The Youth of Today Designing the Smart City of Tomorrow

Challenges to Future Mobility, Energy, and City Climate

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Abstract. Sustainable energy supply, mobility concepts, a healthy city climate – the next generations will face vital urban challenges. The views of the citizens of tomorrow, today's youth, are therefore especially important when designing concepts for future urban areas that incorporate those demands. We therefore explored young pupils' attitude to these three research areas in an empirical approach. 21 students (17-24 years) participated in a workshop. First, they answered a questionnaire on their attitudes towards technology and urban environment. Afterwards, they were divided into focus groups in which they discussed and developed solutions to the three key challenges for future cities. Besides innovative ideas of how younger persons wish to live in urban environments, results reveal a rather uninformed and naïve view on the complex situation. Overall, we conclude that urban challenges should be integrated into the school education to provide a deeper understanding of the complex interaction of energy, mobility and user requirements.

Keywords: User diversity, urban development, attitude towards technology, mobility, energy, city climate.

1 Introduction

The world population is increasing exponentially, causing mankind to face enormous challenges. While diverse fields of research around the globe study today's metropolises and their development, aiming for sustainable solutions, our research focuses on small towns and urban quarters in western societies. Energy supply, mobility, ecology issues in regard to global warming, and air pollution are crucial factors for urban development worldwide. Particularly for western societies, the energy transition, electro-mobility, rural depopulation, and the demographic change play important roles in designing the city of tomorrow. The technological possibilities are tremendous, facilitating smart, integrated solutions from a technical point of view. The technological complexity can be illustrated by the following example: The electric car with its battery plugged into a smart grid can be used to store excess power from regenerative energy sources and keep the driver informed about the current battery level via a connection to a smartphone. From the user's point of view, we face challenges to gain

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usability, usefulness, data security, trust, and acceptance of these complex technology developments. Not everything that is technically possible is also wanted, some wishes cannot be fulfilled, and often the distinct trade-off between personal costs and benefits leads to failure or success of technology development. Therefore, it is important to integrate the future user into the early development process.

Human-computer interaction (HCI) will play a crucial role in urban development [1]. The youth of today is linked up, all the time and everywhere. Intelligent and integrated mobile devices connect living space, urban quarter, and mobility concepts (e.g., car sharing, e-mobility). They will replace present status symbols like the own car or the first house which were dreams of an earlier generation. For the youth of today, HCI devices in combination with urban development can give solutions for not only a smarter but also a green and sustainable city of tomorrow.

In our interdisciplinary research project UFO (Urban Future Outline), we face the integrated challenges of mobility, energy infrastructure, and city climate with experts of each research field in a holistic approach from a user's perspective. The complex coupling of our research fields leads to creative solutions by integrating smart technology into city planning.

1.1 Questions Addressed

While there is some recent research on youths' attitudes towards different single aspects of future cities, e.g., energy [2, 3] and mobility [4], the holistic view on future smart cities, particularly including city climate, deserves further investigation.

Most research in the field of urban development, if user-centered at all, focuses on expert reviews and adults. The smart solutions in this work are designed by average, technology prone youths with different requirements for urban living regarding mobility, sustainable energy supply, and demands for greener cities. As a qualitative approach, 3 focus groups (n_{tot}=21, age 17-24) tried to develop intelligent solutions for mobility, energy, and ecological issues. This approach was supported by a survey to gain quantitative information about the needs and wishes for the future smart city. Furthermore, we wanted to analyze if the attitude towards technology in general plays a role for the attitude towards future energy, future mobility, and future city climate.

2 Methodology

The empirical approach followed a two-step procedure. First, participants were split into 3 focus groups. The students then all completed a questionnaire (see chapter 2.2) about their attitudes [5] towards technology, mobility, energy, and city climate before starting the discussions in the focus groups (see chapter 2.3). This way, they answered the questionnaire without being previously influenced by the other participants' opinion. Finally, the pupils presented their ideas to the other groups.

2.1 Participants

Students from a vocational school (n=18, age range 17 to 24) and a grammar school (n=3, age range 17 to 18) participated in this study. 15 students were male, 6 female. The educational level, secondary modern school degree, matched the German average [6]. The participants visited the research institution for the "Green Day 2013," a national information day on education and "green" jobs[1]. All students joined the same welcome session in order to introduce them into the research field of urban development.

2.2 Quantitative Questionnaire Study

First, all participants completed the same questionnaire. With the exception of three pupils, the participants came from the same class of the same school. Therefore, the question for their educational level was redundant. For demographic data, the students were asked for their age and gender although these data were not considered independent variables due to our homogeneous and rather small sample size.

In a second part, the participants were asked for their attitude towards technology (ATT) in general. The following 5-item set of questions targeting five attitudinal dimensions was answered on a 4-point Likert scale (total negation=1 to full affirmation=4):

1. Interest: "I am interested in technology."
2. Ease of use: "Dealing with technology is easy for me."
3. Trust: "I do not trust technology in general." (negative scale)
4. Fun: "Using technology is fun."
5. Avoidance: "I avoid technology if possible." (negative scale)

The third section of the questionnaire aimed at the environmental awareness and behavior considering attitudes in the three research fields *mobility*, *energy*, and *city climate*. The items measure the green profile, combining today's behavior and the willingness for the use of future technologies. All questions were answered using a 4-point Likert scale (total negation=1 to full affirmation=4) and tested for reliability (see chapter 3.1).

Mobility:

6. "I like to use local public transport."
7. "If the local public transport was better, I would use it more often."
8. "For short distances, I prefer walking and cycling over taking the car."
9. "I would spend more money on eco-friendly than conventional means of transportation."
10. "I can imagine using car-sharing and not buying a car."

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[1] Information about the German Green Day:
`http://www.greenday2013.de/green-day`

Energy:

11. "Renewable energies protect natural resources and help conserve nature in its original state."
12. "Renewable energies interfere with the natural ecosystem (wind turbines, hydro-power plants, etc.)." (negative scale)
13. "We are obliged to use renewable energies, because they are the only ones which don't cause long-term damage to the environment."
14. "When choosing an energy supplier (for electricity, gas, etc.), I prefer the cheapest offer over green energy." (negative scale)
15. "We have to switch to using renewables in the long run, so that our children and grandchildren will have sufficient energy supplies."

City climate:

16. "I would like public spaces planted with fruit trees, vegetables, etc. ("Urban Gardening")."
17. "I can imagine participating in cultivating these urban gardens."
18. "I would like the whole city traffic changed to electro-mobility."
19. "I would like to have more green spaces in the city, even if this would mean less parking spaces."
20. "I imagine a city without cars, even if this would mean longer distances for me."

2.3 Qualitative Focus Groups

The students were separated into 3 focus groups (see Fig. 1). Each group had two hours to discuss one of the topics mobility, energy, and city climate. The composition of the groups was as follows (Table 1):

Table 1. Composition of focus groups

Topic	n_{group}	n_{female}	n_{male}
Mobility	7	3	4
Energy	7	0	7
City climate	7	3	4

Two scientific assistants whose research focused on the respective topic moderated each focus group. After the questionnaire study and an introduction into the respective topic, all groups followed a similar line of action. First, the groups discussed the current state of each topic regarding problems and challenges for sustainability and feasibility. In a second step, the groups were asked to develop a smart and innovative future solution for their topic in the field of urban development. They were encouraged to disregard practicability and focus instead on original ideas. This turned out to be more complicated than expected (see chapter 4.). All discussions were recorded and notes were taken to facilitate the analysis of results. In a final step, the solutions

Fig. 1. Focus groups for mobility, energy, and city climate

were compiled and presented to the other groups who evaluated the ideas regarding creativity, connection to other research fields, and originality.

3 Results

3.1 Quantitative Part: Questionnaire Study

The participants were divided into two groups, according to their ATT score (see chapter 2.3). One participant did not answer the questions on ATT and therefore was not allocated. Because overall ATT was high, participants were divided into a "high ATT" (M> 3.5) and a "medium ATT" (M≤ 3.5) group using a median-split, which was also descriptively authenticated as the sample was bimodal. The ATT scale was tested for reliability using Cronbach's alpha (α=0.795, the scale is also used in other, not yet published research by the authors).

The item blocks for environmental awareness and behavior or green profile considering attitudes in the three fields mobility, energy, and city climate (see 2.3) were also tested for reliability using Cronbach's alpha. While the questions for mobility (5 items, n=21, α=0.605) and city climate (5 items, n=21, α=0.745) were acceptable, the energy attitude (4 items (2nd was left out, because reliability significantly improved, before α =0.385), n=21, α=0.505) could not be indicated reliable for our sample. In parallel research [Zaunbrecher et al., in preparation] the scale was reliable (n=79, α=0.77). It is possible the wording of the energy questions led to misunderstandings (see chapter 4.).

The ATT groups were analyzed for significant differences in attitudes towards future mobility, future energy, and future city climate by applying ANOVAs. Fisher's Exact Probability Test was applied for gender distribution. Results are shown in Table 2.

Table 2. Descriptions of the groups based on ATT score

	Medium ATT	**High ATT**	**Significance**
n	10	10	
Gender	male= 5 female= 5	male= 9 female= 1	n.s.
Age	M= 19.6 SD= 2.6	M=18.4 SD=1.6	n.s.
Mobility	M=2.9 SD= 0.5	M=2.5 SD=0.7	n.s.
Energy	M= 3.1 SD=0.4	M=3.5 SD=0.3	$p \leq 0.05$
City climate	M=2.7 SD=0.5	M=2.7 SD=0.7	n.s.

The only significant difference between the groups was their attitude towards future energy ($F(1,18)= 8.02$, $p\leq 0.05$).

As could be seen in the focus groups (see chapter 3.1), the research fields mobility, energy, and city climate affect each other regarding urban development. The overall environmental awareness and behavior, considering all three topics and combining all 14 items, was also tested for reliability (n=21, α=0.747). This will be validated and improved in further research.

3.2 Qualitative Part: Focus Groups

The qualitative evaluation of the recorded focus groups was carried out using MAXQDA (coding software) and categories were developed with a simplified method of Mayring [7] due to the fact that all focus groups had different topics and not all subjects were comparable. Due to space restrictions, we limit this paper to the innovative and smart solutions the pupils came up with in the focus groups.

Mobility. The discussion in the focus group 'mobility' can be subdivided into 7 main categories, some with additional sub-categories. While the demand to talk about the present situation was enormous, the pupils faced huge problems considering solutions or innovative alternatives for the future.

In the first category <u>car</u>, considering 'traffic' and 'infrastructure,' the ideas for the future did not go further than reducing car traffic by switching common alternatives like bicycles, walking, and banning cars from the city. The issues of 'parking' and 'traffic jams' were also discussed intensively. However, the pupils did not develop any noteworthy solutions for these challenges.

As most of the participants did not have their own car, the *local public transit* was the second topic emphasized. In order to optimize ‘capacity and frequency’ of public transport, it was suggested that operators should communicate better with their users, for example by employing mobile technologies. Although the idea was mentioned, the pupils could not invent intelligent solutions for this. Instead, they started discussing pro and con arguments about public transit.

For the youths, one major problem was the insufficient *transport service at night*. A bus/taxi on-demand could be a cheap and efficient alternative to conventional taxis and busses. The cheap transportation in cities led to another big topic for the youths of our focus group: *costs*. Parking, gasoline, and taxis were considered too expensive and should be cheaper. All of the pupils have the opportunity to use public transit for free with their student tickets. Accordingly, these costs were not mentioned. One idea that was mentioned for a sustainable and greener mobility was the introduction of a financial award when disposing of a polluting car.

Eco-friendliness was only mentioned as ‘not important.’ Ecological improvements seemed to be considered beneficial, but they did not appear in the discussion about future mobility. All focus group members wished for more safety and preferred expanding the use of *camera surveillance* at public transit stations.

Ideas for new and *innovative means of transportation* came hesitantly and were only addressed when the moderators specifically asked for them. Nevertheless, they were not seriously discussed within the focus group. The pupils had immense difficulties disregarding practicability and being creative. They mentioned the Segway PT as a known innovative vehicle, ‘personal aircrafts,’ ‘ropeways,’ ‘self-steering cars on magnetic fields,’ and ‘teleportation,’ but they discussed neither feasibility nor usefulness for future mobility.

The wishes for future mobility were evaluated in a separate brainstorming process. The results are shown in Fig. 2.

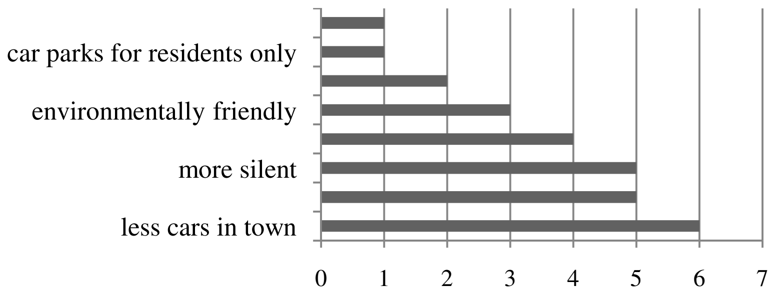

Fig. 2. Number of mentions for future mobility wishes (n=7)

Although the ‘mobility’ focus group had difficulties finding innovative solutions for a smart future city, all pupils agreed on the point that car traffic should be reduced in favor of a smarter, enhanced public transport system.

Energy. The ‘energy’ focus group started with an association process in which each participant had to write down buzzwords connected to the term ‘energy’ (see Fig. 3).

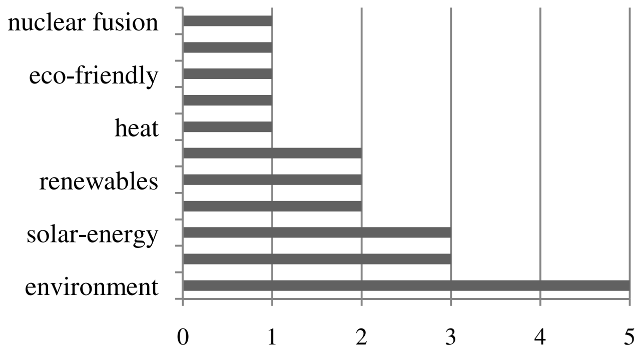

Fig. 3. Number of buzzwords for 'energy' (n=7)

As can be seen, *environment* was the most common term associated with energy. However, in the discussion that followed, the idea that the environment also plays a major role in deciding which form of energy production should be considered for the future smart city was utterly dismissed. The pupils not only associated different types of energy production or their characteristics but also the physical definition ('force'). Next, the different forms of energy production were collected and the pro and con arguments of fossil vs. renewable energies were discussed. Despite knowing that renewables are much better for the next generations, there was no evident preference for any energy transition.

The main arguments for all kinds of energy sources were their *costs.* Even though both conventional power plants and wind farms usually negatively affect the landscape, the students were more concerned with the monetary effects and managed to turn this into a positive argument: As eyesores, power plants must decrease the land's value, they reasoned, which is a benefit as rent and land acquisition would be more affordable. Innovative ideas for future cities' energy can be divided into two potential categories: 'energy savings' and 'energy production.' The ideas were not totally new, some did not even respect the conservation of energy, but the students of the focus group 'energy' were very creative.

The awareness of the importance of *energy saving* was surprisingly high. The pupils appreciate today's energy consumption labels for electronic devices, which they thought should be expanded to more devices and also mention actual costs and saving potentials. In order to save energy, the pupils wanted to have better opportunities to see which technical devices use how much electricity and, even more important, how much this electricity consumption costs. In addition, they want the option to remotely turn off these devices. This could either be put into practice by special remote controls, but it could be done even smarter by apps on their mobile devices. Intelligent systems at home could also be used to turn off devices, for example at night, or lock the front door automatically.

Most innovative were the ideas for *energy production*. Some of the examples mentioned were "doing sports, for example on a treadmill or cardio bike, to produce electricity by movement" and the integration of "little turbines in wastewater pipes as the water is flowing anyway." These smaller ideas were added to holistic ideas like "saving heat energy in summer for cold winter days" or "using thermal energy in intelligent walls with special sensors when the sun is shining."

City Climate. The focus group 'city climate' started with a brainstorming session, as their topic was less tangible compared to mobility and energy. All statements were categorized as illustrated in Fig. 4.

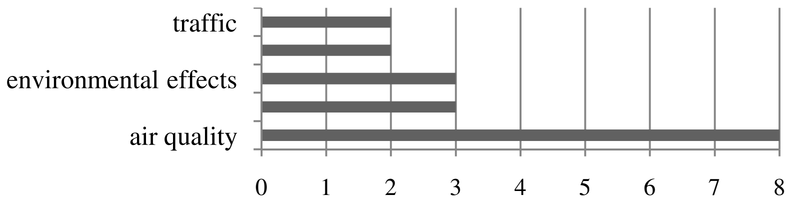

Fig. 4. Number for statements to 'city climate' categories (n=7)

The biggest concerns regarding city climate were related to air quality. The smell in rural areas was considered pleasant compared to urban areas. The stagnant air in cities makes breathing uncomfortable. There was overall agreement that future cities needed more air circulation. The group's innovative ideas for the future city from an ecological point of view can be divided into six categories.

Regarding the city *buildings,* all students agreed that their silhouette and arrangement should impact and support wind flow within the city. Industrial parks should be situated in suburban areas. Another key issue was integrating *water* into the city center. Cities located at lakes or rivers were regarded as far more attractive. Towns without natural connection to water should construct artificial canals throughout the city, leading to a central lake. *Parks* and green spaces inside the city are equally important as water. In fact, parks and water should be connected across the city. Not only the ground but also facades and rooftops could be planted and therefore positively impact the city climate - the rooftops could also be connected with sky bridges. In order to gain room for water, trees, and green spaces, cars should be banned from the city center. The students also discussed possible *payment* systems. Everyone was willing to pay small entrance fees in order to visit parks and garden rooftops. Also, inner city tolls should be implemented as well as a kind of "green seal" for cities.

The students of the city climate group also discussed how mobility could influence the city climate and wanted a city with *no cars*. To achieve this, strict bans in the city center instead of mere low-emission zones with restricted access should be implemented. The group explicitly put the focus on a car-free city center, not just on a city free of exhaust gases. In addition, the students also thought of alternatives: Deliveries to shops in the city center and all non-passenger traffic should be moved to underground means of transportation.

Further *innovative means of transport*, beside sky bridges and underground systems, are electric ground and aerial passenger tramways. The main routes should become bicycle highways with footbridges instead of traffic lights.

Thematic Linkage within the Focus Groups. The statements of all focus groups were also examined for their interdependent arguments (see Fig. 5). Most thematic intersections came up in the city climate group, particularly regarding mobility topics. However, no statements in the energy group could be linked to the city climate group. The city climate as well as the mobility group proclaimed a reduction of cars in future cities. All groups imagined a transition to electric cars.

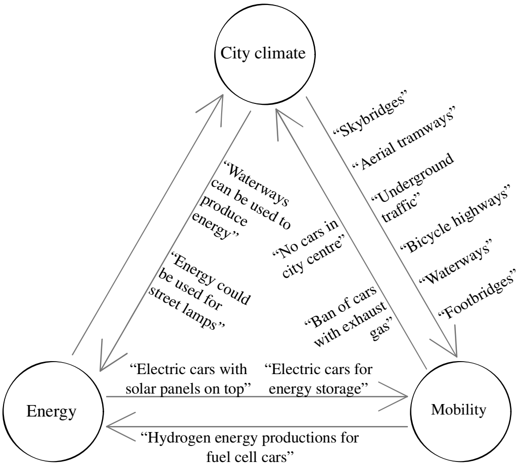

Fig. 5. Thematic linkage between mobility, energy, and city climate groups (n=21)

4 Discussion

The objective of this exploratory study was to understand the cognitive models and insights of teenagers and young adults into the dramatic changes for urban environments, which are related to energy supply, mobility requirements, and city climate. It is necessary that public information and communication seek to specifically support awareness for societal needs in combination with an environmentally friendly attitude of citizens. However, mobility, energy supply, and the diverse needs of citizens for adaptive mobility are highly complex and partly controversial. Individual needs for an adaptive and low-price mobility supply might be at the expense of a green attitude and environmentally saving behavior. Thus, individual motives and wishes might contradict societal needs, and the consequences of both are on completely different time scales. For communities and their citizens, however, it is important not only to understand the different perspectives – energy supply, mobility demands and user diversity –, but also to be aware of different norms and ethics in context of livable urban cities of the future. As found in our study, young adults and students are basically aware of the demands of modern urban environments. They stressed their wish to live in green and wealthy cities and they seem to have also a basic understanding of the shortening of fossil energy and the need to find other energy solutions that also save the environment. The wishes for green cities are consistent with prior research.

Better city climate, parks, and green spaces have a significant effect on the happiness of inhabitants [9]. All groups discussed the costs for future city improvements. While the students were not willing to pay any energy transition, they still could imagine paying entrance fees for parks. This seems counter-intuitive at first sight and raises some questions about their relation to money and income.

The quantitative results revealed no significant influence of ATT on environmental attitudes towards mobility, energy, or city climate. There was also no significant correlation between ATT and gender although this was found in latest research [8]. The overall ATT within the technology prone pupils was very high and two-thirds of the rather small sample was male so these results need validation in further research.

However, it was still striking how low the information level was as well as the ability to discuss on a more complex level. Most of their arguments were highly connected to their individual needs and they seemed unable to take a different perspective or a morality out of their individual scope [10]. Results show that a detailed information and education in dealing with complex issues is an urgent need for this age group. Especially in topical and societally relevant issues (such as the development of cities and urban environments) this seems a mandatory demand of current education policy.

5 Limitations and Future Research Duties

Finally, some limitations have to be addressed. One is the comparatively small sample size which is due to the chosen research method (focus groups). Furthermore, it could be interesting to compare different cultural views. Although the students did have different ethnic backgrounds, we did not compare the results for those groups, because the samples would have been too small. As we already have contact to several school classes in different countries, both constraints hopefully will be improved in future research.

Other limitations refer to the methodology. Answering the questionnaire before the focus group on the one hand successfully introduced participants to the topic. On the other hand, the participants might have been biased and limited in their creativity afterwards, because they might have thought that it was expected they cover the topics from the questionnaire. This trade-off will be discussed and the chronology of tasks could differ for the next focus groups. Regarding the creative process within the focus groups, the given time seemed to be insufficient. A duration of 2 hours was adequate regarding patience and concentration. As we had the impression that the students needed at least 1.5 hours to get into the topic and had just reached the discussion about innovative future solutions for sustainable cities, it could be promising to organize a continuing second meeting. In addition, as a possible reason for the presented outcomes, group dynamic processes should also be considered. Individual behavior is influenced by the presence of others [11], most likely during the teamwork in the presented focus groups. Although the questionnaire had been pretested, it became clear from the results and the questions of the students during the workshop that some items had been misunderstood. Special attention should be paid to the wording of the questionnaire for future research with groups of pupils from mixed ethnic backgrounds.

Another possible influence factor was the moderation of the focus groups. First, it is possible that speaking to an expert in the field was intimidating for the pupils and therefore they were inhibited in their creativity. Second, although all moderators received a briefing on focus group moderation, it has to be taken into account that the experts normally do not work with this method in their discipline. It is thus plausible that the influence of the experts was greater than when trained discussion leaders work with focus groups. However, this also provided the opportunity for interdisciplinary insights into the methods of other disciplines, which can be valuable for future interdisciplinary work.

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