>
</tbody>
</table>
The results provide a sound basis for the design of the planned mobility concept and demonstrate again the need for an alternative mobility concept. It became apparent that there is a need to change the employee’s mobility behaviour from using private cars to “green” means of transportation. Through the provision of vehicles and by offering easier access to public transport through job tickets, a monetary incentive to use the mobility-on-demand system is created, since the vehicles and public transports provided are free of charge.

This monetary effort as a factor in the choice of means of transport has been queried in the survey in combination with other factors such as weather, environmental friendliness, availability of transport facilities, access to parking spaces and speed. The participants were asked to divide 100 points among the factors. Figure 2 shows, that the employees consider functional factors like availability and speed to be more important than normative aspects like sustainability.

![Figure 2: Characteristics in choosing transport options](image)

Through the free provision of vehicles in the system the low-cost hypothesis, which says is that “environmental attitude affect the environmental behaviour most likely in situations that are low-cost [...] linked” (Diekmann, 1998), is fulfilled to give the user a shift from private cars to provided transport options. Matthies et al., however, criticizes, that the low-cost hypothesis does not consider the influence out of the habit (Matthies, 2006). As emerged from the survey, the use of the private cars for have a high rate (summer: 60.8%, winter: 58%) in transportation between the sites. Therefore there is a high likelihood that the user accesses only the provided electric cars. This not intended behaviour could lead to a neglect of the provided electric bikes or the public transport as alternative transport services. With this in mind, an explorative study was designed to further refine the understanding of users’ intentions and expectations towards the mobility system and its opportunities. One common definition of expectations can be found in Dorsch (2014):
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Expectations are cognitions [...] which express the anticipation or the forecast of future events and imply a [subjective] probability estimation of the entering of their occurrence

By this meaning, user expectations can be the cause of an actual use and also be indicative towards a frequency of use. Given this indication, the results can be integrated in the mobility system to better address users’ needs and to apply solutions to systematically address unwanted user behaviour. Also keep in mind, that users’ expectation depend on the knowledge about the specific topic the expectation is about.

Data collection

From April to end of June 2014 98 people applied for participation in the field study. Due to some legal regulations only employees of the Chemnitz University of Technology were allowed to participate. Additionally it was required to agree in different ways of data acquisition during the field test. Therefore 71 applicants were selected. Their mean age was 32 years (SD=7.66) and 49 (69%) of them were male.

The selected employees were invited for participation via a telephone call. During this call a semi-structured guided telephone interview was conducted. This interview contained a questionnaire on how the participants found out about the field study (Q1: “I would like to know: how you got interested in the project?”) and some questions regarding their expectations in participation. Those questions were Q2: “What do you wish or expect from participating in the project study?” Q3: “What was the main reason for participating?” and Q4: “What changes do you expect regarding your future mobility at work?” To complete the telephone interview, an appointment for an instruction regarding the handling of the mobility system and the legal conditions of its usage was made. During the interview, the audio was recorded. After the instruction participants were able to reserve and use the project vehicles. Every reservation and trip with these vehicles was recorded with reservation time, chosen vehicle, starting as well as ending point and time.

Analysis

The data analysis follows a qualitative approach after Meyring (2010) and Kuckartz (2012). The telephone interviews were completely transcribed and analysed. This study is investigating the first three questions. The answers to the questions (Q1: “knowledge”, Q2: “wishes and expectation” and Q3: “main reason”) were isolated and examined. To get a first impression of the text, common words were eliminated and words in direct context to the project were summarized and counted. The result, as shown in Figure 3, is most likely mobility related and targeting towards “simply testing the system/car/EV/ etc.”
A deeper analysis with the method of the content text analysis, introduced by Meyring and developed further by Kuckartz, of the text was conducted by three raters. First step was to develop a category system to get a more plausible and easy to understandable view on the texts. The first 20 interviews were loosely categorized to get an overview over the upcoming categories. After this orienting phase, raters performed “sense-keeping” reductions to the text to understand content and meaning in a more objective way and then developed a holistic category. In two discussions, experts summarized and simplified the category system to a final stage as can be seen in table 2.

Table 2: Category system after text analysis

<table>
<thead>
<tr>
<th>main category</th>
<th>I.</th>
<th>II.</th>
<th>III.</th>
</tr>
</thead>
<tbody>
<tr>
<td>electromobility</td>
<td>a) EVs</td>
<td>a) electric car</td>
<td>a) worthwhile</td>
</tr>
<tr>
<td></td>
<td>b) technology</td>
<td>b) electric bike</td>
<td>b) driving experience</td>
</tr>
<tr>
<td></td>
<td>c) affinity to technology</td>
<td>c) form an opinion</td>
<td></td>
</tr>
<tr>
<td></td>
<td>d) state-of-the-art</td>
<td>d) suitability for daily use</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>e) user friendly</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>f) driving/testing</td>
<td></td>
</tr>
<tr>
<td>general mobility (business trips)</td>
<td>c) replace own car</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>d) leave car at home</td>
<td>b) driving experience</td>
<td></td>
</tr>
<tr>
<td></td>
<td>e) parking slots</td>
<td>c) form an opinion</td>
<td></td>
</tr>
<tr>
<td></td>
<td>f) cost-effective/cheap</td>
<td>d) suitability for daily use</td>
<td></td>
</tr>
<tr>
<td></td>
<td>g) fast</td>
<td>e) user friendly</td>
<td></td>
</tr>
<tr>
<td></td>
<td>h) comfortable</td>
<td>f) driving/testing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>i) spontaneous</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>j) environmental friendly</td>
<td></td>
<td></td>
</tr>
<tr>
<td>project interest</td>
<td>k) support project</td>
<td>e) provide data</td>
<td></td>
</tr>
<tr>
<td></td>
<td>l) research interest</td>
<td>f) be participant</td>
<td></td>
</tr>
<tr>
<td></td>
<td>m) interest in system</td>
<td>g) interested in results</td>
<td></td>
</tr>
<tr>
<td>public interest</td>
<td>n) general interest</td>
<td>h) promote general mobility</td>
<td></td>
</tr>
<tr>
<td></td>
<td>o) university</td>
<td>i) implantation at the university</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>f) ecological</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>g) economic</td>
<td></td>
</tr>
</tbody>
</table>
Four main categories with several subcategories were identified:

**Electromobility**

The category electromobility includes statements that include elemental propositions towards the electric vehicles (Subcategory Ia) and the technical interest (Subcategory Ib) into them. The Subcategory II differentiates into two means of electric vehicles, electric car and bike, the subjects’ technology affinity and their interest in the state of the art. Subcategory III is addressing actions or intentions towards the upper categories. Typical statements are:

- *And for myself also to get a certain feeling, like how this electromobility is working.* → Electromobility, Ib, Iic, IIIf
- *[...] maybe a little more to deal with electric cars in general?* → Electromobility, Ia, Iia, IIIf
- *...so to have the opportunity at all times [...] to drive a pedelec* → Electromobility, Ia, Iib, IIIb

**General mobility**

Main category II is summarizing statements towards general mobility issues. Subjects’ expect the system to be more flexible and faster than their usual mobility solutions. They expect a cost effective and environmental friendly solution. Representative statements are:

- *...when I have a business trip, I will have an easy, unrestricted and uncomplicated solution...* → general mobility, Ig, Ih
- *...business trips [...] no longer have to do with the private car...* → general mobility, Ic
- *The most important ... is, in effect, actually the parking situation* → general mobility, Ie

**Project Interest**

As the study is enrolled at a university, quite a large part of the statements are project related. Colleagues are interested in supporting the project as participant as well as they are interested in the results of the study. Typical statements are:

- *On the one hand to contribute to research at our university.* → project interest, Ik, IIe
- *Hmm... Actually, I'm curious how the study is structured and what I maybe can learn in my own work for user studies...* → project interest, II, IIf
- *Yes of course they need to [scientifically] succeed here.* → project interest, Ik
The last main category is in general addressing normative statements. They are related to public interests to promote a change in general mobility behaviour or the subjects’ concerns about the implementation of the system at the university. Statements that fit that category are listed below:

Public Interest

- I am concerned with [...] the electric mobility as a whole.
  → public interest, I

- A good appearance of the university, so economically speaking, ecologically as well.
  → public interest, II, III

For inter-rater reliability Krippendorff’s alpha was calculated (Hayes & Krippendorff, 2007; Freelon, 2010). It varied between .85 and .56 (see table 3). It revealed that the first two categories “electromobility” and “general mobility” were clearly defined with a high conformity between raters. The both remaining categories “project interest” and “public interest” resulted in a middle alpha value, showing that while coding they can be interpreted broader than the first categories. Nevertheless they seem reliable enough for persisting as distinct categories.

<table>
<thead>
<tr>
<th>main category</th>
<th>electromobility</th>
<th>general mobility (business trips)</th>
<th>project interest</th>
<th>public interest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q2: wishes and expectations</td>
<td>0.85</td>
<td>0.72</td>
<td>0.66</td>
<td>0.62</td>
</tr>
<tr>
<td>Q3: main reason</td>
<td>0.72</td>
<td>0.69</td>
<td>0.61</td>
<td>0.56</td>
</tr>
</tbody>
</table>

Therefore the category system and the statements could be discussed and finally determined. Afterwards, the participants of the study were sorted into groups, which were related to mobility behaviour in system usage afterwards.

The group classification was based on the main categories built before. In Question 3 “main reason” subjects’ were able to focus one topic. Reflecting the mentioned main topic and the statements’ categorization from the answers of Question 2 “wishes and expectations”, the subjects’ were divided into the following groups:

Technology driven group

The technology driven group can be described as having a general interest in electric vehicles and are also interested in the technical background of the new
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Technology including charging stations and typical issues like range anxiety. A high curiosity and affinity for technology as well as an interest in the state-of-the-art are characterizing for the group. 38% of the participants could be assigned to the group.

Mobility driven group

The mobility driven group is keen on optimizing their own in-house mobility. Some of them want to replace their own car for business trips and/or want to leave their private car as a direct reaction to the implementation of the system at home. They have a high interest in a flexible and quick mobility solution which is also cost-effective and spontaneous. Out of all participants, 27% could be assigned to the group.

Others

The Group “others” include participants who have mainly interests in the project as a scientific project. They want to provide data and/or just want to be subjects for the study. A specific main reason cannot be identified. Also environmental statements as part of a general public interest are assigned to that group. The rest of the group are participants which cannot be easily assigned to the first two groups and also do not fit into the project or public interest group.

Results

The main groups “technology driven” and “mobility driven” were now compared with gathered system data to get a distinctive view if the two groups correlate with the overall usage of the system. The data evaluated for the paper includes the booking inquiries and date of the taken business trip. The 68 participants completed overall 881 trips starting at April, 14th until October, 9th in 2014. Exceptions during data evaluation have to be made: As users did not volunteer at the same time, most of the users have individual starting points and therefore a cumulative view is not appropriate. Instead, each dataset for every user needs to be aligned relative to each other. The mean number of taken trips per month is shown in figure 4. Statistical tests showed no effect between expectation groups and long-term usage. The high variances within the expectations groups indicate that expectations are not suitable for long term usage predictions. Data analysis shows that each user group contains power users and users with less than one trip per month.

For short-term, a different result can be shown. Analysing the data on weekly basis, the expectation groups differ in their usage at early stages. The numbers shown in figure 5 indicate high usage behaviour of the “technology driven” and the “mobility driven” group. For the first weeks those groups undertake more trips per week than the group “others”. After that, the two groups alter their behaviour to a more “normal” use close to 0.5 trips per week, which is the average overall system usage by all users per week.
Conclusions

This explorative approach indicates that initial expectations are not a suitable measure for long-term usage predictions. A closer look at short-term usage seems to indicate that initial expectation of users may be linked to short term behaviour while after an initial use all groups seem to adjust their behaviour and tend to adjust also
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However, the link between users’ expectations and short term behaviour shows a potential of the approach to form initial user groups. Those user groups and their expectations can be used in implementation phases of a technical system. With a deeper understanding of the relation between expectations towards technical systems, i.e. a generalized expectation model, a broader audience besides the typical early adopters can be addressed. The system can then be adjusted in a way that system will fit more users’ needs than has been reached by just implementing the user-centred design process. Nevertheless, there is research potential headed for a better general understanding of expectations towards technical systems. When generalizing expectations, user groups can then be clustered into user groups for predicting their behaviour. The next steps in further research is intending to answer the question, if (initial) expectations towards a technical system are suitable for clustering user groups for predicting later users’ usage behaviour.

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ESF: European Social Fund, Online: http://www.smwa.sachsen.de/de/Foerderung/Strukturfonds_in_Sachsen/Europaeischer_Sozialfonds_ESF/120624.html


