Building Smart City Knowledge and Competences Using Problem-Based Learning in a Blended Learning Environment

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1 Introduction

With roughly 70% of the world's humans living in cities by 2050 (United Nations, 2018), dramatic and far-reaching changes to cities are expected. The cities of the future will have to cope with a strong increase in traffic, waste, energy consumption, noise, and pollution. By using modern information and communication technologies (ICT), smart cities offer a promising perspective to handle the challenges induced by the aforementioned urbanization (Giffinger et al., 2007). Following the work of Giffinger et al. (2007), we consider a city as smart if it is able to deliver outstanding, future-oriented performance and services in the six domains smart governance, smart economy, smart people, smart mobility, smart environment, and smart living. In addition, a smart city is characterized by involving relevant stakeholders into the necessary change and decision processes (Jaekel & Bronnert, 2013; Marrone & Hammerle, 2018). This involvement requires two fundamental things from the stakeholders. First, a high amount of engagement is necessary to have the relevant stakeholders actually involved (Ebner et al., 2019). Second, the stakeholders need a specific set of competences concerning the different domains of a smart city to actually and meaningfully contribute to the transformation from cities to smart cities (Zakirova et al., 2021; Baltac, 2019). The proposed chapter will deal with this important second aspect.

In this chapter, we introduce an education concept that addresses the digital transformation of cities to smart cities from both a conceptual and a didactical education perspective. Our key argument is that change processes in cities are not just a matter of content but especially a matter of debate, discussion, and

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negotiation: most of the changes smart cities bring into cities will, at first, stimulate discussions, and concerns, and, if the concerns are not addressed, finally, even result in resistance. Stakeholders acting in such processes therefore need competences that allow them to quickly dive into the conceptual dimensions of specific activities while at the same time being able to quickly internalize and understand the positions of other stakeholders. Finally, stakeholders need competences allowing them to work constructively toward meaningful, socially accepted solutions for smart city problems that are both feasible and financeable.

Our insights base on the learning unit "Digitalization of Cities and Traffic" of the module "Digital Transformation" that we offer since 2019 at the University of Hagen, a German distance-teaching university, for both bachelor and master students. We will introduce the specific problem-based learning concept used in this learning unit, which centers around a virtual group work, in which eight students take over different roles and work on solutions for real-world-inspired complex smart city cases. The cases address very different topics in the six smart city domains, such as car and e-scooter sharing, autonomous vehicles, digital schools and technostress, human-robot co-working, chatbots as governmental service agents, smart buildings, new uses of existing places (e.g., old airports or shopping malls), new forms of shopping (e.g., using beacons, location-based services, augmented reality), package drones, etc. The roles in every case represent typical stakeholders, such as mayor, entrepreneurs, and environmentalists, archetypically representing positive, negative, or neutral positions toward the smart city topics of each problem situation. In line with problem-based learning (Müller Werder, 2013; Schmidt, 1983), the cases and roles leave the students with contradictory and sometimes seemingly irreconcilable views on the topics. Based on the conflicting positions, the students are ought to design a solution or find a compromise in the sense of a concrete project or process proposal for the fictitious smart city "Neuhagen."

The challenges of any distance-learning setting involve, first, to assure that relevant competences are taught comparably intensively and qualitatively as in presence teaching settings (Freeman & Urbaczewski, 2019) and, second, to secure the persistence of the learned contents (Xu & Jaggars, 2013). Beyond the addressed smart city contents, we will therefore also introduce the didactic mechanisms to handle these challenges of distance learning and teaching as well as introduce the technical environment we use (e.g., virtual collaboration rooms like Zoom, Jitsi, Moodle, etc.) to connect with the students and to facilitate the virtual group work. We also present the results of different evaluations of the setup (based on exam results, activity statistics, structured and verbal feedback), reflect on the learnings in every semester since the course started, and describe how we have been and still are incorporating the feedback.

Following, we present the relevant background of our education concept, involving smart cities and required smart city competences as well as problem-based learning in Sect. 2. The design requirements underlying our concept are presented in Sect. 3. In Sect. 4, we introduce the applied process for designing the education concept, and present the concept in Sect. 5. In particular, we outline the module structure and introduce the smart city problem situations. We finish this chapter with an evaluation (Sect. 6) and a conclusion (Sect. 7) discussing the transferability of the concept to other smart city education contexts.

2 Problem-Based Learning as a Concept for Teaching the Contents of Smart Cities and Required Competences

Urbanization and digitization of the city and traffic are associated with many problems. Various smart city initiatives are built on the idea of improving the situation of a city as a whole—but often at the expense of individuals who have to adapt their (e.g., consumption or mobility) behavior. Thus, one of the most wicked challenges of smart cities is to reconcile citizens' needs, concerns, approvals, and disapprovals with the initiatives and technologies. Apart from the observation that the digitalization of cities leads to an increasing interconnection of people, tasks, and technology, thus requiring large investments in information technology (IT) and information systems (IS) infrastructure, smart cities require smart citizens. As a result, a culture of lifelong learning (Phoenix, 2002) is inevitable, as citizens need to understand the technologies involved, their potential advantages and disadvantages, their impact on their personal environment (which can be both positive and negative), and different coping strategies for dealing with the consequences posed by the technologies (Selwyn, 2021).

Making decisions in these contexts of digital transformation and smart cities requires a number of additional competences that are only partially considered in current education concepts such as communication, collaboration, critical thinking, and creativity. Zularnaen et al. (2019) also refer to such competences as "twenty-first-century skills," thus highlighting their rather novel character compared to traditional expected competence sets (such as technical skills; see also Baltac, 2019). A thorough overview of relevant smart city competences is suggested by Fitsilis et al. (2021), who differentiate 5 different knowledge areas with 32 relevant skills and competences for smart city decision-makers. Moreover, since the required competences develop constantly and are best acquired in practical contexts, decision-makers must be empowered to acquire the necessary competences themselves, integrated with their regular professional activities (Zakirova et al., 2021).

Hence, with its complexity and diversity, the transformation of cities toward smart cities and the numerous relevant competences confront lecturers with challenges in preparing students well for future problem situations in their working lives and as engaged citizens. For this reason, it is required to teach students the basics of smart cities in high quality while at the same time enabling them to work independently and intensively on wicked problem situations and develop suitable solutions in these contexts on their own. This is why the education concept presented below employs a problem-based group work, in which lecturers "instead (...) explaining a principle, defining a concept, or guiding students through procedures, [lecturers] assign problems that will force students to inductively discover explanations, definitions, and processes" (Weiss, 2003). In our concept, the students are supposed to independently identify relevant learning contents based on a given problem situation, determine and close their own knowledge and competence gaps, and work out a possible solution. This solution is not defined a priori but depends on the individual interpretations and the knowledge level of the students. Through problem-based learning, comprehensive and transferable knowledge and competences are acquired as well as effective problem-solving skills can be developed.

A main difference to traditional education concepts is that the acquired knowledge is not queried during problem-solving but is created as part of it (Müller Werder, 2013; Weiss, 2003; Hung et al., 2008). The problem situation generates cognitive and emotional conflicts as well as interactions between the students. These conflicts and interactions provide the stimulus for learning and enhance the motivation as well as the willingness to learn. It also promotes long-term cognitive anchoring of learned content, an expansion of problem-solving skills, higher-order thinking, and the acquisition of self-directed and lifelong learning skills (Hung et al., 2008; Nobaew, 2018). An important aspect of lifelong learning is virtuality and persistence. Students need to be able to learn contents in their own pace and setting. To address this, the education concept presented here in one learning unit is designed as a blended leaning module for distance learning that can be adapted for different application scenarios in a smart city and for different competences to be learned.

The seven-step (Fig. 1) represents the didactic process structure of problem-based learning (Müller Werder, 2013; Schmidt, 1983); it serves as an orientation and structuring of the problem-based virtual group work for the students. The evaluation of the own solution and procedure in the group represents an eighth step, which is detached from the content-related problem-solving in group work. The evaluation is of great importance as a reflection step, since the students critically evaluate their own learning strategies as well as the group process. They also cognitively process the learned contents and the developed solution, which is central for learning persistence (Xu & Jaggars, 2013).

3 Required Design Requirements

The design requirements (DRs) of the education concept for the "Digitalization of Cities and Traffic" learning unit presented here were identified in design processes. Due to the blended learning study model at the University of Hagen, which consists of a combination of online and face-to-face teaching, the module is designed for distance learning, i.e., minimal physical presence of the students as well as learning from a distance. Students often complete their studies while working full- or part-time, so flexibility and optionality of group work are important criteria for the success of the education concept. In addition, the students are located over the entire German-speaking area (i.e., Germany, Switzerland, Austria, Liechtenstein),

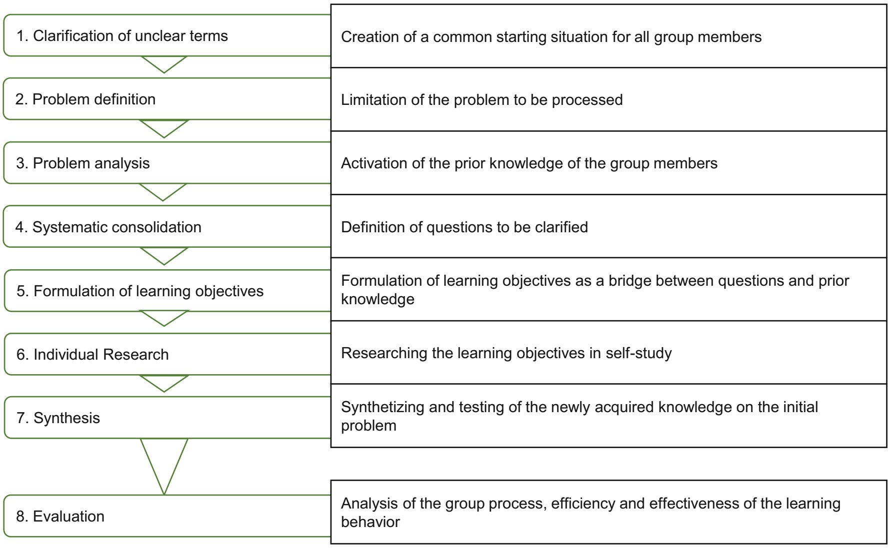

Fig. 1 Steps of the problem-based education concept in virtual group work (based on Müller Werder, 2013; Schmidt, 1983)

some even internationally. The ongoing Covid-19 situation forced many education providers to shift their teaching endeavors to a virtual room. We are therefore confident that our didactical setup is of interest for many lecturers teaching smart cities. Furthermore, the virtual environment supports lifelong learning about smart city concepts for additional interested parties, especially smart city stakeholders. Furthermore, it should be noticed that the whole setup can be transferred to non-virtual settings almost without effort.

The module and the virtual group work in one learning unit must be feasible with few resources. In our case, more than 220 students have to be supervised by 2 research assistants and 1 student assistant. In order to achieve sustainable study and learning success, especially in a distance-learning setting, the education concept should be motivating for the students, e.g., by integrating game elements ("gamification"), which promote both content-related and organizational engagement. Finally, with every problem situation, students are expected to acquire a particular set of smart city competences. Since it is hardly possible to teach all types of competences within one problem situation, it is important to carefully define a well-aligned set of smart city competences involving technical, organizational, as well as soft skills. Altogether, we identified seven DRs that guided our didactical concept development:

- DR1 (Virtuality): Physical meetings of the students are to be kept optional for the processing of the group work.
- DR2 (Flexibility): The group work must allow for time and space flexibility.

- DR3 (Optionality): It must be possible to complete the module successfully without the virtual group work, i.e., students can consciously decide not to participate in the virtual group work.
- DR4a (Legal feasibility): The legal framework of the examination must be adhered to, and assessment-relevant components of the group work must be clearly defined.
- DR4b (Scalability): The group work must be scalable, i.e., it must be realizable even with very large numbers of students and few personnel and financial resources.
- DR5 (Persistence and quality): The didactical concept should foster learning persistence and support the quality of learning.
- DR6 (Competences and skills): The group work should explicitly address the building of a consistent set of smart city competences and skills.

4 Design Process of the Education Concept

We followed a structured design process in order to address all DRs and therefore employed the ADDIE[1] process (see Fig. 2) according to Branch (2009). The design process model involves a cyclical development of the virtual education concept based on the concept of problem-based learning.

The first phase of the ADDIE process focuses on the **analysis** of the module and group work objectives (teaching the basics as well as enabling students to independently familiarize themselves with new problem situations in the context of smart cities and digital transformation), the target group (middle-aged students of business administration, economics, and business informatics, most of whom are employed), and the available resources for implementing the education concept (initially available conference technology (Adobe Connect) and learning management system (Moodle) as well as two research assistants and one student assistant). In the **design** phase, the education concept with clear links between content and learning objectives and introduction to content- and problem-based learning are to be defined. Furthermore, the learning objectives for five thematic learning units within the module as well as the examination components and achievements are to be determined. In the following phase of **development**, the learning resources (e.g., problem situations for group work, methodological introductions, reference material) have to be created, and the required resources as well as the organization of the virtual group work have to be designed more concretely. In the **implementation** phase, the new learning resources are used, and the developed education concept is implemented. In this phase, the supervisors encourage the students as learning guides and contact persons. In the **evaluation** phase, the achievement of objectives is checked, and feedback from the students is compared with the formulated

[1] Abbreviation for analysis, design, development, implementation, and evaluation.

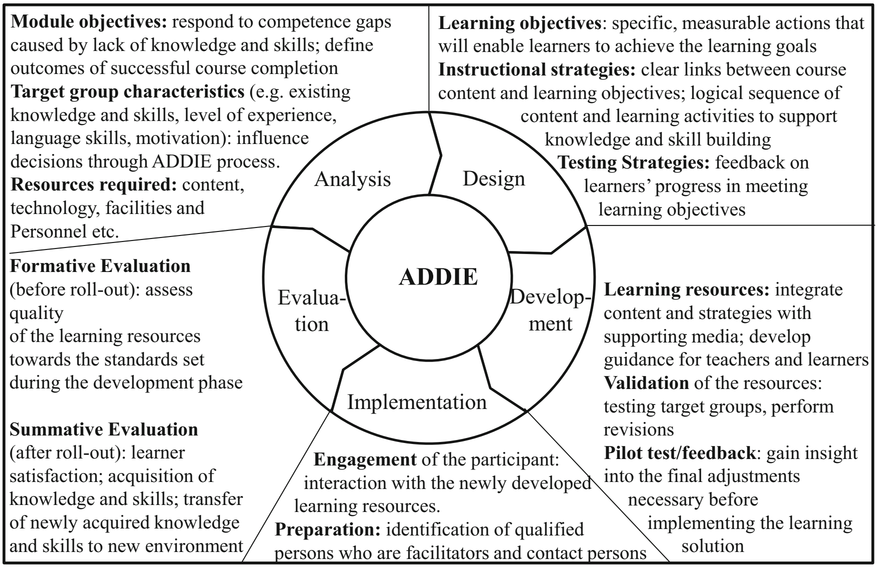

Fig. 2 Phases of the ADDIE process for the development of the education concept (based on Branch, 2009; Obsidian Learning, 2021)

Table 1 Design cycles and major decisions

Design cycle	Major decisions
1	• Development of module content • Design of problem situations • Design of problem-based learning concept • Technical platform (Moodle, Adobe Connect) • Timely and organizational implementation of virtual group work for each semester
2	• Enhanced technical implementation (Zoom) • Tool of automated group formation • Options to improve organizing high numbers of students
3 (ongoing)	• Design of gamification elements • Technical options for further learning support

requirements; if necessary, these represent the basis for the next design process as modified requirements.

In total, we went through two design cycles so far and are currently working on the third cycle. During and after each cycle, we gathered feedback from the students. In Table 1, we summarize the three design cycles along with their major decisions.

5 Design of a Virtual Problem-Based Education Concept for Smart Cities

5.1 Module Structure and Examination

The "Digital Transformation" module is divided into five learning units,[2] each requiring 60 hours of work during the semester. The virtual group work is integrated in the third learning unit to provide students with the required skills and competences to contribute to the transformation process of cities toward smart cities. In the group work, 20 out of 100 module points can be achieved. The remaining 80 module points are part of the module's final written examination. Consequently, participation in the virtual group work is voluntary for the students insofar as the module can also be passed without the virtual group work; however, the 20 points to be achieved through this problem-based group work cannot be compensated (DR3). The virtual group work is divided into three grading domains, with the individual performance outweighing the group performance in total:

1. **Individual performance I**: elaboration of one role and the respective argumentative structure as part of an elevator pitch lasting 90 s (Denning & Dew, 2012) (equivalent to approximately half a page of continuous text).
2. **Group performance**: design of a one-page handout and slides for the final presentation as well as development of a solution for the problem situation in the form of a 3-minute wrap-up.
3. **Individual performance II**: writing of a brief individual (critical) reflection of the group work (maximum two pages; step 8 in Fig. 1).

The semester starts with a virtual meeting to welcome the students and explain the module structure and the timeline of the group work. Following this, the students are able to register themselves for one of the groups via the learning platform Moodle. After a second meeting, the kick-off meeting for the group work phase, the groups will get in touch and agree on three preferences regarding the available problem situations, which they submit. The groups are then automatically assigned by a self-developed VBA (Visual Basic for Application) script to the problem situations in line with their preferences. For synchronous coordination, collaboration, and joint work, each group is provided with a Jitsi room. The main group work phase lasts 6 weeks, in which the students work on the problem situations following the seven-step. A number of support forums (between students), FAQs, and instruction documents are intended to support the students in their most frequent questions. Beyond that, a weekly consultation hour is offered for questions not addressed in the support materials. During this time, the students also prepare

[2] (1) Concepts and technologies of digital transformation, (2) changed value creation through digitization, (3) digitization of cities and traffic, (4) digitization of the financial sector, and (5) use and success of information systems in the age of digitization.

an interim and final presentation, as well as a handout for the other students. The final presentations take place on 4 to 5 evenings via Zoom. The reflection paper (see Fig. 1; step 8) is submitted by the students in PDF format via the learning platform. Students will be notified of the achieved points via the learning platform before the exam.

With this particular group work setting, several of our DRs are addressed. The students are required to playfully design an archetypical role and the respective argumentations with concepts of smart cities and digital transformation. By doing so, we intend to support longer and more intense engagement with the course and learning contents as well as with the module as a whole (DR5). This involves weighing up individual arguments, holding substantive discussions with fellow students, and debating solutions. In addition, compared to other design options, this education concept also enables large numbers of participants to be supervised and examined (DR4b) as well as the virtual implementation and realization (DR1).

5.2 Context of the Problem Situations

In the thematic context of the learning unit "Digitization of Cities and Transport," the socio-technical interconnections of the digital transformation are especially pronounced. Based on the six smart city domains of Giffinger et al. (2007; Giffinger & Haindlmaier, 2010), complex problem situations are developed, each with at least eight different roles of the city development committee of the fictitious city "Neuhagen" (e.g., Marc Mayor, Eric Entrepreneur, Bert Background Information). The roles represent archetypical positions with regard to the respective problem situation and address contradictory, complex, and diverse concepts of the transformation of cities toward smart cities. Fifteen problem situations are currently available. Table 2 provides an overview of six problem situations. Within each problem situation, different smart city concepts and challenges are addressed, thus stimulating the learning of different smart city competences. Each problem situation focuses on a consistent set of smart city competences (DR6), e.g., decision-making and problem-solving, teamwork, specific technologies, stakeholder management and citizen engagement, smart city management and planning competences, entrepreneurial competences, resilience, and sustainability competences.

The problem situations are based on current technological developments as well as real problems discussed in media and press in recent years. Figure 3 shows an exemplary problem situation (upper part) and the structure of a role developed as part of the group solution (bottom part). Figure 4 illustrates one possible solution approach.

Table 2 Overview over six exemplary problem situations

Smart governance: design and use options for an unused area (former airport) in the city **Addressed concepts**: *smart shopping, value co-creation, ambient-assisted living, smart home, smart waste, smart lighting, smart buildings, virtual and augmented reality, beacons, location-based services* **Possible solution**: a smart city area concept with shopping facilities and social smart housing for all generations and needs enriched with smart technologies and solutions
Smart economy: advantages and disadvantages of the use of industrial robots **Addressed concepts**: *digital transformation, human-machine collaboration, industrial robots, IT threats, IT security, hacker attacks, lifelong learning* **Possible solution**: collaboration of humans and robots; robots not as substitute for employees but a supplement; further training and training on the job for employees addressing fears and challenges but also highlighting the chances and potentials
Smart people: use of digital media and tablets in the classroom at school **Addressed concepts**: *blended learning, lifelong learning, technostress, media and digital literacy, bring your own device (BYOD), IT security, data security, applications, big data, digital schools* **Possible solution**: pilot use of tablets in some classes to test potentials and identify challenges in combination with a media concept for teachers; implementation of education apps in the classroom; maintenance and servicing concept for the technology
Smart mobility: problematic parking situation in "Neuhagen" **Addressed concepts**: *smart parking, more advanced systems, soil sensors in streets, computer vision, lidar sensors in buildings, artificial intelligence for forecasting, autonomous vehicles, e-scooters, e-bikes, smart people, environmental awareness, sharing concepts* **Possible solution**: use of smart mobility systems, smart parking, reduction of individual traffic through mobility as a service, ride-sharing services, increased the attractiveness of public transport
Smart environment: use of smart technologies in a city hall building and the associated new construction or modernization of the building **Addressed concepts**: *sensors, actuators, preconditions for smart buildings, information and communication technologies (ICT), cyberphysical systems, wearables, e-health, data security, chatbots as governmental service agents* **Possible solution**: modernization of the existing building to create the prerequisites for a smart building (such as connectivity of personal wearables and the room climate control) in supplement with a new building/extension
Smart living: use of smart home technologies and privacy issues **Addressed concepts**: *smart home technology, internet of things (IoT), open and closed systems, transmission standards, information and communication technologies (ICT), big data, data security, ambient-assisted living systems, freemium, pay-per-use, smart service, cyberphysical systems* **Possible solution**: "Neuhagen" as a model city for smart homes can be subsidized with public funding as part of the smart city initiative in order to reach the environmental requirements; smart home technology implementation to support elderly or disabled people

6 Evaluation and Next Steps

Student feedback on the implementation of problem-based learning and learning goal achievement at the end of the 2019/2020 winter semester (first semester of implementation) was very positive. The module evaluation of 28 students also showed a very good average score of 1.43 for the module (rating of 1–5, from very

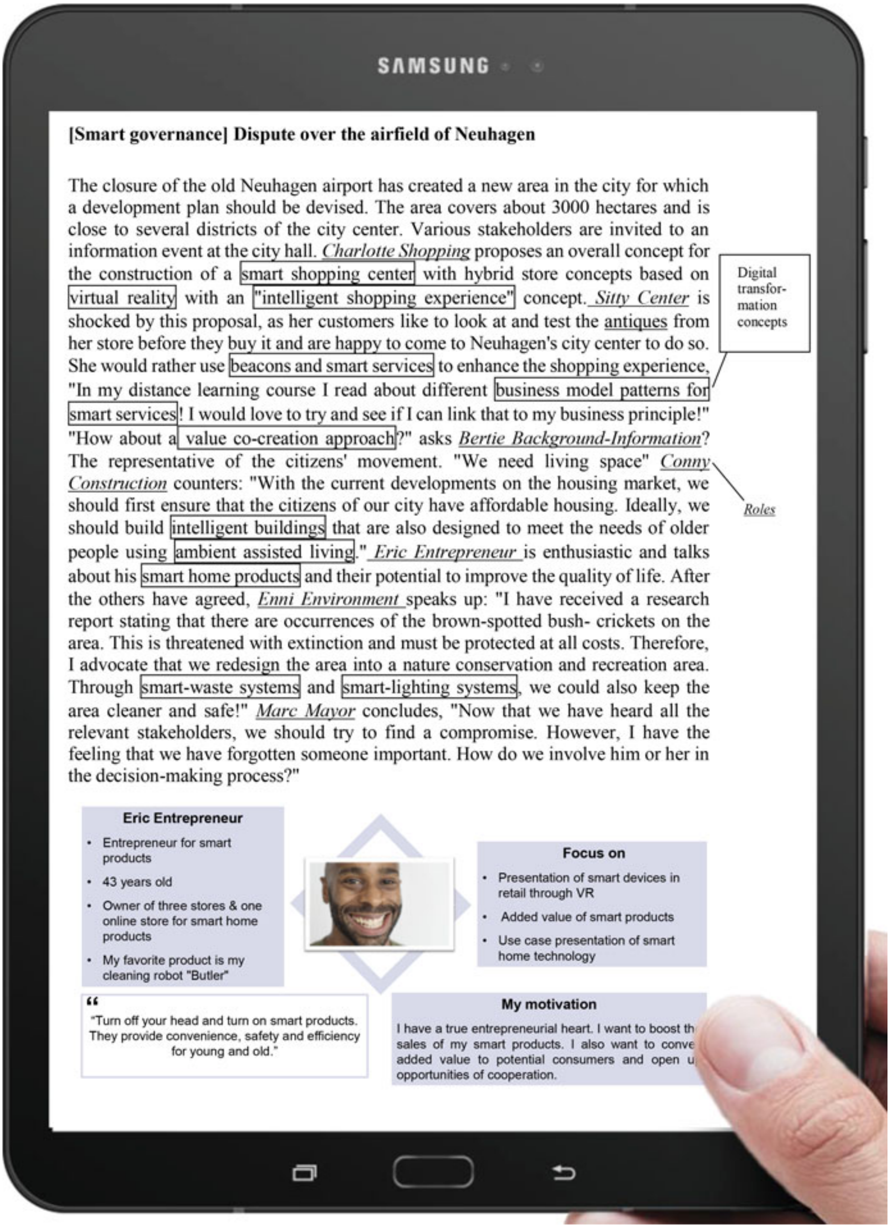

Fig. 3 Exemplary problem situation (concepts of the transformation of cities in boxes and roles underlined) and design of a role

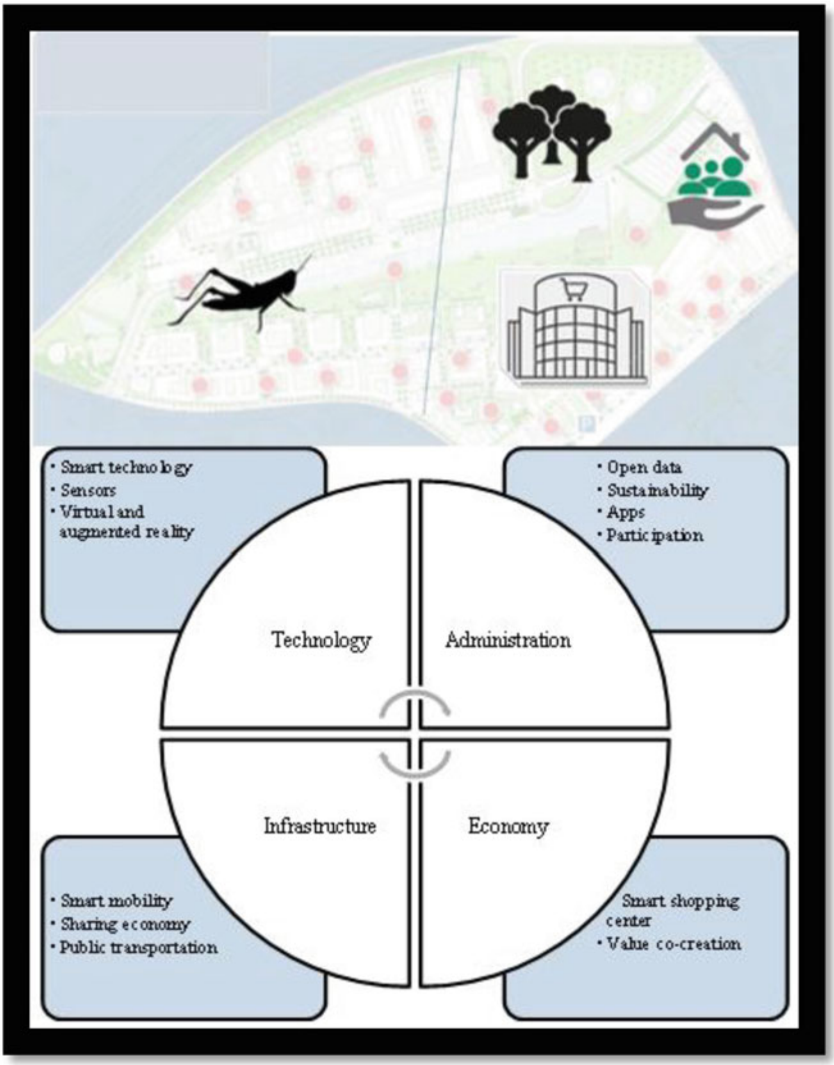

Fig. 4 Possible solution of the problem situation

good to poor). The students further highlighted the high quality of the group work and felt persistence of the learned contents as well as trained competences. However, students pointed out some aspects to be improved: the technical implementation of the virtual group work (change from Adobe Connect to Jitsi and Zoom, DR1, DR2), the time span of the group work (extension of the group work from 4 to 6 weeks, DR2), and further material on the requirements of the virtual group work and problem-based learning (in the form of notes). The notes on the one hand communicated concrete expectations regarding the interim and final presentations and on the other hand supplemented the content of the group work (especially formulation of further problem situations and roles). In addition, a student assistant was assigned for organizational support in future semesters.

In the following semesters, there were only few suggestions for improvement by the students, although the increasing number of participants in the group work (WS 2019/2020, 95; SS 2020, 150; WS 2020/2021, 229; as well as in SS 2021 208 students) resulted in a need to optimize the supervision and realization of the group work. The efficient design of group presentations and the supervision of large numbers of students are thus at the forefront of current further developments. It is currently being analyzed how the virtual group work's supervision can be further improved in terms of efficiency, which aspects of supervision and support can be (further) automated, and at which point individual support for students is definitely required. Evaluating the module results for the last three semesters (SS 2020, WS 2021/22, and SS 2021), students participating in the virtual group work achieve around four points more in the exam than students who do not participate in the group work, leading on average to a better grade.[3]

In addition, a holistic gamification concept is developed to create further incentives for students to actively shape their learning process not only during the group work, in which problem-based learning is anchored, but throughout the whole semester (DR5). For example, a holistic gamification-based education concept requires knowledge of the different motives and goals of the students for the successful completion of the module. The different student motives and goals determine the individual learning progress. For example, a level system with conditional unlocking of certain learning elements and contents is intended to support the students in the structured, step-by-step execution of the group work based on the seven-step. After the fourth step (systematic knowledge deepening), the students receive, e.g., supporting materials for the formulation of learning objectives, which have to be worked out in the fifth step. The level unlocking is complemented with motivational messages such as "Now you are ready for the intermediate presentation!" and "Congratulations. You have completed all the steps of problem-based learning. You are ready for the final presentation!" Conditional unlocking also supports supervisors in that questions about the next steps in the process, as well as the preparatory work students are doing, are more guided and accompanied (e.g., for the interim presentation). If the students receive all information at once at the beginning, there is a high risk that students are overwhelmed by the number of things to consider and remember. As a result, they will not remember relevant information when they need it. Badges such as "Bug Hunter" for identifying errors in the course materials should also provide students with an extrinsic incentive to help improve the course material. Finally, students will also be able to embed the faces of their roles as avatars in the learning platform. The different motives and goals of the students are taken into account in the final concept

[3] In the German system, grades range from 1.0 (with honors) to 5.0 (fail) with steps of 0.3 and 0.7, e.g., 1.3 or 1.7. In the exam, the grades are distributed in five-point steps.

through different gamification elements, so that as far as possible all students receive gamified support according to their preferences. For example, badges to be achieved provide an incentive for the "achiever" player type to actively participate in the gamified learning environment, while for "explorers" new discovery opportunities in the learning platform provide greater incentives (Anschütz et al., 2020). The gamification concept is currently being conceptualized.

7 Transferability of the Approach and Outlook

The presented virtual education concept represents a design option for problem-based learning in a virtual form and can be transferred as well as adapted if necessary to other courses. Other forms of designing problem-based learning can be found, for example, in Hung et al. (2008) and for German-speaking lecturers in Müller Werder (2013). Especially due to the current Covid-19 protection measures, the virtual format also offers potentials for education concepts in presence, since the individual steps of the problem-based education concept do not necessarily have to be gone through in presence but can be transferred to a virtual or hybrid format relatively easily.

A problem-based education concept such as the one presented in this chapter requires constant support for the students from supervisors. This is particularly the case in a virtual implementation, since students often lack the exchange with fellow students. In such an (virtual) education concept, however, communication and interaction are in particular essential for successful completion of the group work. The organizational effort of group work can be reduced for large numbers of students by automated group selection activities as well as by consolidated information transfer of the groups to the chair. Nevertheless, a certain effort remains, especially due to the evaluation of the individual examination performances and coordination with the supervisors. In addition, due to problems with the students' collaboration in groups as well as discontinuation of group work, the intervention of the supervisors is needed throughout the group work phase.

For the virtual group work, it was necessary for the students to familiarize themselves intensively with the topics of the entire module (this was also confirmed by the students in the module evaluation). We also observed an unusually high participation rate of students in the module's final exam (compared to other modules). While in other modules many students often withdraw shortly before the exam, the group work seems to have a positive effect on the exam participation rate. The difference between the number of group work participants and exam participants has been 15–20 students in each exam during the last three semesters. While we have to admit that part of this persistence is probably related to the fact that it is not possible to carry over the points achieved from group work into following semesters[4] (legal restriction), feedback from students still indicates a

[4] Students would have to repeat the group work exercise in the next semester.

positive impact of the group work on the willingness to take the exam. With values between 35 and 50% in the last four semesters, the activity rate, which illustrates the relationship between enrollment numbers and exam numbers, is higher than the average activity rate at the faculty (around 30%). The average exam grade of 2.3 is also higher than the average exam grade of other modules in the faculty (around 2.6).

Overall, the implementation of the virtual education concept based on problem-based learning is an enrichment of the distance-learning program at the University of Hagen. The exchange among the students and with the supervisors is valuable for the further development of the education concept. For example, due to tight contact with the students, opportunities arose for the implementation of specific guest lectures (e.g., a virtual smart factory tour) and the revision of learning contents. Another advantage of the concept is that the learning content and smart city competences are not only learned for the exam but are processed more substantially and cognitively, thus being present over a longer period. The complex problem situations and group discussion, involving transfer, conflicts, and emotional reactions, make the learned knowledge and competences applicable and accessible in everyday situations (Weiss, 2003; Hung et al., 2008). Further observation and analysis will nevertheless have to address how the transfer of such an education concept, which is also more complex for the students, affects other modules and the success of the students when several modules use these concepts in parallel.

The described education concept for the module "Digital Transformation" at the University of Hagen as well as the development along the ADDIE design process support intensive and qualitative teaching and learning as well as high persistence of the learning content. For university education concepts, but especially for the accompaniment of change processes in cities toward smart cities, it is not only about content and concepts but above all about debates, discussions, and negotiations about different possibilities which are addressed through the problem-based learning approach. With our virtual education concept, we provide future city stakeholders with competences that allow them to work constructively toward meaningful, socially accepted solutions that are both feasible and fundable.

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