Reflecting on the Smart City: How Student Teachers Learn to Teach Smart Pupils

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Abstract

Smart cities, despite their supposed benefits, also pose challenges to inhabitants. The promised improvements of quality of life, sustainability and efficiency are accompanied by a lack of data security and privacy, and a loss of spontaneous and chaotic but enjoyable urban life. School has to prepare pupils for life in the smart city, and therefore universities have to equip pre-service teachers for this task. This paper seeks to examine how portfolio work supports pre-service teachers in this undertaking. Portfolios compiled in a teacher-training seminar for geography and interviews with participants were analyzed and categorized. The results demonstrate that students created complex images of the smart city. The images widely agree with attributions assigned to smart cities by experts. Additionally, the study revealed abilities which the students developed through portfolio writing and identified tasks that supported them in this. For example, one student visualized his ideal city in an essay and thereby identified his own interests. The students described their learning process precisely and reflected on their opinion forming. The findings indicate that portfolio work is valuable in the learning field of smart cities in particular, as well as in the domain of the digitalization of society in general.

Keywords:

1 The role of emancipated citizens in the smart city

Today's pupils will live in cities that are organized in a fundamentally different way compared to present urban spaces. They will live in smart cities. Three developments have facilitated the spread of the concept of the smart city: fast, low-cost information and communication technology, ubiquitous mobile devices, and the possibility to collect data extensively (Greenfield, 2013, p. 11). In smart cities, the use of big data helps to optimize governmental processes and to organize urban systems more efficiently. Ideally, citizens have more influence through e-participation in governmental decisions (Mandl & Zimmermann-Janschitz, 2014, p. 616).

The idea of a city which is, for example, carbon-neutral thanks to an efficient and demand-based energy supply and which helps disabled people to be mobile thanks to a flexible, user-

driven traffic concept is desirable (Kaczorowski, 2014, p. 140). However, these worthwhile goals coincide with purposes that show the neoliberal origin of this city concept. All the sensors, applications and devices that constitute the smart city produce an enormous volume of data. That is the currency with which inhabitants pay to enjoy the advantages. Therefore, their privacy is negotiable, controlled by the quasi-monopolistic power of a few technology companies, which provide for the smart city (Greenfield, 2013, pp. 15–16).

The current generation of pupils will live and work in these cities, and build and shape them through their participation. They will decide how smart cities are organized and what role the ICT companies will play in the governmental structure. Therefore, pupils have to reflect critically on the threats and opportunities of the smart city and judge its influence on social processes. Consequently, new questions arise for geography education: school has to prepare for life in the smart city and for the challenges that come along with it.

This paper attempts to show how geography teacher training can help pre-service teachers to succeed in this task. The first step is for them to understand and reflect upon the topic. University students (referred to from now on as 'students') probably have no experience of preparing the next generation for life in the smart city, since there is hardly any didactic adaptation of the topic. Before they can teach the subject, students must understand the content and form an opinion about it. Hence, it is important for them to reflect and formulate their own position in the debate. By reflecting, students become aware of the challenges and opportunities of the concept. Thus, they can develop ideas on how to prepare pupils for life in the smart city.

The purpose of this paper is to answer the question of how teacher training can help pre-service teachers in geography to reflect on and prepare their future pupils for life in the smart city.

The first section will lay out the theoretical framework, explain the smart city concept, and examine implications for geography education. The potential of portfolio work to foster reflectivity is also briefly described in this section. These implications influenced the structure of a seminar conducted in the summer term 2017 at Goethe University, Frankfurt, which is presented here. The second section is concerned with the methodology used for the study. The third part presents the findings of the research, focusing on the two key topics: the students' attitudes towards the smart city and their reflections on their learning process. In the discussion, the results are related to the theoretical framework.

2   Smart cities and implications for education

Developers and the companies involved affirm that smart cities improve quality of life and create demand-based, sustainable city management. Complete observation by cameras and sensors as well as the algorithm-based analysis of big data render this goal attainable. The smart city concept, as invented by Cisco Systems and IBM, impacts five sections of the urban system: the economy, mobility, the environment, living and governance. In this initial concept, citizens are considered nothing more than natural data sources in an 'urban cum global network' (Halpern, LeCavalier, Calvillo, & Pietsch, 2013, pp. 280–81). The developers

believe that technology can improve inhabitants' lives. A broader definition, as for example presented by Mandl and Schaner (2012), enhances the citizens' role and considers 'smart people' as the sixth section: they have to shape the city by active (e-)participation.

A closer look at Songdo, South Korea reveals the extensive digitalization of everyday life and the corresponding challenges and risks. The city, located 40 km southwest of Seoul, is under construction in three phases, from 2003 to 2020, for 65-70,000 inhabitants. Cisco primarily implements the technical aspects of the smart city concept: „Every wall, room, and space is a potential conduit to a meeting' (Halpern et al., 2013, p. 280). Thus, companies are able to contact employees also at remote places using omnipresent communication interfaces. Permanent data collection helps to optimize the city and its processes permanently. For that purpose, ubiquitous video observation of public and private spaces was installed. Sensors on the streets and in parking lots, and the monitoring of consumption in the home give information with which to adapt the urban infrastructure. Dominant principles in the city are sustainability and the pursuit of greater bandwidth. Cisco created a *self-perpetuating system* (Halpern et al., 2013, p. 282), because the company builds the infrastructure and offers services which generate new demands among the citizens. These again need an extended infrastructure and greater bandwidth. As a side effect, the company obtains a never-ending stream of public and private data.

Smart cities are one phenomenon within the process of mediatization (Krotz, 2007, p. 13). This long-term social and cultural change implies that we do not act *with* media, but *within* media. Media such as computers, tablets and smartphones have formed a network that is only partly addressed to humans, because the devices communicate with each, as is the case in the smart city. The task of media education in the digitalized world is to provide the theoretical basics and methodology to reveal the complex structures and to indicate educational potential (Jörissen, 2013). When transferring this to the phenomenon of the smart city, new tasks for geography education arise.

The increasing number of smart cities demands emancipated, 'smart', citizens. They have to examine critically and regulate the formation process. Autonomy, self-definition and reflection/reflectivity are required skills in this new educational area (Grünberg & Dorsch, 2016). Primarily, citizens must be able to use digital media autonomously. This is not irrelevant, since Kaczorowski (2014, p. 88), for example, predicts a digital divide: only those citizens who have sufficient knowledge and skills to use technology will be able to participate. If the administrations of the new cities follow Mandl and Schaner's (2012) integrative approach, citizens will have new responsibilities: they will have to decide in which direction the city they live in should develop. Now, they are not only affected by decision processes, but they also begin to control these. Of course, this concept is not completely new: political education always aimed to motivate pupils to participate in their communities. Nevertheless, the scope of direct influence – as some cities have already created on online participation platforms – demands certain skills, which are taken from approaches of geomedia education, such as 'spatial citizenship' (Jekel, Gryl, & Oberrauch, 2015): the spatial citizen is able to initiate social discourses by use of geomedia. The inhabitants of the smart city communicate their interests and perspectives on space and the environment via digital media, such as maps, blogs and bulletin boards. In doing so, they produce a new

interpretation of space, aiming to influence a decision process. Hence, pupils have to reflect that every medium, every map or photograph, is a limited and socially constructed perspective on the world (Harley, 1989). They also have to learn how to approach private data: informational emancipation (Marotzki, 2000) will be essential for life in the smart city. As soon as the big data concept begins affecting private data, pupils have to scrutinize the process. The school's task is to foster these abilities. Therefore, teachers also have to prepare themselves during their studies or advanced training.

3   Portfolios as instruments to foster reflection

Portfolios are target-oriented collections of work which show the individual effort, progress and achievements of learners (Häcker, 2011, p. 86). Learners decide what to present in their portfolios. Portfolios are therefore an instrument that individualizes learning because they record learning and working progress over a longer period.

Most studies regard the improvement in reflective thinking as the most important advantage of portfolio work. Poppi and Radighieri (2009), for example, measured a significantly higher ability to carry out self-assessment through portfolio work in language studies. In a study by Wakimoto and Lewis (2014), 90 % of the psychology students examined agreed that portfolio work fosters the reflectivity competence. Häcker (2011) analysed the effect of portfolio work on self-directed learning in middle schools in Germany. According to his results, portfolios primarily foster self-regulated learning: they allow pupils to decide *how* to learn something, but not *what* to learn. Additionally, the method helps to identify and cultivate personal interests, though it cannot compensate for the absence of interest in a topic (Häcker, 2011, p. 302). Portfolios enable students to achieve a positive attitude towards their learning process and to take responsibility for it ('ownership of learning') (Shroff, Trent, & Ng, 2013).

4   Course structure

A teacher training seminar at the Geography department of Goethe University Frankfurt was conceptualized, based on the theoretical framework presented here. It was conducted in the summer term 2017 with the title '*Smart pupils in the Smart City?*'. For the purposes of course assessment, the 21 students drew up individual portfolios.
The course dealt with the topics presented in Table 1. During each session, a group of students introduced one of the topics in a presentation. This was followed by discussion and tasks regarding the issue, which took up the most significant portion of the course. Additionally, participants deepened most of the topics in their portfolios at home.

Table 1: Course structure

Topics	Portfolio tasks
1. Introduction to the phenomenon of the 'smart city'	Write about your expectations and pre-knowledge.
2. Concept of the smart city; big data	Online lesson: How to write a reflection.
3. Examples: Smart cities Songdo & Hamburg	none
4. Risks of the smart city	Pick one aspect of the smart city concept that you consider critical. Describe how pupils in geography classes can learn to deal with these risks.
5. E-government and e-participation	Think of a problem in your neighborhood. How could you solve that problem? Start an initiative on the participation platform www.frankfurt-gestalten.de or www.ffm.de. Reflect on the results.
6. The role of the smart city in school books	none
7. Structural media education by Jörissen and Marotzki (2009)	none
8. Discussion with Christian Kreutz (expert on e-participation)	Pick one aspect of the discussion and reflect on it.
9. Reflexive map working	none
10. Education for spatial citizenship	Create a school task using the map of Songdo. Make sure that it meets the criteria for education for spatial citizenship. Complete your portfolio partner's task and reflect on your working process.
11. Conclusion and discussion	Reflect on the contents of the course. Has the course met your expectations?

The idea for the course structure was first to introduce the theoretical framework of the smart city as a topic. The portfolio tasks should help students reflect on certain elements of the concept and to form an opinion about it. Additionally, participants discussed critical aspects of the concept, such as privacy issues, data security, and the monopolies presented by single ICT companies. A second focus was on e-participation as an essential feature of smart cities. The students were required to start their own initiative on an online participation platform and to advertise it. In doing this, they developed sensitivity towards the manipulative power of images, maps and an appealing verbalization. In the second half of the course, students used the knowledge and experience acquired to discuss learning methods and tasks in terms of their suitability to implement the smart city as a topic in geography classes in a comprehensive and critical manner.

5   Methods

The portfolios compiled by the seminar participants were categorized by applying Mayring's (2015) qualitative content analysis. The first set of categories for this project covers the students' images of the smart city. It answers the question of how the students evaluate life in the smart city. Descriptions of the learning and opinion-forming processes frame the second set of categories, which consists of answers to two questions. First, which elements of the seminar helped in forming their opinion? Second, how do they rate the topic's significance for their personal learning? In a further stage, guided interviews were conducted with the participants. The aims were to reveal how students reflect on life in the smart city, and to identify key features (i.e. tasks and seminar content) that influenced their reflections. The interviews were later categorized, using the categories described above.

6   Results

The results show significant reflections recorded by the seminar participants and in the interview statements. They illustrate how the students imagine life in the smart city. Additionally, they give an indication of the course content and tasks that were effective in stimulating reflection and in forming an opinion about the smart city.

Students' images of the smart city

Before they attended the seminar, all the students interviewed had either no opinion (because they lacked knowledge regarding the topic) or condemned the idea of the smart city wholesale. As expected, the contrast between the vague opinions before the seminar and the differentiated statements after it is significant. In addition, the perception of the smart city after the seminar differs among participants. Figure 1 shows 14 categories (i.e. *mental images*) deduced from their final reflections.
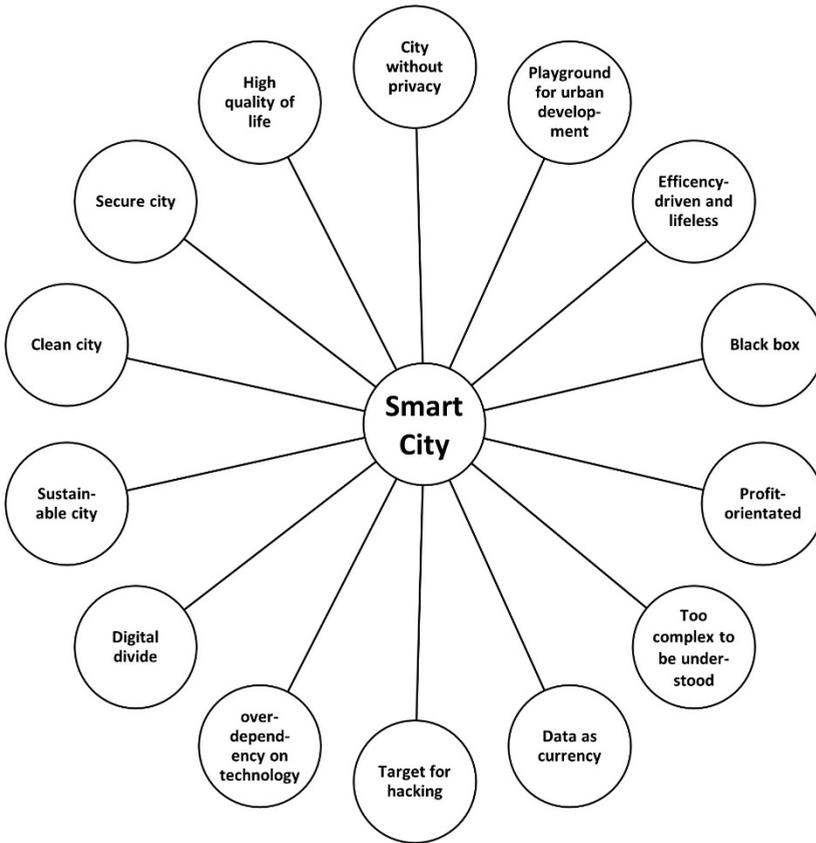
Figure 1: Smart city images deduced from students' portfolios (author's illustration)

Characteristic statements

The smart city as a model of cold and lifeless efficiency

'Additionally, companies promise efficiency, organization and sustainability in a perfectly planned form, while citizens simply wish for a better quality of life and might not want to give up the urban sense of life as well as the space for individuality and creativity. [1]
Essay, student a., 'Lehramt an Haupt- und Realschulen', female (translated by the author)

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[1] 'Zudem versprechen die Konzerne Effizienz, Ordnung und Nachhaltigkeit in perfekt geplanter Form, während sich die Bürger schlicht eine Verbesserung der Lebensqualität wünschen und eventuell überhaupt nicht auf das urbane Lebensgefühl und den Raum für Individualität und Kreativität verzichten möchten.'

The smart city as a playground for urban development

'Until given the task, I had never thought about the question of what could be changed in Frankfurt. It was interesting to see how much more you perceive your environment.' [2]
Reflection on initiative, student b., 'Lehramt an Haupt- und Realschulen', female (translated by the author)

The smart city as a black box

'Many people assume that maps are created from significant data that cannot be manipulated. Working on the task, I realized that map data can in fact be manipulated and that it is important to prepare pupils for that. The fact that it is not really easy to determine who provides which map data and whether this data depicts reality caused me problems. [3]
Reflection on initiative, student c., 'Lehramt an Gymnasien', male (translated by the author)

The smart city as a city without privacy

'At the same time, I consider life in the smart city impossible for me. My personal privacy is too important to me, which means that I don't want to exchange it for supposed advantages of a completely interconnected system. [4]
Reflection on discussion with Christian Kreutz, student d., 'Lehramt an Haupt- und Realschulen', male (translated by the author)

Reflecting on the learning process

The study dealt with the question of how portfolio work helps pre-service teachers to reflect on life in the smart city. The earlier results showed that the participants' views on the smart city became both more critical and more differentiated. Of course, one would expect these findings after any academic seminar. However, the interviews indicate that portfolio work fosters a reflective view on the topic. Students were able to

- describe how they formed their opinions,
- identify what was important for their learning processes,
- evaluate the significance of the seminar topics for their personal ways of behaving and living.

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[2] 'Bis zu dem Zeitpunkt, wo die Aufgabe gestellt worden ist, habe ich mir nie Gedanken darüber gemacht, was man an Frankfurt verändern könnte. Es war interessant zu sehen, wie viel mehr man auf einmal auf seine Umgebung achtet.'

[3] 'Viele gehen davon aus, dass Karten auf der Grundlage von Daten erstellt werden, die etwas aussagen und nicht manipuliert werden können. Während der Bearbeitung der Aufgabe ist mir aber klar geworden, dass die Kartendaten sehr wohl manipuliert werden können und dass es wichtig ist die Schülerinnen und Schüler darauf vorzubereiten. Probleme bereitet hat mir die Tatsache, dass es gar nicht so leicht zu erkennen ist, wer welche Kartendaten zur Verfügung stellt und ob diese wirklich der Realität entsprechen.'

[4] 'Zugleich bin ich jedoch auch der Ansicht, dass ein Leben in einer *Smart City* für mich nicht möglich wäre. Für mich ist die eigene Privatsphäre zu wichtig, als dass ich sie gegen die vermeintlichen Vorteile eines vollvernetzten Systems eintauschen wollen würde.'

Forming their opinions

'The topic of my presentation was "risks of the smart city". At the start of the course, I was very critical of the smart city concept. However, I realized that my presentation and engaging with the topic partly changed my mind. Through working on the task, I was able to differentiate things much better and to strengthen my argumentation with concrete examples. [5]
Reflection on essay, student e., 'Lehramt Förderschule', female (translated by the author)

This student shows a high level of self-reflection in her portfolio. By writing about the task, she realizes that meaningful tasks help to differentiate the advantages and disadvantages of the smart city and to strengthen argumentation ability. She will probably remember this when planning her own geography lessons on smart cities in school.

Describing the learning process

The author of the following paragraph describes factors that promoted her understanding of the smart city concept:

'[T]his task motivated me particularly because I had to discuss the advantages and disadvantages, the opportunities and threats of smart cities. By working on the task, I had to engage more deeply with a certain topic. The problem of data security and privacy is omnipresent in contemporary situations and discussions. It was the first to come to my mind, which prompted it to overshadow other relevant risks. Hence, I deliberately decided to deal with another topic I was not familiar with before the seminar, though it was evident to me. Dealing with a new topic rendered the task appealing to me and added to me reconsidering a new aspect of smart cities and therefore learning something new. [6]
Reflection on essay, student a., 'Lehramt an Haupt- und Realschulen', female (translated by the author)

Since she was free to find a topic of her own, she wrote about a relevant problem (the monopoly of certain companies in the smart city) that she had not discussed before.

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[5] 'Mein Referatsthema war die Kritik an der Smart City (…). Ich habe das Konzept der Smart City von Anfang an sehr kritisch gesehen, hab aber festgestellt, dass mich genau mein eigenes Referat und die Auseinandersetzung mit der Kritik ein wenig umgestimmt hat. (…) Durch die Bearbeitung der Aufgabe habe ich es für mich nochmal viel besser differenzieren können und meine Argumentation anhand von festen Beispielen belegen können.'

[6] 'Aus diesem Grund hat mich diese Aufgabe besonders motiviert, da ich mich Vorfeld mit den Vor- und Nachteilen und Chancen und Risiken von Smart-Cities auseinandersetzen musste und mich im Verlauf der Bearbeitung der Aufgabe vertieft mit einer konkreten Problematik befassen musste. Das Problem Datenschutz und Privatsphäre kennt man aus vielen Situationen und Diskussionen in der heutigen Zeit und es war auch das erste was mir dazu einfiel, doch dadurch überschattete es für mich zunächst andere relevante Risiken. Daher wollte ich mich bewusst mit einer Problematik auseinandersetzen, die mir vor dem Seminar noch nicht so bewusst war, obwohl sie sehr einleuchtend war. Sich mit einer neuen Problematik zu befassen hat die Aufgabe so interessant für mich gemacht und dazu beigetragen, dass ich Smart-Cities noch einmal unter einem neuen Aspekt betrachtet habe und damit etwas neues dazu gelernt habe.'

Significance of the topics for personal behaviour and living

By reflecting on the tasks and contents, the students became aware of the significance (or non-significance) for their personal life, which the following portfolio entry demonstrates:

'In the following, I would like to focus on one aspect of the talk with Christian Kreutz. In his presentation, he described aspects of the digital and collaborative city. He also talked about the personal significance of 'city' for him. That appealed me. Hence, I would like to deal with the questions of what 'city' means to me and why I cannot consider life in a fully planned smart city. [7]
Reflection on discussion with Christian Kreutz, student f., 'Lehramt Förderschule', male (translated by the author)

The discussion motivated the student to deepen one aspect (the meaning of 'city') and to relate it to his own life. He concluded that the concept of the smart city would not coincide with his own idea of city life, which to him is spontaneous, fragmented, and sometimes dirty and inefficient.

7   Discussion

The students' mental images of the smart city cover a whole range of attributions that are created in the discourse of the topic. For example, the image of the *efficiency-driven and lifeless city* which is drawn by student f. ('why I cannot consider a life in fully planned smart city') follows the thoughts of Greenfield (2014), who sees the smart city as an 'inappropriate model of optimization'. Such an optimization destroys the inefficient pleasures of urban life (Greenfield, 2014, p. 25). The image of *a playground for urban development* can be found in the theory of Halpern et al. (2013): Songdo is a 'test-bed' for Cisco. In this urban area, developers experiment with the possibilities of technology. They aim to create a blueprint for other smart city projects. 'Performative, inductive, and statistical, the experiments enacted in this space transform territory, population, truth, and risk with implications for representative government, subjectivity, and urban form' (Halpern et al., 2013, p. 275). Student c. fears the *black box* character of the smart city: a citizen can hardly judge whether a map in an urban participation process is manipulated. 'The city ceases to be modular, with unforeseen consequences regarding emergencies and control' (Halpern et al., 2013, p. 299). Data and algorithms drive the transformation of the city, which rearrange the hierarchies of objects and people. The examples quoted show that writing a portfolio helps students to comprehend theory individually.

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[7] 'Im Folgenden möchte ich auf einen Aspekt aus dem Seminargespräch mit Christian Kreutz vom 27. Juni genauer eingehen. In seiner Präsentation hat er Züge der digitalen und kollaborativen Stadt dargestellt. Im Gegenzug dazu ist er jedoch auch darauf eingegangen, was „Stadt" für ihn persönlich bedeutet. Dies hat mich besonders angesprochen. Im Zuge dessen möchte ich mich nun näher damit beschäftigen, was Stadt für mich bedeutet und warum ich mir ein Leben in einer rein geplanten Smart City nicht vorstellen könnte.'

The statement by student f. also confirms one of the most important propositions about portfolio work: in an act of self-definition, the student *thinks about his own interests* and visualizes his ideal city. Presumably, he will motivate his future pupils in his geography lessons to define their ideal city and to think about their role in this city as well. This finding coincides with Häcker (2011), who considers portfolio work a suitable instrument for the representation and cultivation of personal interests.

Portfolio work helps learners to reflect on their learning process and to identify tasks and content which were meaningful for their learning (Mansvelder-Longayroux, Beijaard, & Verloop, 2007, p. 60). In the same way, the participants of the seminar were able to identify the tasks that helped them most to form an opinion about smart cities. For example, student d. rethought his opinion in the process of writing the essay:

'And when I was working on it, I was thinking. It definitely was like that. I thought like: Ok, might I be too radical towards the smart city? Am I, let's say, too conservative, too old-fashioned? [8]
Interview, student d., 'Lehramt an Haupt- und Realschulen', male (translated by the author)

This statement also shows the ability of student d. to *describe his learning process*. Student a. reflected in a similar way on how she found a topic for her essay (see Results). Shroff et al. (2013) call this the 'ownership of learning': portfolio work motivates students to find personal value in their learning and to take responsibility for it.

8   Conclusion

There is no doubt that future cities will be more connected, more digitalized and more controlled by algorithms than cities today. Therefore, the topic of the smart city is of high significance to geography education: today's pupils have to be prepared to live in these cities, to anticipate critical consequences, and to influence the cities' development through participation. School is the place for preparation, and teachers need to cope with that task.

During their studies, pre-service teachers must identify and reflect on their own position in the smart city debate. This is the only way they can plan geography lessons in which pupils can develop the required skills. The purpose of the seminar presented here was to support students in this subject matter.

Reflections by the participants and interviews revealed that writing a portfolio is effective: it helped students to realize the significance of the topic for their own lives and to form an opinion about the smart city concept. The reason for that lies in the reflective character of portfolio work. During the writing process, they reflected on the consequences for urban society and for their everyday lives. Through portfoloio work, the students were also able to describe their learning process and to identify tasks and content that had helped them build up their knowledge and form an opinion. The students pointed out three tasks of the

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[8] 'Und als ich dann dabei war, da hab ich so überlegt. Das war echt so gewesen. Wo ich so gedacht habe: Ok, bin ich nicht vielleicht zu radikal gegenüber der Smart City? Bin ich zu sag ich mal konservativ, zu altmodisch?'

seminar portfolio in particular, which have in common that they stimulated them to think about themselves, their interests and their learning: (a) in the essay, participants had to identify what they considered to be the most important problem; (b) to start their initiative on the participation platform, they had to think about deficiencies in their hometown and about solutions for how to reduce them; (c) by writing reflections on the tasks and their work, students realized the relevance of the topic for their own lives.

Additionally, students were able to understand theoretical attributes of the smart city concept identified by experts and critics. The students' evaluation of the concept became more differentiated throughout the course of the seminar, and especially through compiling their portfolios. For all these reasons, portfolio work is a suitable instrument for reflecting on the strengths and weaknesses of the smart city in universities and in schools. Nevertheless, the study also reveals that the task structure is of crucial importance: a 'classic' seminar concept that encourages students to reflect on their interests by handing them meaningful tasks might have a similar effect. Two participants said in the interview that even the other students' presentations, and the discussions that followed in particular, helped them to forge an opinion.

Acknowledgment

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