Universität Hamburg
DER FORSCHUNG | DER LEHRE | DER BILDUNG

FAKULTÄT
FÜR MATHEMATIK, INFORMATIK
UND NATURWISSENSCHAFTEN

Intelligent Assistance Systems for the Smart Utilization of Participation Data for Urban Planning and Design

Cumulative Dissertation to achieve a Doctoral Degree at the Faculty of Mathematics, Informatics, and Natural Sciences

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2026
Hamburg, Germany

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Date of the Disputation:	08.10.2026

Abstract

Motivation & Research Goal

Citizen participation has become an important part of urban planning, enabling the incorporation of local knowledge to increase legitimacy and create public value. The increasing digitalization of participation has significantly expanded opportunities for citizen engagement through online participation platforms. However, these platforms also introduce new challenges. Citizens often receive insufficient guidance when formulating contributions, resulting in short, unstructured, or incomplete submissions. At the same time, urban experts face growing difficulties in analyzing large volumes of participation data. Recent advances in Artificial Intelligence (AI), particularly Machine Learning (ML) and Large Language Models (LLM), provide new opportunities to address these challenges. Nevertheless, knowledge for integrating AI into urban participation processes remains limited. Thus, this dissertation investigates how AI can support both citizens during participation and urban experts during the subsequent analysis of participation data.

Research Design

This cumulative dissertation follows the Design Science Research (DSR) paradigm to investigate the design, implementation, and evaluation of AI in urban participation. The research comprises twelve scientific peer-reviewed publications that employ various research methods, including literature reviews, interviews, workshops, prototype evaluations, ML development, and the Knowledge Discovery in Databases (KDD) framework. The research goal is structured around three research questions addressing (RQ1) the design of intelligent assistance systems supporting citizens during urban participation, (RQ2) the information and data required for citizens and subsequent analytical processes, and (RQ3) the design of AI-supported systems assisting urban experts in analyzing citizens' contributions.

Results

Across the included studies, numerous AI-supported prototypes were designed and evaluated with citizens and urban experts. The resulting design principles (DP) were synthesized into generalized meta-design principles (MDP) and consolidated into an initial higher-level design theory. The findings demonstrate that AI can support citizen participation and urban experts. For citizens, the developed artifacts show that AI-supported feedback, adaptive questioning, and conversational assistants improve the comprehensibility and completeness of citizen contributions. For urban experts, the developed analytical systems demonstrate that classification, clustering, and LLM can support urban experts in the analysis of participation data. For this dissertation, all the identified design principles were synthesized into 17 meta-design principles organized into eight design clusters, representing recurring design mechanisms for AI-supported urban participation.

The dissertation contributes to both research and practice. From a theoretical perspective, it synthesizes the findings of twelve publications into a consolidated body of prescriptive design knowledge to constitute an initial *Type V* theory for design and action, providing generalized guidance for designing AI-supported urban participation systems. From a practical perspective, the dissertation contributes multiple validated AI-supported prototypes demonstrating how AI can be integrated into existing participation processes.

Limitations

However, some limitations should be considered. The empirical studies were primarily conducted within German urban planning contexts and therefore reflect limited cultural, political, and administrative diversity. Furthermore, most evaluations followed qualitative DSR approaches, limiting statistical generalizability and long-term observations of system adoption. In addition, the rapid evolution of AI technologies should be considered, and this dissertation only presents a subset of existing solutions.

Future Research

Future research should investigate AI-supported participation systems across diverse cultural and governance contexts, while conducting long-term field studies to evaluate organizational adoption and sustained user interaction. Furthermore, emerging technologies such as multimodal foundation models, AI agents, digital twins, and urban data spaces provide promising opportunities to extend intelligent participation systems beyond the approaches investigated in this dissertation.

Collectively, the presented findings provide a comprehensive foundation for advancing intelligent urban participation systems that combine effective citizen engagement with scalable, trustworthy AI-supported analytical processes.

Keywords

Citizen Participation, Urban Planning Data Analysis, Artificial Intelligence, Design Science Research

Kurzfassung

Motivation & Forschungsziel

Bürgerbeteiligungen sind zu einem wichtigen Bestandteil der Stadtplanung geworden, um lokales Wissen einzubeziehen, die Legitimität zu stärken und einen öffentlichen Mehrwert zu schaffen. Die zunehmende Digitalisierung hat die Möglichkeiten durch digitale Beteiligungsplattformen erheblich erweitert. Diese bringen jedoch auch neue Herausforderungen mit sich. Bürgerinnen und Bürger erhalten bei der Formulierung ihrer Beiträge oft keine Unterstützung, was zu kurzen, unstrukturierten oder unvollständigen Eingaben führen kann. Gleichzeitig sehen sich urbane Expertinnen und Experten mit wachsenden Herausforderungen bei der Analyse großer Mengen konfrontiert. Jüngste Fortschritte im Bereich der künstlichen Intelligenz (KI), des maschinellen Lernens (ML) und großer Sprachmodelle (LLM), bieten neue Möglichkeiten, diese Herausforderungen anzugehen. Dennoch ist das Wissen über die Integration von KI in städtische Beteiligungsprozesse begrenzt. Daher untersucht diese Dissertation, wie KI sowohl in der Beteiligung als auch bei der Analyse der Beteiligungsdaten unterstützen kann.

Forschungsdesign

Diese kumulative Dissertation folgt dem Design Science Research (DSR) Paradigma, um die Konzeption, Umsetzung und Bewertung von KI in der urbanen Partizipation zu untersuchen. Diese Dissertation umfasst zwölf wissenschaftliche von Expertinnen und Experten begutachtete Publikationen, die verschiedene Forschungsmethoden wie Literaturrecherchen, (Experten-)Interviews, Workshops als auch das Knowledge Discovery in Databases (KDD) Framework anwenden, um Prototypen und ML-Modelle zu entwickeln. Die Forschung gliedert sich in drei Forschungsfragen, die sich mit (RQ1) dem Design intelligenter Assistenzsysteme zur Unterstützung von Bürgerinnen und Bürgern bei der städtischen Partizipation, (RQ2) den für nachfolgende Analyseprozesse erforderlichen Informationen und Daten sowie (RQ3) dem Design KI-gestützter Systeme zur Unterstützung von Expertinnen und Experten bei der Analyse der Beiträge befassen.

Ergebnisse

In den einbezogenen Studien wurden zahlreiche KI-gestützte Prototypen iterativ entwickelt und gemeinsam mit Bürgerinnen und Bürgern als auch urbanen Expertinnen und Experten evaluiert. Die daraus resultierenden Gestaltungsprinzipien wurden zu Meta-Gestaltungsprinzipien (MDP) zusammengefasst und zu einer initialen übergeordneten Theorie konsolidiert. Die Ergebnisse zeigen, dass KI, vielfältig unterstützen kann. Die für Bürgerinnen und Bürger entwickelten IT-Artefakte zeigen, dass KI-gestütztes Feedback, und Gesprächsassistenten die Verständlichkeit und Vollständigkeit der Beiträge verbessern. Im Bereich der urbanen Expertinnen und Experten wird deutlich, dass die entwickelten

Klassifikations- und Clustering-Ansätze als auch große Sprachmodelle die Analyse von Beteiligungsdaten unterstützen können. Für diese Dissertation wurden alle identifizierten Gestaltungsprinzipien zu 17 Meta-Gestaltungsprinzipien zusammengefasst, die in acht Cluster gegliedert sind und wiederkehrende Mechanismen für KI-gestützte städtische Partizipation darstellen.

Die Dissertation leistet sowohl einen Beitrag zur Forschung als auch zur Praxis. Aus theoretischer Perspektive fasst sie die Ergebnisse von zwölf Publikationen zu einem konsolidierten Korpus normativen Designwissens zusammen und bilden eine initiale Typ-V-Theorie (Gestaltung und Handlung), die Leitlinien für die Gestaltung KI-gestützter Systeme zur städtischen Partizipation liefert. Aus praktischer Perspektive trägt die Dissertation mehrere validierte KI-gestützte Prototypen bei, die veranschaulichen, wie KI in bestehende Partizipationsprozesse integriert werden kann.

Limitationen

Bei der Anwendung und Weiterentwicklung der Ergebnisse sind einige Einschränkungen zu berücksichtigen. Die empirischen Studien wurden vorwiegend im Kontext der deutschen Stadtplanung durchgeführt und spiegeln daher nur eine begrenzte kulturelle, politische und administrative Vielfalt wider. Darüber hinaus folgten die meisten Auswertungen qualitativen Ansätzen, was die statistische Verallgemeinerbarkeit und langfristige Beobachtungen zur Systemakzeptanz einschränkt. Zudem sollte die rasante Entwicklung von KI-Technologien berücksichtigt werden, wovon diese Dissertation nur einen begrenzten Teil berücksichtigt.

Ausblick

Zukünftige Forschungsarbeiten sollten KI-gestützte Partizipationssysteme in vielfältigen kulturellen und regierungsnahen Kontexten untersuchen und dabei langfristige Feldstudien durchführen, um die organisatorische Akzeptanz und die nachhaltige Nutzerinteraktion zu bewerten. Darüber hinaus bieten neue Technologien wie multimodale Grundmodelle, KI-Agenten, digitale Zwillinge und städtische Datenräume vielversprechende Möglichkeiten, intelligente Partizipationssysteme über die in dieser Dissertation untersuchten Ansätze hinaus zu erweitern.

Insgesamt bieten die vorgestellten Ergebnisse eine umfassende Grundlage für die Weiterentwicklung intelligenter städtischer Partizipationssysteme, die eine effektive Bürgerbeteiligung mit skalierbaren, vertrauenswürdigen und KI-gestützten Analyseprozessen verbinden.

Schlagwörter

Bürgerbeteiligung, Stadtplanung, Datenanalyse, Künstliche Intelligenz, Design Science Research

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List of Abbreviations

ACM	Association for Computing Machinery
AI	Artificial Intelligence
AIS	Association for Information Systems
API	Application Programming Interface
CRediT	Contributor Role Taxonomy
CSCW	Conference on Computer-Supported Cooperative Work and Social Computing
CSS	Cascading Style Sheets
CSV	Comma-Separated Values
DESRIST	International Conference on Design Science Research in Information Systems and Technology
DP	Design Principle
DSR	Design Science Research
ECIS	European Conference on Information Systems
EGOV	Electronic Government
FEDS	Framework for Evaluation in Design Science Research
GenAI	Generative Artificial Intelligence
GloVe	Global Vectors for Word Representation
GPT	Generative Pre-trained Transformer
HCI	Human-Computer Interaction
HICSS	Hawaii International Conference on System Sciences
HMD	HMD Praxis der Wirtschaftsinformatik
HTML	HyperText Markup Language
ICIS	International Conference on Information Systems
IS	Information Systems
ISS	Issue
IT	Information Technology
KDD	Knowledge Discovery in Databases
LLM	Large Language Model
LMM	Large Multimodal Model

MDP	Meta-Design Principle
ML	Machine Learning
MR	Meta-Requirement
MVP	Minimum Viable Process
NLP	Natural Language Processing
PACIS	Pacific Asia Conference on Information Systems
RAG	Retrieval-Augmented Generation
RG	Research Goal
ROI	Return on Investment
RQ	Research Question
SWOT	Strengths, Weaknesses, Opportunities and Threats
UI	User Interface
UPP	Urban Participation Platform
VR	Virtual Reality
WebXR	Web Extended Reality

1 Introduction

Urban areas have become the major living environment for the global population (Butt, 2021; United Nations, 2022). In Europe, more than two-thirds of the population already resides in cities, and forecasts indicate a continued concentration of people, resources, and activities in urban regions (United Nations, 2018). While cities are often framed as environments of economic growth, cultural exchange, and innovation, they simultaneously face increasing social tensions, inequality, and conflict (Stelzle et al., 2017). These contradictions render urban planning and development increasingly complex and contested endeavors (Borchers, Gierlich-Joas, Tavanapour, et al., 2024; Mohsin et al., 2019). In response to these increasing challenges, governments and planning authorities have gradually shifted away from purely technocratic and expert-driven planning paradigms toward more participatory and inclusive approaches (Bono Rossello et al., 2023; Stelzle & Noennig, 2017).

Citizen participation has emerged as a central instrument to integrate local knowledge, increase transparency, and enhance the legitimacy and acceptance of urban projects (Stelzle et al., 2017). At the same time, advances in digital technologies have enabled new forms of participation that promise to scale engagement beyond traditional on-site formats (Royo et al., 2020). However, while digital participation platforms have substantially increased the volume of citizen contributions, they have also exposed fundamental limitations in how participation data is collected, processed, and utilized (Borchers, Cao, Tavanapour, et al., 2024; Romberg & Escher, 2024).

1.1 Motivation and Problem Statement

Urbanization is not merely a demographic trend. It is a transformative force that affects social relations, economic opportunities, and political governance (Borchers, Soroko, Tavanapour, et al., 2024; Caragliu et al., 2011). As cities grow denser and more diverse, competition for limited urban resources, such as affordable housing, public space, mobility infrastructure, and environmental quality, intensifies. These pressures disproportionately affect all citizens and exacerbate existing inequalities, leading to social fragmentation and contestation within urban societies (Bono Rossello et al., 2025). Urban planning is inherently implicated in these dynamics, as planning decisions shape the distribution of opportunities and burdens across different population groups.

Historically, planning processes were predominantly expert-led, relying on professional knowledge from architects, engineers, and administrators (Stelzle et al., 2017). While this approach enabled efficiency and technical rigor, it often neglected

the lived experiences, needs, and values of local residents and those affected by urban development and change. Numerous high-profile urban projects have demonstrated that neglecting citizen perspectives can lead to strong resistance, delays, increased costs, and long-term damage to public trust (Borchers et al., 2023b; Müller-Seitz et al., 2016). Against this backdrop, citizen participation has gained prominence as both a democratic ideal and a pragmatic tool (Royo et al., 2020). From a normative perspective, participation is rooted in principles of democratic governance, inclusion, and fairness (Arnstein, 1969). Citizens are increasingly recognized not merely as passive recipients of planning outcomes but as legitimate stakeholders with valuable local knowledge (Cantador et al., 2017). From a meta-perspective, participation is expected to improve the quality of planning outcomes by incorporating diverse perspectives, identifying potential conflicts early, and fostering acceptance and ownership among affected communities (Romberg & Escher, 2024; Stelzle & Noennig, 2017).

However, despite widespread consensus on the importance of participation, its practical implementation remains highly challenging. Traditional participatory formats such as public hearings, workshops, and neighborhood meetings are resource-intensive and often have limited reach (Stelzle & Noennig, 2017). They typically require physical presence, specific time commitments, and a certain level of confidence and expertise, which systematically excludes large segments of the population (Stelzle & Noennig, 2017). As a result, participation processes frequently suffer from low representativeness and limited scalability (Müller, 2021; Panori et al., 2021). Digital participation tools have been introduced as a solution to these challenges. Online platforms, mobile applications, and interactive mapping tools enable citizens to participate asynchronously and independently of location. These tools have significantly lowered participation barriers and, in many cases, increased the number of contributors per project (Lieven, 2017; Royo et al., 2020). Yet, the digitalization of participation has not eliminated the core challenges of participatory planning. While digital tools facilitate the collection of large volumes of citizen input, they also generate vast amounts of unstructured and heterogeneous data (Romberg & Escher, 2024). Contributions often consist of free-text comments, short statements, emotional expressions, or loosely formulated ideas (Borchers, Gierlich-Joas, Tavanapour, et al., 2024). The content varies widely in terms of length, quality, specificity, and relevance. Moreover, digital participation tends to amplify asymmetries in communicative competence, as citizens differ significantly in their ability to articulate coherent and actionable contributions (Borchers, Habash, et al., 2025; Romberg et al., 2022). From the perspective of urban planners and public authorities, this creates a fundamental scalability problem. The manual analysis of hundreds or thousands of qualitative contributions is time-consuming, costly, and prone to inconsistencies (Lago et al., 2019; Romberg & Escher, 2024). As

participation scales up, the gap between the volume of collected input and the capacity to meaningfully analyze it widens (Arana-Catania et al., 2021a; Davies et al., 2022).

The recent advances in artificial intelligence (AI) and machine learning (ML) offer promising opportunities to address these challenges. Techniques such as natural language processing (NLP), automated classification, sentiment analysis, and summarization could be used in this domain if they generate accurate predictions (Cai, 2021). More recently, large language models (LLMs) and hybrid architectures have enabled more context-aware and flexible forms of interaction and analysis (Borchers, Uba, et al., 2026; Pinto & Macadar, 2024). However, the application of these technologies in the domain of citizen participation remains fragmented and underexplored (Romberg & Escher, 2024).

1.2 Research Goal and Research Questions

Building on the challenges outlined above, this dissertation pursues the overarching research goal (RG) of advancing the design and implementation of intelligent assistance systems for participatory urban planning. Rather than focusing on participation as an end, the research adopts a socio-technical perspective that conceptualizes participation as a data-driven process encompassing the collection of citizens' contributions, the motivation of citizens, and the development of approaches and tools for subsequent processes to analyze these data by urban experts to support decision-making (Romberg & Escher, 2024; Stelzle et al., 2017).

RG	Development of intelligent assistance systems to support citizens in the participation process and enhance data collection, as well as tools for the smart utilization of participation data to support urban experts in sense-making and decision-making.

This research goal emphasizes three key aspects. First, it focuses on *designing* IT artifacts, thereby aligning with the design science research paradigm. Second, it highlights *intelligent assistance systems*, understood as socio-technical systems that support human capabilities rather than replace human judgment (Müller, 2021; von Heyden & Parsons, 2025). Third, it foregrounds the *smart utilization of participation data*, shifting attention from mere data collection to meaningful data processing and use in planning and decision-making contexts.

To operationalize this research goal, the dissertation is structured around three interrelated research questions (RQs). Together, these questions cover the RG, from citizen contributions to expert analysis and interpretation.

RQ1	How should intelligent assistance systems be designed to support citizens in participating in urban planning projects?

RQ1 addresses the input side of participatory processes. It focuses on citizens as primary contributors and examines how intelligent systems can lower participation barriers while simultaneously improving the relevance and comprehensibility of citizens' contributions. This question is motivated by the scientific literature, which highlights that digital participation often yields short, vague, or poorly structured inputs that are difficult to interpret and use (Cai, 2021; Romberg & Escher, 2024). From a design perspective, RQ1 explores how contextual information, feedback mechanisms, and conversational interfaces should be designed to support citizens in articulating their needs, ideas, and arguments more clearly. The relevance of this question lies in its potential to enhance both inclusiveness and effectiveness (Stelzle et al., 2017). By supporting citizens during the contribution process, intelligent systems can help bridge differences in expertise, language proficiency, and communicative skills, thereby fostering more equitable participation (Borchers et al., 2023b).

RQ2	What data and information are relevant for citizens and the analysis processes?

RQ2 shifts the focus from interaction design to the data. It examines what types of data and content should be collected during participatory processes to support meaningful analysis and decision-making. While participation platforms often collect large amounts of unstructured text, not all data is equally useful for planning purposes (Royo et al., 2020). This RQ addresses the challenge of balancing openness and structure. On the one hand, participation should often allow citizens to express themselves freely and authentically, depending on the phase of the urban project (Stelzle et al., 2017). On the other hand, data needs to be structured to enable automated processing and aggregation (Cai, 2021). The relevance of RQ2 lies in its contribution to bridging the gap between citizen-generated content and analytical requirements.

RQ3	How should citizen contributions be evaluated automatically and visualized for urban experts?

RQ3 addresses the output side of participatory processes, focusing on urban planners and other professional stakeholders who must analyze citizens' contributions and extract insights and requirements. It examines how intelligent systems should be designed to support intelligent, therefore, the (semi-)automated evaluation of large-

scale citizen contributions. This question encompasses techniques for classification, clustering, sentiment analysis, and summarization, as well as the design of visualizations that enable experts to explore and interpret results effectively (Bachiller et al., 2021; Cai, 2021).

1.3 Thesis Outline

The three RQs are deliberately structured as an integrated sequence. This is done because they reflect the process of citizen participation in urban planning, in which data is usually collected by engaging citizens and then analyzed by experts, as specified in Section 1.2. Therefore, RQ1 focuses on supporting citizens during participation (input), RQ2 defines the data foundation for analysis (processing), and RQ3 addresses the utilization of results by experts (output).

Wrapper	1. Introduction
	2. Theoretical Foundation
	3. Research Design
	4. Publications
	5. Theoretical Contributions
	6. Practical Contributions
	7. Limitations
	8. Implications for Future Research
	9. Conclusion

Table 1. Outline of this cumulative Dissertation regarding the Wrapper

After this section, this cumulative dissertation follows with Section 2, in which the theoretical foundation of this work is presented. In Section 3, the research design according to the Design Science Research (DSR) Paradigm is described. In Section 4, all published publications are named, including their rankings. This also includes publications published during the dissertation period that do not contribute to the RQs. Publications which were submitted and under review, conditionally accepted or accepted but not published at the point of the submission of this dissertation, are not named in this document. Section 5 summarizes and highlights the theoretical contribution, and Section 6 the practical contribution of this dissertation. In Section 7, the limitations are named, and Section 8 outlines implications for future work. Finally, Section 9 concludes this dissertation and summarizes it.

After Section 9, all included publications are incorporated in this cumulative dissertation, and their content is shown, including authors and outlet information. Therefore, this document continues after Section 9 as shown in Table 2.

Publications	10. Publication 1	Publication C1: Toward Intelligent Platforms to Support Citizen Participation in Urban Planning
	11. Publication 2	Publication C2: Designing mobile Applications for Citizen Participation in Urban Planning
	12. Publication 3	Publication C3: Exploring AI supported Citizen Argumentation on Urban Participation Platforms
	13. Publication 4	Publication C4: Let Citizens Speak Up: Designing Intelligent Online Participation for Urban Planning
	14. Publication 5	Publication C5: Toward the ML-based Analysis of Citizens' Inputs from E-Participation in Urban Planning
	15. Publication 6	Publication C6: Designing AI-based Systems to support the Analysis of Citizens' Inputs from E-Participation
	16. Publication 7	Publication C7: Hear Me Out: Supporting Citizens to Create Comprehensible Contributions on Urban Participation Platforms
	17. Publication 8	Publication C10: Emergency Management: Designing mobile Applications to support Citizens during Storm Floods
	18. Publication 9	Publication C13: Developing Machine Learning Models for the Analysis of Citizens' Contributions from E-Participation
	19. Publication 10	Publication C14: Emergency Management: Designing Situation Maps to support Rescue Forces during Flood Disasters
	20. Publication 11	Publication C15: Facilitating Urban Participation Project with Generative AI to Support Citizen Engagement and Interaction
	21. Publication 12	Publication C16: Analyzing Data from Urban Citizen Participation by Applying the Retrieval Augmented Generation Architecture

Table 2. Outline of this cumulative Dissertation regarding the Publications

2 Theoretical Foundation

Urban planning has been a centralized responsibility in the hands of local governments, states, cities, or municipalities. It is thus often strongly influenced and regulated by public authorities, guidelines, laws, and regulations (Peter & Yang, 2019). This allows governments to shape the living and cultural space according to the government's intentions and associated policies (Bidandi & Williams, 2020; Sangawongse et al., 2021). This is still practiced and exercised in varying degrees all around the world, as is the case in Spain (Royo et al., 2020) and Germany (Lieven, 2017), but also in varying implementations in more authoritarian countries like China (Tang, 2021).

2.1 Citizen Participation

Citizen participation has become a central concept in contemporary urban planning, public administration, and governance research. It reflects a fundamental shift from expert-driven, hierarchical decision-making toward more collaborative approaches to shaping urban environments (Stelzle et al., 2017). In the context of growing urban complexity, social diversity, and political pluralism, citizen participation is increasingly regarded as both a democratic necessity and a practical instrument for improving planning outcomes (Repette et al., 2021).

Citizen participation can be defined as the active involvement of citizens in decision-making processes that affect their living environment, public services, and collective goods (Haveri & Anttiroiko, 2021; Royo et al., 2020). In urban planning, citizen participation encompasses all activities through which residents contribute their perspectives, experiences, needs, ideas, and preferences to the planning, design, and implementation of urban projects (Borchers et al., 2023b). Following this, citizens are recognized as legitimate stakeholders whose local knowledge and lived experience complement professional expertise (Stelzle et al., 2017). Citizen participation can vary in scope, intensity, and impact depending on political frameworks, legal requirements, project objectives, and the degree of openness of planning authorities. As a result, citizen participation should not be understood as a single, standardized practice but rather as a continuum of participatory forms that differ in their level of citizen influence and responsibility (Stelzle & Noennig, 2017).

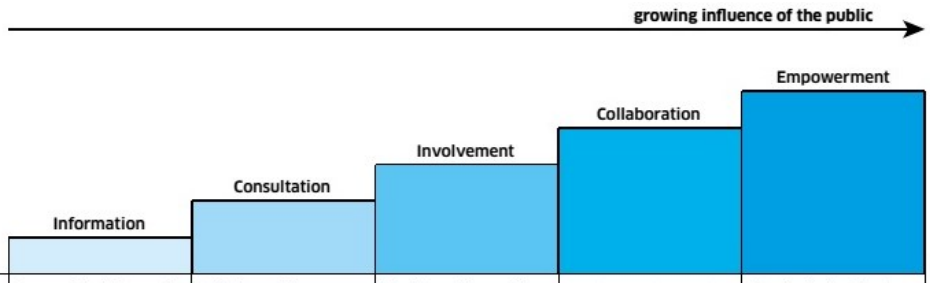
The objectives of citizen participation are multifaceted and aim to enhance legitimacy by enabling citizens to influence decisions that directly affect their daily lives and, therefore, should create public value. By opening planning processes to public input, authorities demonstrate transparency and accountability, thereby strengthening trust in institutions and governance structures (Demirdoven et al., 2020; Haveri & Anttiroiko, 2021). From a substantive perspective, citizen participation seeks to

improve the quality of planning outcomes. Citizens possess situated and experiential knowledge that is often inaccessible to planners and experts (Recalde et al., 2020). This local knowledge can help identify needs, uncover conflicts, and highlight unintended consequences of planned projects. Incorporating such insights in urban planning projects early can lead to more robust and context-sensitive solutions (Stelzle et al., 2017). Another key objective is to increase acceptance and social sustainability of urban projects. Urban development initiatives frequently face resistance when affected residents feel excluded or inadequately represented, which can lead to legal complaints and delays. When citizens perceive that their contributions and requirements are taken seriously, they are more likely to support urban projects (Borchers, Soroko, Tavanapour, et al., 2024; Rexhepi et al., 2018).

2.2 The Levels of Citizen Participation

One of the most influential foundations of citizen participation was developed by Sherry Arnstein, whose work has shaped participatory theory across urban planning, public administration, and governance. In her publication "A Ladder of Citizen Participation," published in 1969, Arnstein conceptualized participation as a hierarchical model consisting of eight distinct levels that reflect the degree of power and influence granted to citizens (Arnstein, 1969). These levels range from (1) manipulation and (2) therapy, which are categorized as non-participation, to (3) informing, (4) consultation, and (5) placation, which she described as tokenistic and symbolic forms of participation. At the upper end of the ladder, (6) partnership, (7) delegated power, and (8) citizen control represent genuine participation, as they enable citizens to directly influence or control decision-making processes (Arnstein, 1969).

Arnstein's ladder has been widely adopted as an analytical and normative framework to classify participatory approaches, ensuring that relevance lies in its explicit emphasis on power relations, making visible the implicit differences between participation as symbolic inclusion and participation as actual influence (Tritter & McCallum, 2006). Despite its widespread use, Arnstein's model has also been subject to criticism and refinement. Wouters et al. argue that the ladder's lower rungs should not be framed as participation at all, as they fail to acknowledge citizens as meaningful contributors to decision-making processes (Wouters et al., 2011) and therefore propose a reduced model as shown in Figure 1. According to this critique, approaches that merely inform or consult citizens without a credible commitment to consider their input risk undermining trust and diluting the normative promise of participation. Labeling such approaches as participatory is therefore misleading and counterproductive.



	Information	Consultation	Involvement	Collaboration	Empowerment
Objective of the participa-tion	To provide balanced and objective information to the public, to support the understanding of the problem, the altermatives, possibilities and solutions.	Include public feedback to the analysis and decisions.	Work together with the public during the process to ensure the concerns and objective are completely under-stood and taken into account	Work together with the public on every aspect inluding the alternative findings and the identification of the prioritised outcome.	The final decision is the the hand of the public.
Message to the public	We inform you.	We inform you, listen to your concerns and objectives and give feedback how this information has influenced the decision.	We work with you, to ensure that your concerns and objectives are directly included in the alternatives developed and we give you feedback about how this information influenced the decision.	We listen to your advice and ideas during the develop-ment of alternatives and integrate your advise and recom-mendations into the decision to the maximum possible extent.	We implement your decisions.
Responsibility for decision	Authorities	Authorities	Authorities	Authorities	Citizens

Figure 1. Level of Citizen Participation (Stelzle & Noennig, 2019, pp. 5, Figure 2)

Building on this critique, Wouters et al. proposed a revised conceptualization of citizen participation that explicitly excludes forms of non-participation and pseudo-participation (Wouters et al., 2011). Their model emphasizes that participatory approaches should only be classified as such if citizens' contributions are taken seriously and have the potential to influence outcomes (cf. Figure 1). This reframing shifts the focus away from the formal presence of participatory mechanisms toward their substantive impact, aligning participation values more closely with contemporary expectations of democratic governance and collaborative urban planning (Stelzle et al., 2017).

2.3 Participation Process

Citizen participation in urban planning is widely acknowledged as beneficial for legitimacy, project acceptance, and the integration of local knowledge (Borchers, Soroko, Tavanapour, et al., 2024; Borchers, Uba, et al., 2026). However, despite its normative appeal, participation often fails in practice due to unclear responsibilities, poorly defined objectives, or insufficient integration into formal planning procedures. Many participatory initiatives remain isolated activities, detached from subsequent decision-making and design phases. To address these, a structured and process-oriented perspective on participation is required. Rather than treating participation as a single event or optional add-on, it should be embedded into the overall lifecycle (Recalde et al., 2020).

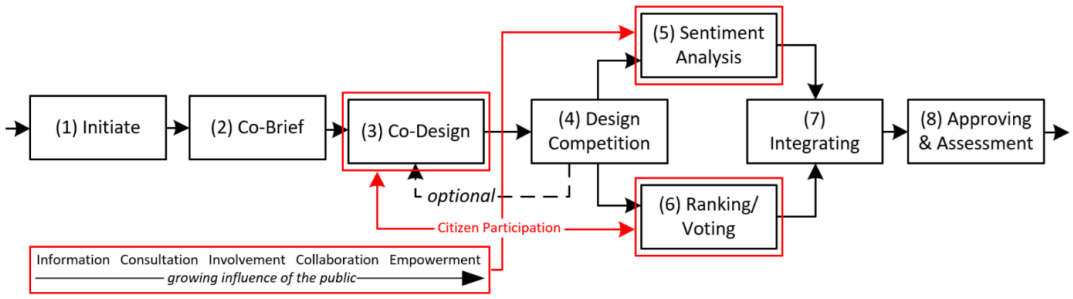


Figure 2. Overview of a holistic Process of Citizen Participation

Stelzle designed the Minimum Viable Process (MVP) for citizen participation and presents such a perspective (Stelzle et al., 2017). The relevance of the MVP lies in its balance between flexibility and structure. It does not prescribe specific methods or technologies but instead offers a procedural framework that can be adapted to different project contexts, governance settings, and participation goals. By explicitly linking participatory activities to planning and approval stages, the MVP helps practitioners avoid symbolic participation and increases the likelihood that citizen input contributes to tangible outcomes (Stelzle et al., 2020, 2021). Moreover, the MVP is compatible with both analog and digital participation formats and can therefore accommodate contemporary e-participation platforms and intelligent assistance systems. Figure 2 presents a summary of the MVP, reduced to its core steps and highlighting the participatory elements on which this work focuses (Stelzle et al., 2017, 2020).

The process begins with (1) project initiation, in which the urban project is formally defined, and a project team is assembled or commissioned. This step establishes the organizational foundation and clarifies responsibilities, resources, and timelines. Clear project ownership is essential to ensure that participatory results are later considered and not disregarded (Stelzle et al., 2021). In (2) co-briefing, the project objectives, constraints, and success criteria are jointly defined by the project lead and key stakeholders, such as planners, designers, and public authorities. This step is critical, as it determines the scope of participation and the degree of influence granted to citizens. Decisions regarding legal constraints, budgetary limits, and participation intensity are explicitly documented, creating transparency about what participation can and cannot achieve. Based on this foundation, (3) co-design constitutes the core participatory phase. Citizens are invited to contribute their needs, ideas, and perspectives through analog, digital, or hybrid formats. Depending on the target group and project context, participation may take the form of workshops, surveys, participatory mapping, online platforms, or interactive visualization tools (Stelzle & Noennig, 2017). After the co-design phase, the collected contributions are evaluated and synthesized to assess their coherence, feasibility, and relevance for the project's objectives. If contributions are contradictory, unclear, or insufficiently actionable, the process allows for iteration. The co-design phase may be repeated or adjusted by

narrowing or expanding participation to improve results. In (4) vision development and publication, urban planners and designers translate the synthesized input into several concrete project visions or design alternatives. These visions reflect both professional expertise and citizen contributions and are made publicly available to enable further feedback. Subsequently, (5) commenting allows citizens to provide qualitative feedback on the proposed visions. Citizens can express support, concerns, or suggestions for refinement. This step deepens engagement by shifting participation from open-ended ideation to the evaluation of concrete alternatives. In parallel or subsequently, (6) voting enables citizens to quantitatively express preferences among the proposed options (Fossen & Anderson, 2014). Voting provides a structured and scalable mechanism to identify priorities and dominant perspectives, complementing the qualitative insights from comments. The results from commenting and voting are then, in step (7), integrated into a comprehensive project design. This integration requires careful interpretation, balancing citizen preferences with technical, legal, and economic constraints. Transparency is crucial at this stage to explain how citizen input influenced the final design. Finally, with step (8) approval, the project is formally reviewed and authorized by the project lead and relevant planning authorities. This step ensures compliance with regulations and grants the necessary permits. Importantly, approval marks the transition from participatory design to implementation, closing the participatory loop (Stelzle et al., 2017, 2021).

The holistic participation process can be linked to the levels of citizen participation described in section 2.2, as the levels of inclusion and power can vary in steps (3), (5), and (6). During co-design (step 3), participation may range from consultation to collaboration, depending on whether citizens merely provide input or actively co-create solutions (Stelzle et al., 2017). In commenting (step 5), participation typically corresponds to consultative levels, as citizens respond to predefined project visions. Although creative freedom is limited, this stage enables focused feedback, the impact of which depends on whether comments are meaningfully considered in subsequent integration (Borchers, Gierlich-Joas, Tavanapour, et al., 2024). Voting (step 6) introduces a more formalized mechanism of influence. While voting alone does not ensure empowerment, it can support delegated influence when results significantly shape decisions. If voting outcomes are binding or clearly reflected in the final design, this step approaches higher levels of participation (Heiberg et al., 2017).

By embedding this process, cities, urban areas, authorities, and governments can reach the promised benefits of citizen participation. However, the challenges, as described in Section 1.1, exist and should be faced, as planned with this dissertation.

2.4 Urban Participation Platforms

Urban participation platforms represent a key response to the growing demand for inclusive, scalable, and transparent citizen participation (Borchers et al., 2022; Royo et al., 2020). The emergence of urban participation platforms is linked to the historical development of citizen participation in urban planning. The general trend shows a gradual shift from expert-driven decision-making toward more inclusive approaches that recognize citizens as legitimate stakeholders (Gutiérrez et al., 2018; Stelzle & Noennig, 2019). Early forms of enhanced participation were largely project-based. Participation was initiated selectively, typically when governments or investors anticipated resistance, public controversy, or legitimacy challenges related to major construction projects or neighborhood developments (Recalde et al., 2020; Yazdanpanah Shahabadi & Sajadzadeh, 2020). In such cases, participation was often motivated not solely by democratic ideals but also by economic considerations, such as reducing delays, avoiding legal disputes, and protecting return on investment (Ceballos & Larios, 2016). While these project-based approaches marked an important step toward inclusion, they were typically temporary, fragmented, and limited in scope.

Urban participation platforms enable institutionalized, continuous participation, shifting it from isolated projects to a permanent component of urban governance. By providing digital infrastructures that are always available, platforms support long-term engagement, repeated participation, and the systematic documentation of citizen input (Stelzle & Noennig, 2017). This institutionalization reflects a broader transformation toward digital government and civic technology, in which participation platforms serve as enduring interfaces between citizens and public authorities (Royo et al., 2020; Smith & Martín, 2021). Several urban participation platforms have been developed by cities and companies and deployed internationally, serving as reference implementations for digital citizen participation. Prominent examples include CONSUL, DECIDIM, and city-specific platforms such as the Urban Participation Platform Dresden (Consul Democracy, 2023; Royo et al., 2024).

DECIDIM, developed in Barcelona, follows a similar philosophy but places a stronger emphasis on transparency, traceability, and deliberation (Royo et al., 2020). DECIDIM allows citizens not only to comment and vote but also to track how their contributions are processed and integrated into decisions. This focus on procedural transparency addresses common criticisms of digital participation, such as perceived tokenism or lack of accountability. Other platforms, such as the Urban Participation Platform Dresden, illustrate how municipalities adapt participation platforms to local contexts (Jannack et al., 2020). These platforms are often integrated with municipal services and tailored to specific participation formats, ranging from urban development projects to regulatory consultations. Across these platforms, a set of

typical mechanisms for submitting proposals and applications, discussion forums for deliberation, surveys for structured feedback, and voting systems to express preferences are identified. Some platforms also offer geographic filtering and authentication mechanisms, often linked to population registries, to restrict participation to affected target groups when necessary (Repette et al., 2021). Collectively, these functions transform participation platforms into comprehensive civic infrastructures rather than isolated communication tools (Borchers, Soroko, Tavanapour, et al., 2024).

Urban participation platforms are applied across a wide range of participation contexts, from local neighborhood projects to city-wide policy initiatives. Their primary benefit lies in their ability to scale participation. Unlike on-site formats, which are constrained by time, space, and logistical resources, digital platforms enable large numbers of citizens to participate asynchronously and over extended periods (Krätzig & Warren-Kretzschmar, 2014; Royo et al., 2024). This scalability contributes to greater inclusiveness, as citizens who are unable or unwilling to attend physical meetings can still engage. Platforms also support continuous documentation, creating a transparent record of contributions, discussions, and decisions. Moreover, digital participation can be combined with analog formats, resulting in hybrid participation scenarios that leverage the strengths of both approaches (Stelzle & Noennig, 2017).

However, the application of urban participation platforms also introduces significant challenges. One recurring issue is the heterogeneity and quality of citizen contributions. Digital participation often results in large volumes of short, unstructured, or emotionally charged inputs that are difficult to interpret and integrate into planning processes (Borchers et al., 2022; Stelzle et al., 2017). Without adequate moderation or analytical support, planners may struggle to extract actionable insights from this data. Another challenge concerns engagement and motivation (Steinbach et al., 2019). While platforms lower access barriers, they do not automatically foster meaningful interaction or deliberation. Asynchronous communication, anonymity, and limited feedback can reduce the depth of discussion and citizens' perception of impact (Correia et al., 2023).

Urban participation platforms contribute to citizen participation at multiple levels, depending on how they are designed and applied. Regarding the levels of citizen participation, they can often contribute to all levels (cf. Section 2.2). However, the mere existence of a platform does not guarantee high-level participation, and the degree of empowerment depends on how citizen input is processed and integrated into decisions (Stelzle et al., 2017; Wouters et al., 2011). Furthermore, urban participation platforms can also support many steps in the holistic citizen participation process if the required functionalities are provided (cf. Section 2.3). This

usually applies to commenting and voting functions, so that the platform can be a fully digital alternative or extend on-site participation processes.

2.5 Artificial Intelligence in Citizen Participation

Artificial Intelligence (AI) is commonly understood as the broad field of computer science concerned with creating computational systems (e.g., intelligent agents) capable of performing tasks that typically require human intelligence, such as interpreting information, drawing inferences, and supporting decision-making (Borchers, Habash, et al., 2025; Collins et al., 2021). Machine Learning (ML) is a subfield of AI that focuses on algorithms and statistical models that learn patterns from data and can subsequently generate predictions or structures, e.g., classifications, clusters, rankings (Borchers, Hallmann, et al., 2026). Instead of relying on explicitly coded rules, ML models learn decision functions from training data, making them especially suitable for handling large, heterogeneous datasets such as free-text contributions from e-participation (Romberg et al., 2022). Natural Language Processing (NLP) is described as a subfield of AI/ML that focuses on the computational processing and understanding of human language. Because citizen participation platforms frequently elicit unstructured text (rather than structured numeric responses), NLP enables automated interpretation, summarization, and categorization of contributions at scale (Cai, 2021; Chotirat & Meesad, 2021).

2.5.1 Potential of AI in Citizen Participation

Digital participation platforms can quickly generate hundreds or thousands of qualitative contributions, while expert-led analysis remains expensive, slow, and inconsistent (Clarinval, 2021). AI-based automation is discussed to increase efficiency and enable near real-time support for moderation, synthesis, and decision preparation (Romberg & Escher, 2024). AI can reduce information overload by automatically structuring citizen inputs into interpretable representations, such as:

- topic detection and clustering to identify dominant themes and emerging concerns (Lieven et al., 2021),
- classification into categories aligned with planning objectives (Romberg et al., 2022),
- sentiment analysis to assess approval, rejection, and emotional tone (Pitogo & Ramos, 2020),
- summarization to create digestible overviews for planners and decision-makers (Jugran et al., 2021).

This is especially relevant because participation data is often free-text, multi-topic, and uneven in quality, characteristics that make manual evaluation difficult and time-consuming (Borchers, Gierlich-Joas, Tavanapour, et al., 2024). A second, increasingly important potential is to use AI not only “after the fact” for analysis, but

also during participation to improve the interaction quality (Borchers, Soroko, Tavanapour, et al., 2024). AI-based systems, particularly conversational agents, can provide immediate feedback, help citizens clarify their contributions, ask follow-up questions, and reduce barriers to engagement (Memmert & Bittner, 2022). More recent work also points to LLMs and Retrieval-Augmented Generation (RAG) as promising architectures for combining generative capabilities with project- and domain-specific knowledge bases, enabling more context-aware analysis and interaction while aiming to improve information control (Nikishina et al., 2025).

Cai's work is frequently referenced as a foundational point of departure, as it systematically reviews NLP applications in urban research and highlights their potential to extract insights from large-scale textual data. While Cai's analysis does not focus exclusively on participation platforms, it provides strong evidence that NLP techniques, such as topic modeling, entity recognition, and semantic analysis, are well-suited to identifying patterns in citizen-generated content relevant to urban planning. This work underpins the argument that AI-based methods can help planners cope with the volume and heterogeneity of participation data, even though their practical application in participatory settings remains limited (Cai, 2021). Complementing this perspective, Romberg and colleagues provide one of the more concrete empirical examples of ML-based analysis in participation-related domains (Romberg & Escher, 2024). By developing a corpus of German-language citizen contributions in mobility planning and applying multidimensional classification techniques, their work demonstrates how supervised machine learning can structure participation data into analytically meaningful categories (Romberg et al., 2022).

Beyond these examples, several studies discuss automatic summarization and clustering of participation content to reduce information overload for planners (Cai, 2021). In contrast, others apply sentiment analysis to capture approval, rejection, or emotional tone in discussions on participation platforms (Gupta et al., 2023). Additional work explores geographic visualization of clustered contributions to reveal spatial patterns of interest and concern across urban districts. Collectively, these studies demonstrate that AI can meaningfully augment expert workflows by accelerating sense-making and enabling new analytical perspectives. However, they also share a common limitation, as most approaches remain isolated, task-specific, and evaluated on small or project-specific datasets (Romberg & Escher, 2024).

2.5.2 Challenges of AI in Citizen Participation

Despite increasing academic interest, AI and ML are still only briefly and selectively examined in the context of citizen participation. Several structural and methodological gaps explain this situation and motivate further research.

First, there is a notable lack of real-world deployments and longitudinal evaluations. Most existing studies rely on retrospective data analysis, which limits their

generalizability and practical relevance (Romberg et al., 2022). While participation platforms generate large volumes of data, few municipalities have operationalized AI-based analysis in routine planning practice, and even fewer have evaluated its impact over time (Royo et al., 2020). Second, data availability and standardization remain major obstacles. Participation data is typically project-specific, unstructured, and subject to legal and privacy constraints. Publicly available datasets and shared benchmarks are rare, which hampers reproducibility and cross-project comparison (Abed, 2024; Bono Rossello et al., 2025). As a result, many ML models are developed in isolation and cannot easily be transferred to new contexts. Third, participation processes exhibit high contextual variability. Categories, evaluation criteria, and planning objectives differ across projects, making it difficult to develop stable classification schemes. This variability challenges supervised learning approaches and increases the effort required for model training and adaptation (Moghayedi, 2025; Romberg et al., 2022). Fourth, questions of transparency, explainability, and trust are particularly salient in public-sector participation. Black-box models and opaque decision logic are difficult to justify in democratic contexts, especially when analytical results influence planning outcomes. This challenge becomes even more pronounced with the use of LLMs, whose reasoning processes are not easily interpretable (Cortés-Cediel et al., 2023; Hao et al., 2024).

Finally, while expert-facing AI support has received increasing attention, citizen-facing AI assistance remains underexplored. Only a small number of studies examine how AI can actively support citizens during participation, for example, by providing feedback, prompting reflection, or encouraging more structured contributions. Even in these cases, open questions remain regarding acceptance, trust, and the appropriate balance between guidance and influence.

3 Research Design

This cumulative dissertation addresses the description of RG and RQs (cf. Section 1.2) in a systematic and elaborate approach. While RQ1 focuses on human-AI interaction between citizens and tools, RQ2 elaborates on the data, and RQ3 focuses on the interaction of experts with this data, e.g., citizens' contributions.

Design Science Research (DSR) is a research paradigm widely known in information systems. It supports the creation of local and global theories, as well as practical knowledge. In contrast to descriptive work, which describes phenomena without causal mechanisms, DSR constructs theories of design and action across various areas (Baskerville et al., 2018). DSR achieves this by developing IT artifacts through systematic issue (ISS) identification, the formulation of meta-requirements (MR), and the derivation of design principles (DP), which can follow different established DSR processes (Hevner, 2007; Peffers et al., 2012; Vaishnavi et al., 2004).

For the domain of citizen participation (RQ1), included and required data (RQ2), and the data analysis by experts (RQ3), the DSR paradigm is appropriate. This is argued to focus on the design of new innovative tools to support human-IT/AI interaction and the usage, e.g., behavior of citizens and experts of these tools, which should, based on the RG, support citizens in the creation of their contributions and experts in the extraction of knowledge and insights for subsequent processes (Amershi et al., 2019).

3.1 Design Science Research Paradigm

At its core, the DSR paradigm conceptualizes research as an interaction between application environments, knowledge bases, human capabilities, and IT artifacts. Together, these elements frame the design, evaluation, and contribution of IT artifacts as shown in Figure 3.

The application environment (cf. Figure 3 left) represents the real-world context in which a problem is situated and in which an artifact is intended to operate (Hevner et al., 2004). It includes organizational structures, stakeholders, processes, regulations, and socio-political conditions (Gregor & Hevner, 2013; Hevner, 2007). In the context of this dissertation, the application environment consists of urban planning processes, citizen participation practices, public authorities, citizens, and digital participation platforms (cf. Section 1).

Human capabilities (cf. Figure 3 right) are critical in DSR, as all IT artifacts and knowledge should address a relevant target group and audience. Designing innovative artifacts requires creativity, reasoning, and problem-solving skills, while evaluation and interpretation depend on social and cognitive abilities such as collaboration, reflection, and judgment. DSR acknowledges that artifacts do not operate

independently and should consider human capabilities in terms of cognitive tasks and social and organizational structures (Hevner, 2007).

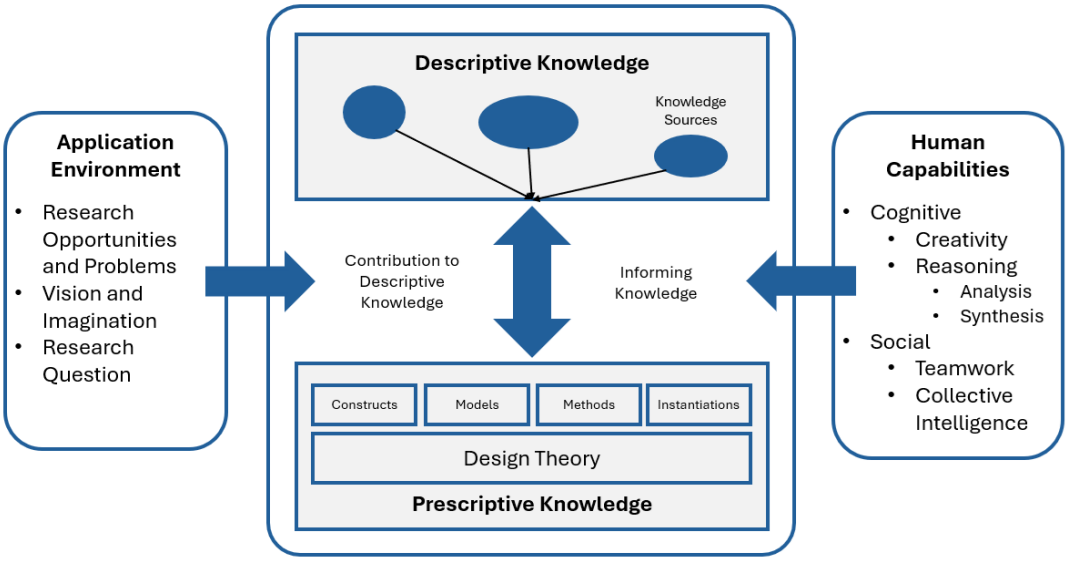


Figure 3. The Roles of Knowledge, the Application Environment, and Human Capabilities in Design Science Research according to Gregor & Hevner (2013)

Descriptive knowledge (cf. Figure 3 center) provides explanatory and analytical insights into phenomena in the natural, artificial, and social worlds. It includes observations, measurements, patterns, and theories that explain "what" it is and "why" it is. In DSR projects, descriptive knowledge is used to understand problem contexts, stakeholder behavior, and underlying mechanisms. Prescriptive knowledge refers to design-oriented knowledge that explains "how" to build artifacts to achieve desired outcomes (Gregor & Hevner, 2013). It encompasses constructs, models, methods, algorithms, representations, and design principles. Prescriptive knowledge is often the primary knowledge contribution of DSR and is instantiated through IT artifacts, e.g., executable and/or testable prototypes or similar (Baskerville et al., 2018). A key insight of DSR is that both kinds of knowledge are interrelated, as descriptive knowledge informs the design of artifacts by explaining requirements, constraints, and user behavior, e.g., the application environment and human capabilities (cf. Figure 3 left and right). Conversely, the evaluation and use of artifacts generate new descriptive knowledge regarding their effectiveness, user behavior, and contextual influences, which may subsequently refine prescriptive knowledge (Hevner et al., 2004).

IT artifacts are a central outcome of DSR and can take many forms, such as software prototypes, models, methods, and design theories (Gregor et al., 2020). In this dissertation, as the RG and especially the RQs imply the development of prototypes to extend urban participation platforms and experts in data analysis, to support data-driven decision-making, is of special interest (cf. Section 1.2).

3.2 Cyclic Approach of Design Science Research

DSR is inherently iterative and cyclic. Rather than following a linear research process, it operates through interactive cycles that ensure relevance, rigor, and continuous refinement, as reflected in most of the publications of this dissertation (cf. Section 4.2).

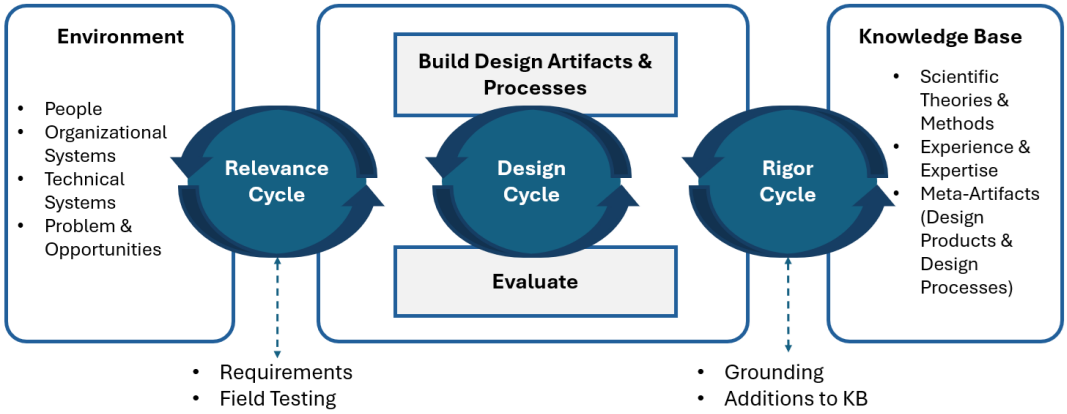


Figure 4. Design Science Research Cycles according to Hevner (2007)

The relevance cycle connects the research project to the application environment. It ensures that the problem addressed is practically relevant and grounded in real-world needs. Requirements are often derived from stakeholders, e.g., citizens and urban experts, who have considered or used potential solutions and are aware of or have experienced constraints and challenges in the examined domain (Hevner, 2007). The rigor cycle links the research to the existing knowledge base. It ensures that prior theories, empirical findings, and existing artifacts inform artifact design and evaluation. This cycle prevents ad hoc design and supports scientific credibility by building on existing literature (Romberg & Escher, 2024).

The dissertation draws on descriptive theories of participation and prescriptive knowledge from prior participation systems and AI-based analysis approaches. The design cycle represents the core of DSR, encompassing iterative processes of building, evaluating, and refining artifacts (Gregor & Hevner, 2013). Design activities translate requirements and theoretical insights into concrete solutions, which are then evaluated against predefined criteria. Feedback from evaluation informs subsequent design iterations. Furthermore, the three cycles are interdependent. Insights from the application environment may trigger new design iterations, while evaluation results may reveal gaps in existing theories, prompting engagement with the rigor cycle. Together, the cycles ensure that DSR remains both practically relevant and scientifically grounded (Baskerville et al., 2018).

3.3 Design Science Research Strategy

The RG and RQs formulated in Section 1.2 can be differentiated by the two user groups, citizens and urban experts, as illustrated in Figure 2 in the holistic process of citizen participation in Section 2.3, even though they collaborate first actively, depending on the on-site, hybrid, or fully digital participation scenario, and later indirectly (Borchers, Soroko, Tavanapour, et al., 2024). Active collaboration primarily occurs during participation, e.g., the co-design phase, particularly in on-site participation scenarios. In contrast, no further interaction with citizens typically takes place during the expert-based analysis phase. While subsequent interaction with citizens is possible as part of downstream process steps, for example, to collect additional data or validate intermediate findings, these interactions again follow the interaction approaches characteristic of citizen participation itself (Stelzle et al., 2017).

RQ1 explicitly focuses on supporting citizens during participation processes and was investigated in relative isolation from RQ3 and with strong connections to RQ2 throughout this dissertation. RQ2 addresses the necessity of specific forms of data and data types that IT- and AI-supported systems should incorporate and process, as described in the existing literature and further confirmed and refined within this dissertation. RQ3, in turn, focuses on the semi-automated analysis of data generated through citizen participation, thereby directly relating to the domain investigated within RQ1. Consequently, RQ2 serves as the conceptual link between RQ1 and RQ3, enabling the investigation of RQ1 and RQ3 as distinct yet interconnected research streams, with data serving as the central interface between them. This dissertation follows this structure and opens two DSR streams within one large DSR project. Accordingly, the following sections specify both streams in the context of the methodological approach and cycles.

3.3.1 Citizens' Relevance and Rigor Cycle

A total of seven studies were conducted to answer RQ1, and six also directly addressed RQ2 from the citizens' perspective. This also applies to RQ3, which was relevant in two cases, as shown in Figure 5, where the citizens' perspective was elaborated on in RQ2 and RQ3, thereby enabling a more comprehensible examination of citizen participation. Figure 5 presents an overview of all publications in relation to the DSR cycles and the named applied methods for both the relevance and rigor cycles, including the number of included citizens or experts and whether one or more prototypes were developed, which applies to all publications except one.

The publication *Toward Intelligent Platforms to Support Citizen Participation in Urban Planning* exclusively addresses the rigor cycle. It identifies issues from the scientific literature, formulates meta-requirements, and derives design principles to

propose a new design for participation platforms (Borchers et al., 2022). In the publication *Designing Mobile Applications for Citizen Participation in Urban Planning*, Borchers et al. (2023b) investigate the research question of how mobile applications should be designed to support citizen participation in urban projects. The study addresses the specific application context, namely mobile participation, which differs from conventional web-based participation approaches that rely on larger displays and desktop-oriented interactions. This distinction is not only due to screen size but also to smartphone capabilities, including the use of location data and personalized user information. Based on a literature review and aligned with the rigor cycle, the publication identifies several challenges and meta-requirements, which are condensed into design principles. The resulting prototype was evaluated with ten citizens in a focus group setting, thereby directly incorporating the target group into the design and evaluation process as required by the relevance cycle (Borchers et al., 2023a).

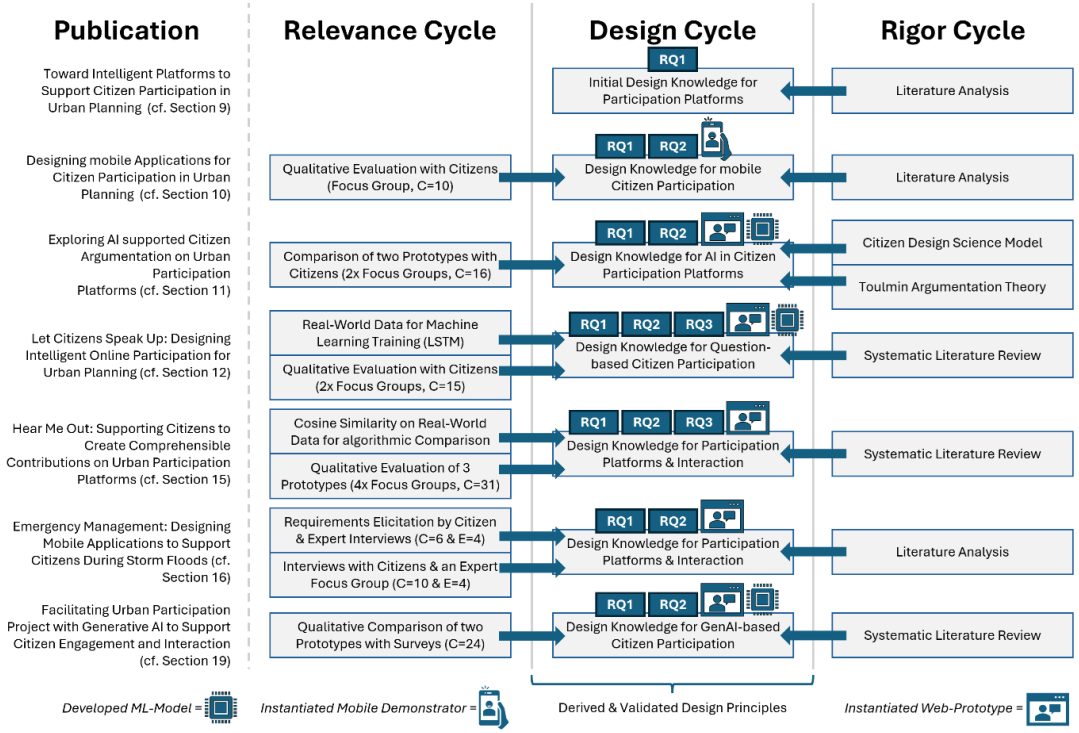


Figure 5. Publications with a focus on RQ1 and RQ2

The publication *Exploring AI-Supported Citizen Argumentation on Urban Participation Platforms* shifted the focus to the then-emerging application of artificial intelligence in citizen participation. The study investigates how AI-based feedback generated from participants' textual inputs can encourage citizens to formulate more detailed, comprehensible, and argumentative contributions regarding their needs and ideas for urban projects. Building on the literature as part of the rigor cycle, the publication addresses the widespread problem of short, unclear, and ambiguous textual contributions in online participation settings. The proposed approach

evaluates contributions according to predefined thematic dimensions relevant to the participation project. It provides participants with feedback on whether all relevant dimensions have been considered (Borchers et al., 2023b). A related but distinct approach is pursued in the publication *Let Citizens Speak Up: Designing Intelligent Online Participation for Urban Planning*. Similar to Borchers et al. (2023a), the publication aims to support citizens during contribution processes but relies on a question-based interaction design. Unlike today's generative LLM interactions, the approach intentionally restricts interactions to predefined questions. This addresses a need frequently highlighted in rigor cycles work and is considered enabling, as it helps participants experience a sense of completion once all questions have been answered (Borchers, Gierlich-Joas, Tavanapour, et al., 2024), as noted in the relevance cycle by the included citizens (cf. Figure 5). The publication *Hear Me Out: Supporting Citizens to Create Comprehensible Contributions on Urban Participation Platforms* builds on and extends the findings of *Exploring AI-Supported Citizen Argumentation on Urban Participation Platforms* and evaluates them in a larger and more qualitative setting (Borchers, Soroko, Tavanapour, et al., 2024). As illustrated in Figure 5, four focus groups involving 31 citizens were conducted to evaluate three different prototypes. The first prototype served as a baseline without intelligent support functions. The second prototype incorporated the AI-based feedback mechanisms previously investigated by Borchers, Soroko, Tavanapour, et al. (2024), while the third prototype additionally introduced a two-dimensional map and prioritization functionality. The extensive integration of citizens once again demonstrates the strong practical grounding required by the relevance cycle (Gregor & Hevner, 2013). In the publication *Emergency Management: Designing Mobile Applications to Support Citizens During Storm Floods*, the map-based interaction approach is further extended to the context of mobile emergency applications (Borchers, Milutzki, Bode, et al., 2025). The study investigates which geographical and contextual factors are relevant to support citizens in navigating emergency situations more effectively. Following the logic of the relevance cycle, the study involved ten citizens and four domain experts to examine citizen interaction in a highly time-critical setting. The emergency management context differs from urban citizen participation to support and increase transferable insights regarding user interaction, information presentation, and geographically contextualized participation. With the emergence of LLMs and the release of the first widely adopted generative AI systems by OpenAI in November 2022, interest in more flexible forms of human–AI interaction increased significantly (Mattmann & Broderick, 2024). This development is reflected in the publication *Facilitating Urban Participation Project with Generative AI to Support Citizen Engagement and Interaction* (Borchers, Uba, et al., 2026). The publication introduces an LLM extended regarding the retrieval-augmented generation (RAG) architecture, which not only asks participants questions but also explains project-related information in a flexible yet context-specific manner.

Similar to previous studies, such as Borchers, Soroko, Tavanapour, and Bittner (2024), the evaluation compared a baseline and an RAG-based prototype to enable comparisons of different user interactions and contributions, embedding relevance via citizen contributions and rigor via a literature review.

Overall, the chosen DSR approach with the seven publications shown in Figure 5 highlights a high level of inclusion that is specified and required by the relevance cycle to ensure real-world considerations and contributions, and a strong inclusion of the existing knowledge base, as demanded by the rigor cycle, to enable the derivation of new findings and solutions, extending existing theories and comprehensively examining RQ1 and RQ2.

3.3.2 Experts' Relevance and Rigor Cycle

A total of five publications focused mainly on RQ3, always in combination with the data aspects proposed by RQ2, as the analysis by experts is directly affected by the availability and structure of the data, e.g., citizens' submissions.

The publication *Toward the ML-based Analysis of Citizens' Inputs from E-Participation in Urban Planning* marks the beginning of the examination of RQ3 by interviewing eleven experts in urban planning and collecting data from past citizen participation (Borchers, Cao, & Bittner, 2024). Both ensure alignment with the relevance cycle. Regarding the rigor cycle, the work was based on the Citizen Design Science Model (Müller, 2021) as well as on existing, widely used, and recognized ML standards (Lieven et al., 2021; Pitogo & Ramos, 2020). An independent literature review was not conducted for this publication, as Cai (2021), Romberg, and Escher (2024) had already laid a comprehensive foundation in this area.

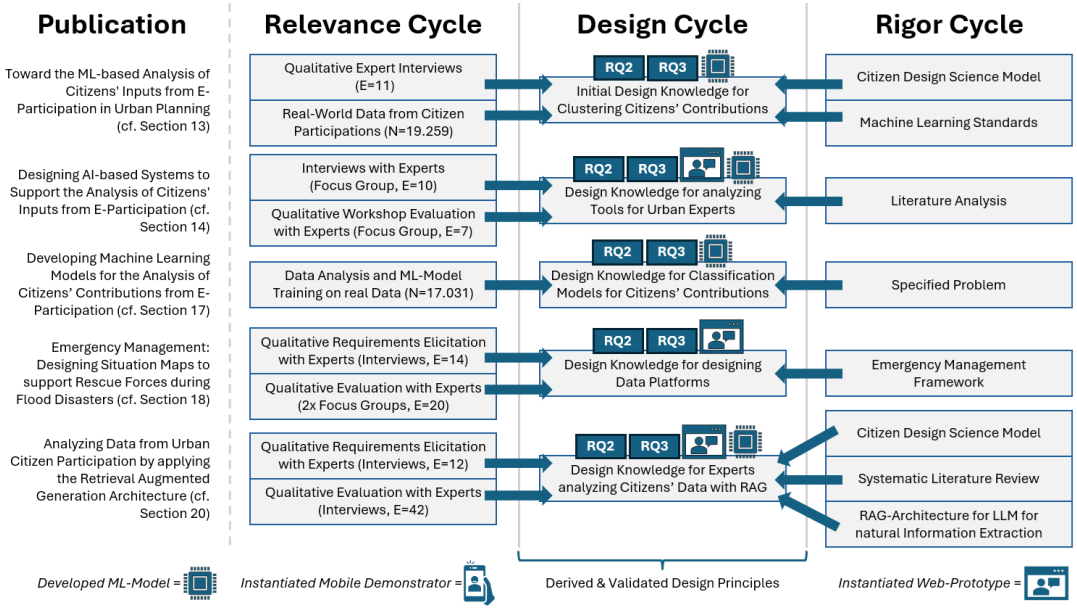


Figure 6. Publications with a focus on **RQ2** and **RQ3**

The expert-oriented work continued with the publication *Designing AI-Based Systems to Support the Analysis of Citizens' Inputs from E-Participation*, with ten interviews for requirements elicitation and one focus group for the evaluation of the findings, which were combined with the results for the rigor cycle and then instantiated in terms of a web prototype (Borchers, Cao, Tavanapour, et al., 2024). The publication *Developing Machine Learning Models for the Analysis of Citizens' Contributions from E-Participation* builds on the dataset from the work by Borchers, Cao, and Bittner (2024) and focuses on the classification problem, as highlighted in the rigor cycle by many scientific publications (Borchers, Cao, Tavanapour, et al., 2024; Cai, 2021; Romberg et al., 2022). In this publication, the data is analyzed, and ML classification models are trained, evaluated, and compared to highlight the potential accuracy and challenges related to data quality, quantity, and more (Borchers, Habash, et al., 2025). The publication *Emergency Management: Designing Situation Maps to support Rescue Forces during Flood Disasters* focuses on geographical data, which can provide a better overview of cities, urban areas, and specific environments where changes can occur. The publication does that by focusing on emergency management and building on the literature corresponding to the rigor cycle. Considering the relevance cycle, experts were included in eliciting requirements and evaluating the interactive map to test and further specify functions and urban data (Borchers, Milutzki, Fetzer, et al., 2025). In the publication *Analyzing Data from Urban Citizen Participation by applying the Retrieval Augmented Generation Architecture*, a RAG system is developed to examine LLM-based possibilities for the flexible analysis of citizens' submissions from urban participation (Borchers, Milutzki, et al., 2026). This is done to extend the view from traditional ML models, which were explored in the previous publications (Borchers, Cao, & Bittner, 2024; Borchers, Cao, Tavanapour, et al., 2024; Borchers, Habash, et al., 2025). In the rigor cycle, the Citizen Design Science Model was used as a foundation, and a literature review was conducted to capture the state of the art of LLMs in urban planning. Building upon this, we used the RAG architecture (H. Li et al., 2022) for the development of a prototype, combined with the insight from twelve expert interviews from the relevance cycle. The prototype, together with a baseline, was evaluated by 42 experts from a crowdsourcing platform to quantify its usability, its functionality, and their experience in analyzing citizens' submissions with an LLM, e.g., a RAG system (Borchers, Milutzki, et al., 2026).

Overall, the chosen DSR approach, as shown in Figure 6, with the five publications, highlights a strong connection to the existing knowledge base, e.g., the rigor cycle, through literature reviews and the direct continuation of the research gaps described. Additionally, the relevance cycle ensures real-world considerations and contribution. Together, both cycles and the contributions support the derivation of new findings and solutions, considering RQ2 and RQ3.

4 Publications

During the research for this cumulative dissertation, 19 publications have been created and published, and most of them directly or indirectly relate to the RG and RQs stated in Section 1.2. All articles were submitted to reputable and peer-reviewed information systems conferences and a journal. Out of the 19 publications, 12 are included in this cumulative dissertation, and of all of them, the author of this dissertation is also the first author. In the following two sections, the articles are named and briefly described regarding the outlet name, article title, and authors[1].

4.1 Related Publications

Table 3 presents the journal article, which is not included in this cumulative dissertation, as indicated by the "-" in the column "Included", while "x" highlights whether it is included in this cumulative dissertation and corresponds to the RQs of this work.

No.	Included	Publication
J1.	-	Borchers, Marten; Volquardsen, Hauke; Willruth, Jan; Milutzki, Enrico; Semmann, Martin; and Bittner, Eva (2025), Entwicklung von ML-basierten Vorhersagesystemen für den Energieverbrauch von Elektrobussen im öffentlichen Nahverkehr. In: *HMD Praxis der Wirtschaftsinformatik*. https://doi.org/10.1365/s40702-025-01185-5

Table 3. Overview of all Journal Publications

Table 4 presents the conference articles chronologically by publication date and is subdivided by outlet type. Twelve conference articles directly corresponding to the RQs are used to answer them and are therefore included in this dissertation, which is documented in the following table with “x” in the column “Included”.

No.	Included	Publication
C1.	x	Borchers, Marten; Tavanapour, Navid; & Bittner, Eva (2022). Toward Intelligent Platforms to Support Citizen Participation in Urban Planning. In: *Proceedings of the Pacific Asia Conference on Information Systems* (PACIS). https://aisel.aisnet.org/pacis2022/82
C2.	x	Borchers, Marten; Tavanapour, Navid; & Bittner, Eva (2023). Designing Mobile Applications for Citizen Participation in Urban Planning. In: *Proceedings of the 56th Hawaii International Conference on System Sciences* (HICSS). https://aisel.aisnet.org/hicss-56/cl/design_development_and_evaluation/5
C3.	x	Borchers, Marten; Tavanapour, Navid; & Bittner, Eva (2023). Exploring AI supported Citizen Argumentation on Urban Participation Platforms. In: *Proceedings of the 56th Hawaii*

[1] Last updated on 06.07.2026

		International Conference on System Sciences (HICSS). https://aisel.aisnet.org/hicss-56/dg/ai/3
C4.	x	Borchers, Marten; Gierlich-Joas, Maren; Tavanapour, Navid; & Bittner, Eva (2024). Let Citizens Speak Up: Designing Intelligent Online Participation for Urban Planning. In: 19th International Conference on Design Science Research in Information Systems and Technology (DESRIST). https://link.springer.com/chapter/10.1007/978-3-031-61175-9_2
C5.	x	Borchers, Marten; Cao, Thu-Bao; & Bittner, Eva (2024). Toward the ML-based Analysis of Citizens' Inputs from E-Participation in Urban Planning. In: *Proceedings of the Pacific Asia Conference on Information Systems* (PACIS). https://aisel.aisnet.org/pacis2024/track16_shareecon/track16_shareecon/6
C6.	x	Borchers, Marten; Cao, Thu-Bao; Tavanapour, Navid; & Bittner, Eva (2024). Designing AI-Based Systems to Support the Analysis of Citizens' Inputs from E-Participation. In: *Proceedings of the 32nd European Conference on Information System* (ECIS). https://aisel.aisnet.org/ecis2024/track23_designresearch/track23_designresearch/7
C7.	x	Borchers, Marten; Soroko, Daria; Tavanapour, Navid; & Bittner, Eva (2024). Hear Me Out: Supporting Citizens to Create Comprehensible Contributions on Urban Participation Platforms. In: *Proceedings of the ACM on Human-Computer Interaction*, Volume 8, Issue CSCW2, Article No.: 432, Pages 1 – 26. https://doi.org/10.1145/3686971
C8.	-	Memmert, Lucas; Borchers, Marten; Plückhahn, Juliane; & Bittner, Eva (2025). Solving Coding Challenges Jointly with a Large Language Model: Understanding Student Journeys Through Bloom's Taxonomy. In: *58th Hawaii International Conference on System Sciences* (HICSS). https://hdl.handle.net/10125/109714
C9.	-	Borchers, Marten; Milutzki, Enrico; & Bittner, Eva (2025). Designing ML-based Prediction Systems for the Energy Consumption of electric Buses to support Public Transport Providers. In: *58th Hawaii International Conference on System Sciences* (HICSS). https://hdl.handle.net/10125/109050
C10.	x	Borchers, Marten; Milutzki, Enrico; Bode, Alexander; Magdych, Valeria; Semmann, Martin; & Bittner, Eva (2025). Emergency Management: Designing Mobile Applications to Support Citizens During Storm Floods. In: *Chatterjee, S., vom Brocke, J., Anderson, R. (eds) Local Solutions for Global Challenges.* DESRIST 2025. Lecture Notes in Computer Science, vol 15704. Springer, Cham. https://doi.org/10.1007/978-3-031-93979-2_17
C11.	-	Milutzki, Enrico; & Borchers, Marten (2025). Facing Climate Change: A Literature Review on Crisis Apps for Warning and Engaging Citizens during Storm Surges. In: *Proceedings of the Pacific Asia Conference on Information Systems* (PACIS). https://aisel.aisnet.org/pacis2025/iot_smartcity/iot_smartcity/6
C12.	-	Milutzki, Enrico; & Borchers, Marten (2025). 应对气候变化：风暴潮期间警告和公民参与的危机应. In: *Proceedings of the Pacific Asia Conference on Information Systems* (PACIS). https://aisel.aisnet.org/pacis2025/translated/translated/15

C13	x	Borchers, Marten; Habash, Delzar; & Bittner, Eva (2025). Developing Machine Learning Models for the Analysis of Citizens' Contributions from E-Participation. In: *Proceedings EGOV-CeDEM-ePart conference*, August 31 - September 4, 2025, University for Continuing Education, Krems, Austria. https://ceur-ws.org/Vol-4127/
C14	x	Borchers, Marten; Milutzki, Enrico; Fetzer, Lisa; Magdych, Valeria; Bittner, Eva; & Semmann, Martin (2025). Emergency Management: Designing Situation Maps to support Rescue Forces during Flood Disasters. In: *Proceedings of the 46th International Conference on Information Systems* (ICIS). https://aisel.aisnet.org/icis2025/sustain/sustain/2
C15	x	Borchers, Marten; Uba, Chikaodi; Milutzki, Enrico; Ittner, Fynn, Magdych, Valeria; Bittner, Eva; & Semmann, Martin (2026). Facilitating Urban Participation Project with Generative AI to Support Citizen Engagement and Interaction. In: *Proceedings of the 59th Hawaii International Conference on System Sciences* (HICSS). https://hdl.handle.net/10125/111674
C16	x	Borchers, Marten; Milutzki, Enrico; Oelgschläger, Simon; Magdych, Valeria; Semmann, Martin; & Bittner, Eva (2026). Analyzing Data from Urban Citizen Participation by Applying the Retrieval Augmented Generation Architecture. In *Proceedings of the 59th Hawaii International Conference on System Sciences* (HICSS). https://hdl.handle.net/10125/111679.
C17	-	Milutzki, Enrico; Borchers, Marten; Hummel, Jan; Magdych, Valeria; Bittner, Eva; and Semmann, Martin (2026). From Alerts to Action: Designing Crisis Apps that Enable Self-Help in Storm-Flood Events. In: Proceedings of the *59th Hawaii International Conference on System Sciences* (HICSS). https://hdl.handle.net/10125/111665
C18	-	Milutzki, Enrico; Memmert, Lucas; Borchers, Marten; Zeybek, Ramazan; Magdych, Valeria, Semmann, Martin; and Bittner, Eva (2026). Designing Mobile Applications for Spontaneous Volunteers: Insights from a Design Science Research Approach. In: vom Brocke, J., Chandra Kruse, L., Hevner, A., Rosemann, M., Chiarini Tremblay, M., Winter, R. (eds) Design for Better Futures: Beyond the Science of the Artificial. Completed Research. DESRIST 2026. Lecture Notes in Computer Science, vol 16606. Springer, Cham. https://doi.org/10.1007/978-3-032-28313-9_7

Table 4. Overview of all Conference Publications

4.2 Included Publications

To address the RQs of this cumulative dissertation, the thesis includes the twelve articles highlighted in Table 4. In the following, each included publication is summarized, including the conference, track, research aim, applied methodology, research contribution regarding the RG and RQs, and the co-authors' contribution.

The co-authors' contributions are documented using the Contributor Role Taxonomy (CRediT), which distinguishes 14 roles that the main author and co-authors can have. All authors can have more than one role, and more than one person can also exercise

a role. Additionally, "lead" and "support" are specified when more than one person performs a role. The roles prescribed by the CRediT taxonomies are the following (*CRediT*, 2022):

(1) **Conceptualization** includes ideas, formulation, and/or the evolution of the overarching research goal
(2) **Data Curation** includes activities to annotate data and produce metadata, scrub data, and maintain research data for initial and later use. This also includes software, if necessary, for interpreting the data.
(3) **Formal Analysis** includes the application of statistical, mathematical, computational, or other formal techniques to analyze or synthesize study data.
(4) **Funding Acquisition** includes the acquisition of financial support for the project leading to this publication.
(5) **Investigation** includes the implementation of planned methods to generate data and evidence that underpin scientific findings, therefore describes the conduct of experiments or similar.
(6) **Methodology** includes the development or design of the research methodology of a publication.
(7) **Project Administration** includes the management and coordination responsibility for research activity planning and execution.
(8) **Resources** included the provision of study materials, such as computing resources or analytical tools.
(9) **Software** includes the software development and design of computer programs and code, their testing, hosting, and, if required, hardware.
(10) **Supervision** includes oversight and leadership for research activity planning and execution, including mentorship
(11) **Validation** includes the verification of the findings regarding the overall replication, reproducibility of results, experiments, and further research output.
(12) **Visualization** includes preparation, creation and/or presentation of the published work, its visualizations, data, and further.
(13) **Writing - Original Draft** includes the preparation and creation of the published work, with a special focus on writing the draft and publication.
(14) **Writing - Review & Editing** includes critical review, commentary, or revision in the pre- and/or post-publication stages.

Title	Toward Intelligent Platforms to Support Citizen Participation in Urban Planning			
Conference	Pacific Asia Conference on Information Systems (PACIS)			
Track	Crowds, Social Media, and Digital			
Type	Research in Progress		**Ranking**	C
Research Question(s)	How to design IT artifacts to support citizen participation on urban participation platforms?			
Methodology	Design Science Research			
Research Contribution	This publication contributes to the overall RG, especially RQ1, by describing the design of a web prototype that supports citizens in submitting their contributions by adding an interactive feedback mechanism. In doing so, the publication also contributes to RQ2, as the feedback considers six content dimensions of interest to both citizens and urban experts. Furthermore, the publication describes 12 issues, ten meta-requirements, and four design principles within the design science research paradigm.			
Co-Authors' Contribution	Marten Borchers	Conceptualization (lead), Data Curation, Formal Analysis, Methodology (lead), Project Administration, Software, Supervision, Validation, Visualization, Writing - Original Draft, Writing - Review & Editing (lead)		
	Dr. Navid Tavanapour	Methodology (support), Writing - Review & Editing (support), & Conceptualization (support)		
	Prof. Dr. Eva Bittner	Conceptualization (support) & Funding Acquisition		
Citation	Borchers, Marten; Tavanapour, Navid; & Bittner, Eva (2022). Toward Intelligent Platforms to Support Citizen Participation in Urban Planning. In: *Proceedings of the Pacific Asia Conference on Information Systems* (PACIS). https://aisel.aisnet.org/pacis2022/82			

Table 5. Contribution of the C1 Publication to the RG

Title	Designing Mobile Applications for Citizen Participation in Urban Planning		
Conference	Hawaii International Conference on System Sciences (HICSS)		
Track	Design, Development, and Evaluation of Collaboration Technologies		
Type	Completed Research	**Ranking**	B
Research Question(s)	How to design mobile applications to support citizen participation in urban projects?		
Methodology	Design Science Research		
Research Contribution	This publication contributes to the overall RG, especially RQ1, by describing the design of a mobile prototype that supports citizens in submitting their contributions, including photos, and extending them with visual marks and textual descriptions. Furthermore, the publication contributes to RQ2 by specifying the required data. The publication describes nine issues, nine meta-requirements, and four design principles, which were extended to seven design principles as a result of the evaluation.		
Co-Authors' Contribution	Marten Borchers	Conceptualization (lead), Data Curation, Formal Analysis, Methodology (lead), Project Administration, Software, Supervision, Validation, Visualization, Writing - Original Draft, Writing - Review & Editing (lead)	
	Dr. Navid Tavanapour	Methodology (support), Writing - Review & Editing (support), & Conceptualization (support)	
	Prof. Dr. Eva Bittner	Conceptualization (support) & Funding Acquisition	
Citation	Borchers, Marten; Tavanapour, Navid; & Bittner, Eva (2023). Designing Mobile Applications for Citizen Participation in Urban Planning. In: *Proceedings of the 56th Hawaii International Conference on System Sciences* (HICSS). https://aisel.aisnet.org/hicss-56/cl/design_development_and_evaluation/5		

Table 6. Contribution of the C2 Publication to the RG

Title	Exploring AI supported Citizen Argumentation on Urban Participation Platforms		
Conference	Hawaii International Conference on System Sciences (HICSS)		
Track	AI in Government		
Type	Completed Research	**Ranking**	B
Research Question(s)	How can AI-based feedback system increase citizens' argumentation on urban participation platforms?		
Methodology	Empirical Study		
Research Contribution	This publication contributes to the overall RG, especially RQ1, by describing the design of a web prototype that supports citizens by providing an interactive feedback mechanism. The publication also contributes to RQ2, as the feedback considers six content dimensions of interest to both citizens and urban experts and follows Toulmin's Argumentation Theory in analyzing the AI impact.		
Co-Authors' Contribution	Marten Borchers	Conceptualization (lead), Data Curation, Formal Analysis, Methodology (lead), Project Administration, Software, Supervision, Validation, Visualization, Writing - Original Draft, Writing - Review & Editing (lead)	
	Dr. Navid Tavanapour	Methodology (support), Writing - Review & Editing (support), & Conceptualization (support)	
	Prof. Dr. Eva Bittner	Conceptualization (support) & Funding Acquisition	
Citation	Borchers, Marten; Tavanapour, Navid; & Bittner, Eva (2023). Exploring AI supported Citizen Argumentation on Urban Participation Platforms. In: *Proceedings of the 56th Hawaii International Conference on System Sciences* (HICSS). https://aisel.aisnet.org/hicss-56/dg/ai/3		

Table 7. Contribution of the C3 Publication to the RG

Title	Let Citizens Speak Up: Designing Intelligent Online Participation for Urban Planning		
Conference	International Conference on Design Science Research in Information Systems and Technology (DESRIST)		
Track	DSR for a Resilient World		
Type	Completed Research	**Ranking**	B
Research Question(s)	How to design IT artifacts to support citizens in contributing in online participation projects in urban planning?		
Methodology	Design Science Research		
Research Contribution	This publication contributes to the overall RG, especially RQ1, by describing the design of a web prototype that supports citizens in submitting their contributions by adding an interactive questioning mechanism. In doing so, the publication also contributes to RQ2, as the feedback analyzes the submission with respect to considered and not considered topics, which are stored in a flexible matrix in the backend. Furthermore, the publication describes ten issues, ten meta-requirements, and four design principles that were extended to six due to the evaluation.		
Co-Authors' Contribution	Marten Borchers	Conceptualization (lead), Data Curation, Formal Analysis, Methodology (lead), Project Administration, Software, Supervision, Validation, Visualization, Writing - Original Draft, Writing - Review & Editing (lead)	
	Dr. Maren Gierlich-Joas	Writing - Original Draft, Writing (support) & Review & Editing (support)	
	Dr. Navid Tavanapour	Methodology (support) &, Writing - Review & Editing (support)	
	Prof. Dr. Eva Bittner	Conceptualization (support) & Funding Acquisition	
Citation	Borchers, Marten; Gierlich-Joas, Maren; Tavanapour, Navid; & Bittner, Eva (2024). Let Citizens Speak Up: Designing Intelligent Online Participation for Urban Planning. In: *19th International Conference on Design Science Research in Information Systems and Technology* (DESRIST). https://link.springer.com/chapter/10.1007/978-3-031-61175-9_2		

Table 8. Contribution of the C4 Publication to the RG

Title	Toward the ML-based Analysis of Citizens' Inputs from E-Participation in Urban Planning			
Conference	Pacific Asia Conference on Information Systems (PACIS)			
Track	Sharing Economy and crowd-based Platforms			
Type	Completed Research		**Ranking**	C
Research Question(s)	How to analyze citizens' inputs from e-participation with machine learning to support participation experts?			
Methodology	Knowledge Discovery in Database Framework			
Research Contribution	This publication contributes to the overall RG, especially RQ2, by describing the structure of collected data from an inductive cluster. Furthermore, the publication contributes to RQ3 by developing and evaluating clustering machine learning models. Based on this, the publication proposes a processing pipeline and a cluster hierarchy.			
Co-Authors' Contribution	Marten Borchers	Conceptualization (support), Formal Analysis (support), Methodology (support), Project Administration, Visualization, Supervision, Validation, Writing - Original Draft, Writing - Review & Editing		
	Thu-Bao Cao	Data Curation, Formal Analysis (lead), Methodology (lead) & Software		
	Prof. Dr. Eva Bittner	Conceptualization (support) & Funding Acquisition		
Citation	Borchers, Marten; Cao, Thu-Bao; & Bittner, Eva (2024). Toward the ML-based Analysis of Citizens' Inputs from E-Participation in Urban Planning. In: *Proceedings of the Pacific Asia Conference on Information Systems* (PACIS). https://aisel.aisnet.org/pacis2024/track16_shareecon/track16_shareecon/6			

Table 9. Contribution of the C5 Publication to the RG

Title	Designing AI-Based Systems to Support the Analysis of Citizens' Inputs from E-Participation Inputs from E-Participation			
Conference	European Conference on Information System (ECIS)			
Track	Design Research and Design Methods in Information Systems			
Type	Completed Research		**Ranking**	A
Research Question(s)	How to design IT artifacts to support the AI-based analysis of citizens' inputs from e-participation?			
Methodology	Design Science Research			
Research Contribution	This publication contributes to the overall RG, especially RQ2 and RQ3, by developing and evaluating a web prototype that includes a classification model trained to analyze data. In addition, this was combined with a sentiment model, and for the visualization of findings, plots were automatically generated. To easily find statements, a semantic keyword search was also included. The publication describes eleven issues, nine meta-requirements, and four design principles, which were subsequently extended through a qualitative evaluation with expert interviews into six design principles.			
Co-Authors' Contribution	Marten Borchers	Conceptualization (lead), Formal Analysis (support), Methodology (lead), Project Administration, Visualization, Supervision, Validation, Writing - Original Draft, Writing - Review & Editing (lead)		
	Thu-Bao Cao	Data Curation, Formal Analysis (lead), Methodology (support) & Software		
	Dr. Navid Tavanapour	Writing - Review & Editing (support)		
	Prof. Dr. Eva Bittner	Conceptualization (support) & Funding Acquisition		
Citation	Borchers, Marten; Cao, Thu-Bao; Tavanapour, Navid; & Bittner, Eva (2024). Designing AI-Based Systems to Support the Analysis of Citizens' Inputs from E-Participation. In: *Proceedings of the 32nd European Conference on Information System* (ECIS). https://aisel.aisnet.org/ecis2024/track23_designresearch/track23_designresearch/7			

Table 10. Contribution of the C6 Publication to the RG

Title	Hear Me Out: Supporting Citizens to Create Comprehensible Contributions on Urban Participation Platforms		
Conference	Conference on Computer-Supported Cooperative Work and Social Computing		
Track	Social and Crowd Computing		
Type	Completed Research	**Ranking**	B
Research Question(s)	How to support citizens in creating comprehensible contributions on urban participation platforms?		
Methodology	Design Science Research		
Research Contribution	This publication contributes to the overall RG, especially RQ1, by describing three prototypes that were compared and evaluated, and by examining different approaches to including citizens on urban participation platforms. In doing so, interactive features and AI-based feedback are explored, including an automatic submission analysis that provides real-time feedback contributing to RQ2. According to the design science research paradigm, ten issues, eight meta-requirements, and three design principles were described, which were then extended to five design principles after evaluation.		
Co-Authors' Contribution	Marten Borchers	Conceptualization (lead), Data Curation, Formal Analysis, Methodology (lead), Project Administration, Software, Supervision, Validation, Visualization, Writing - Original Draft (lead), Writing - Review & Editing (lead)	
	Daria Soroko	Writing - Review & Editing (support)	
	Dr. Navid Tavanapour	Methodology (support) & Writing - Review & Editing (support)	
	Prof. Dr. Eva Bittner	Conceptualization (support) & Funding Acquisition	
Citation	Borchers, Marten; Soroko, Daria; Tavanapour, Navid; & Bittner, Eva (2024). Hear Me Out: Supporting Citizens to Create Comprehensible Contributions on Urban Participation Platforms. In: *Proceedings of the ACM on Human-Computer Interaction*, Volume 8, Issue CSCW2, Article No.: 432, Pages 1 – 26. https://doi.org/10.1145/3686971		

Table 11. Contribution of the C7 Publication to the RG

Title	Emergency Management: Designing Mobile Applications to Support Citizens During Storm Floods			
Conference	International Conference on Design Science Research in Information Systems and Technology (DESRIST)			
Track	Sustainable Development and Environmental Solutions			
Type	Completed Research		**Ranking**	B
Research Question(s)	How should mobile emergency apps be designed to support citizens during storm floods?			
Methodology	Design Science Research			
Research Contribution	This publication contributes to the overall RG, especially RQ1, by describing the interactive mechanism in time-critical environments, comparable to citizen participation, in which participants often lack time. Furthermore, aspects of interactive maps are considered in more detail, as are checklists. The publication describes twelve issues, twelve meta-requirements, and four initial design principles, which were later extended to seven based on insights from the evaluation with citizens.			
Co-Authors' Contribution	Marten Borchers	Conceptualization (lead), Formal Analysis (lead), Methodology (lead), Project Administration, Supervision, Validation, Visualization (lead), Writing - Original Draft (lead), Writing - Review & Editing (lead)		
	Enrico Milutzki	Methodology (support), Formal Analysis (support), Writing - Original Draft (support) & Writing - Review & Editing (support)		
	Alexander Bode	Conceptualization (support) & Data Curation, Formal Analysis (support), Software, Visualization (support)		
	Valeria Magdych	Visualization (support)		
	Dr. Martin Semmann	Writing - Review & Editing (support)		
	Prof. Dr. Eva Bittner	Conceptualization (support) & Funding Acquisition		
Citation	Borchers, Marten; Milutzki, Enrico; Bode, Alexander; Magdych, Valeria; Semmann, Martin; & Bittner, Eva (2025). Emergency Management: Designing Mobile Applications to Support Citizens During Storm Floods. In: *Chatterjee, S., vom Brocke, J., Anderson, R. (eds) Local Solutions for Global Challenges*. DESRIST 2025. Lecture Notes in Computer Science, vol 15704. Springer, Cham. https://doi.org/10.1007/978-3-031-93979-2_17			

Table 12. Contribution of the C10 Publication to the RG

Title	Developing Machine Learning Models for the Analysis of Citizens' Contributions from E-Participation			
Conference	EGOV-CeDEM-ePart (EGOV)			
Track	CEUR-ONGOING RESEARCH			
Type	Completed Research		**Ranking**	-
Research Question(s)	How should textual citizens' contributions from e-participation be classified with machine learning techniques?			
Methodology	Knowledge Discovery in Databases Framework			
Research Contribution	This publication contributes to the overall RG, especially RQ2, by analyzing real-world citizen contributions from surveys and urban participation, describing them, and elaborating on textual data. Furthermore, this publication contributes to RQ3, as the data were cleaned and manually labeled according to the created labels, e.g., categories based on topics and findings from the labeling process. Afterward, the data were preprocessed and used to train machine learning models for category (class) prediction. The findings are described in terms of accuracy and training variations and formulated into seven insights.			
Co-Authors' Contribution	Marten Borchers	Conceptualization (lead), Data Curation (support), Methodology (support), Project Administration (support), Supervision, Validation, Visualization, Writing - Original Draft, Writing - Review & Editing (lead)		
	Delzar Habash	Conceptualization (support), Data Curation (lead), Formal Analysis, Methodology (lead), Software & Project Administration (lead)		
	Prof. Dr. Eva Bittner	Conceptualization (support) & Funding Acquisition		
Citation	Borchers, Marten; Habash, Delzar; & Bittner, Eva (2025). Developing Machine Learning Models for the Analysis of Citizens' Contributions from E-Participation. In: *Proceedings EGOV-CeDEM-ePart conference*, August 31 - September 4, 2025, University for Continuing Education, Krems, Austria. https://ceur-ws.org/Vol-4127/			

Table 13. Contribution of the C13 Publication to the RG

Title	Emergency Management: Designing Situation Maps to support Rescue Forces during Flood Disasters		
Conference	International Conference on Information Systems (ICIS)		
Track	IS for Sustainability		
Type	Completed Research	**Ranking**	A
Research Question(s)	How should IT artifacts be designed to support informed decision-making of emergency forces during floods in urban areas?		
Methodology	Design Science Research		
Research Contribution	This publication contributes to the overall RG and RQ1 by exploring the possibilities for designing and interacting with urban maps, including providing different types of data layers that support users in gaining a better understanding of districts and other areas of interest. Furthermore, this publication contributes to RQ2 by exploring and designing a map that specifies data attributes and how it can be intuitively provided to users. The publication describes twelve issues, twelve meta-requirements, and five design principles, which were extended to eight design principles due to the evaluation.		
Co-Authors' Contribution	Marten Borchers	Conceptualization (lead), Data Curation (lead), Formal Analysis (lead), Investigation (lead), Methodology (lead), Project Administration (lead), Resources (support), Supervision, Validation, Visualization (lead), Writing - Original Draft, Writing - Review & Editing (lead)	
	Enrico Milutzki	Formal Analysis (support), Visualization (support), Writing - Review & Editing (support)	
	Lisa Fetzer	Data Curation (support), Formal Analysis (support), Investigation (support), Project Administration (support), Software & Resources (lead)	
	Valeria Magdych	Visualization (support)	
	Prof. Dr. Eva Bittner	Conceptualization (support) & Funding Acquisition (support)	
	Dr. Martin Semmann	Conceptualization (support), Writing - Review & Editing (support) & Funding Acquisition (lead)	
Citation	Borchers, Marten; Milutzki, Enrico; Fetzer, Lisa; Magdych, Valeria; Bittner, Eva; & Semmann, Martin (2025). Emergency Management: Designing Situation Maps to support Rescue Forces during Flood Disasters. In: *Proceedings of the 46th International Conference on Information Systems* (ICIS). https://aisel.aisnet.org/icis2025/sustain/sustain/2		

Table 14. Contribution of the C14 Publication to the RG

Title	Facilitating Urban Participation Project with Generative AI to Support Citizen Engagement and Interaction		
Conference	Hawaii International Conference on System Sciences (HICSS)		
Track	e-Democracy, e-Participation and e-Voting		
Type	Completed Research	**Ranking**	B
Research Question(s)	How should AI-based chatbots be designed to support citizens' engagement and interaction on urban participation platforms?		
Methodology	Design Science Research		
Research Contribution	This publication contributes to the overall RG, especially RQ1, by describing the design of a web prototype and the usage of AI systems, e.g., an LLM that analyses citizens' submissions. This is done using a prompt-based approach, with guiding requirements and a description of the urban project's objective. Open questions are generated and asked of the participant to enhance data elicitation and interaction. In doing so, the publication also contributes to RQ2, as the analysis itself and contextual knowledge specify the data and information demands for urban experts in subsequent processes. The publication contains twelve identified issues, formulates eleven meta-requirements, and proposes five initial design principles, which were extended to seven due to the evaluation findings.		
Co-Authors' Contribution	Marten Borchers	Conceptualization (lead), Data Curation (support), Formal Analysis (lead), Investigation (support), Methodology (lead), Project Administration, Software (support), Supervision, Validation, Visualization (lead), Writing - Original Draft, Writing - Review & Editing (lead)	
	Chikaodi Uba	Conceptualization (support), Formal Analysis (support), Writing - Original Draft (support) & Writing - Review & Editing	
	Enrico Milutzki	Conceptualization (support) & Writing - Review & Editing (support)	
	Fynn Ittner	Data Curation (lead), Formal Analysis (support), Investigation (lead), Methodology (support), Software (lead)	
	Valeria Magdych	Visualization (support)	
	Prof. Dr. Eva Bittner	Conceptualization (support) & Funding Acquisition (support)	
	Dr. Martin Semmann	Writing - Review & Editing (support) & Funding Acquisition (lead)	
Citation	Borchers, Marten; Uba, Chikaodi; Milutzki, Enrico; Ittner, Fynn, Magdych, Valeria; Bittner, Eva; & Semmann, Martin (2026). Facilitating Urban Participation Project with Generative AI to Support Citizen Engagement and Interaction. In: *Proceedings of the 59th Hawaii International Conference on System Sciences* (HICSS). https://hdl.handle.net/10125/111674. Completed Research.		

Table 15. Contribution of the C15 Publication to the RG

Title	Analyzing Data from Urban Citizen Participation by Applying the Retrieval Augmented Generation Architecture		
Conference	Hawaii International Conference on System Sciences (HICSS)		
Track	Emerging Topics in Digital Government		
Type	Completed Research	**Ranking**	B
Research Question(s)	How should RAG-based IT artifacts be designed to support urban experts' analysis of participation data?		
Methodology	Design Science Research		
Research Contribution	This publication contributes to the overall RG, and especially RQ2 and RQ3. In this study, a web prototype was developed using the retrieval-augmented generation (RAG) architecture for large language models (LLMs) to support urban experts in analyzing citizens' contributions. To develop the prototype and RAG, we used insights, data, and information from real-world urban participation projects, which directly address RQ2. Furthermore, as the tool enables intuitive interaction with data to analyze it for subsequent processes, we demonstrate how data can be automatically analyzed, as requested in RQ3. The publication describes eleven issues, twelve meta-requirements, and four design principles, which were extended to six as a result of the evaluation with urban experts from different domains.		
Co-Authors' Contribution	Marten Borchers	Conceptualization (lead), Data Curation, Formal Analysis (support), Investigation, (support), Methodology (lead), Project Administration, Resources (lead), Supervision, Validation, Visualization (lead), Writing - Original Draft & Writing - Review & Editing (lead)	
	Enrico Milutzki	Conceptualization (support) & Writing - Review & Editing (support)	
	Simon Oelgeschläger	Formal Analysis (lead), Investigation (lead), Resources (support) & Software	
	Valeria Magdych	Visualization (support)	
	Prof. Dr. Eva Bittner	Conceptualization (support) & Funding Acquisition (support)	
	Dr. Martin Semmann	Writing - Review & Editing (support) & Funding Acquisition (lead)	
Citation	Borchers, Marten; Milutzki, Enrico; Oelgschläger, Simon; Magdych, Valeria; Semmann, Martin; & Bittner, Eva (2026). Analyzing Data from Urban Citizen Participation by Applying the Retrieval Augmented Generation Architecture. In: *Proceedings of the 59th Hawaii International Conference on System Sciences* (HICSS). https://hdl.handle.net/10125/111679		

Table 16. Contribution of the C16 Publication to the RG

4.3 Ranking Overview

Table 17 presents an overview of the VHB and CORE rankings for all publications, indicating whether they are ranked in the corresponding ranking systems. The VHB ranking ranges from “A” to “D”, while “A” is the highest ranking. The CORE ranking ranges from “A*” to “C” while “A*” represents the highest ranking.

No.	Included	Outlet	Ranking	
			VHB[2]	CORE
J1.	-	HMD	C	-
C1.	x	PACIS	C	A[3]
C2.	x	HICSS	B	A[3]
C3.	x	HICSS	B	A[3]
C4.	x	DESRIST	B	A[3]
C5.	x	PACIS	C	A[3]
C6.	x	ECIS	A	A[3]
C7.	x	CSCW	B	A[4]
C8.	-	HICSS	B	A[3]
C9.	-	HICSS	B	A[3]
C10.	x	DESRIST	B	A[3]
C11.	-	PACIS	C	A[3]
C12.	-	PACIS	C	A[3]
C13	x	EGOV-CeDEM-ePart	-[5] (C)	-
C14	x	ICIS	A	A[3]
C15	x	HICSS	B	A[3]
C16	x	HICSS	B	A[3]
C17	-	HICSS	B	A[3]
C18	-	DESRIST	B	A[3]
Rankings of the included Publications		A	2	11
		B	7	-
		C	2	-
		Not ranked	1	1

Table 17. Overview of all Article Rankings

[2] According to the VHB Publication Media Ranking from the 18th of April 2024
[3] According to the CORE 2018 Ranking
[4] According to the CORE 2023 Ranking
[5] Part of the IFIP WG 8.5 International Conference on Electronic Government (EGOV in LNCS) Conference

5 Theoretical Contributions

This Section synthesizes the theoretical contributions of this work, considering the proposed RG and RQs in Section 1.2 and the included publications, as described in Section 4.2. As specified by the DSR paradigm, theoretical contributions are differentiated into five different types of theories.

Type I theory is used to analyze, describe, and classify phenomena by providing concepts, frameworks, or taxonomies. Their purpose is to improve understanding rather than explain causes or predict outcomes (Gregor, 2006). *Type II* theory explains why and how phenomena occur by describing underlying mechanisms and relationships. However, they do not provide testable predictions about future events (Gregor, 2006). *Type III* theory for predicting focuses on forecasting outcomes based on identified relationships between variables. They predict what will happen but do not necessarily explain why it happens (Gregor, 2006). *Type IV* theory is for explaining and predicting causal explanations with empirically testable predictions. They represent the traditional view of scientific theory by explaining and forecasting phenomena (Gregor, 2006). *Type V* theory is for design and action, prescribing how artifacts, methods, or systems should be designed to achieve desired goals. They provide actionable design knowledge and form the theoretical foundation of DSR (Gregor, 2006; Gregor et al., 2020).

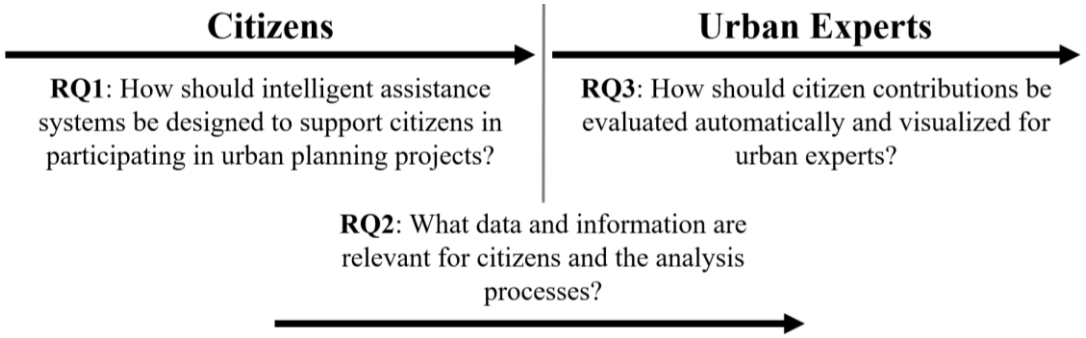


Figure 7. Assigned Research Questions to the Target Users of Citizens and Urban Experts

The theoretical contribution of this dissertation corresponds to *Type V*, a theory of design and action, as nearly all the included publications address the design of functions and their impact on the behavior of citizens or experts. Figure 7 illustrates the breakdown by target group and RQs, building upon Sections 1 and 3.

In the following, all included publications are examined according to their target group, and the various design principles are condensed into eight design clusters to propose an initial theory within the framework of this cumulative dissertation. For the target group of citizens, nine meta-design principles (MDPs) were derived from the seven publications focusing on supporting citizens during participation, as shown in Figure 5 in Section 3.3.1 and described in Section 5.1. For the target group of urban experts, eight meta-design principles were derived from five publications focusing

on the analysis of citizens' contributions, as shown in Figure 6 in Section 3.3.2 and described in detail in Section 5.2. To derive the meta-design-principles, following Gregor's *Type V* theory perspective, all design principles were reduced to their core elements and compared with one another (Gregor, 2006; Gregor & Hevner, 2013). If the design principles' core addresses the same topic, they were merged, e.g., summarized into an approved and validated meta-design principle.

This analysis included all publications that focus on supporting citizens in urban participation on urban platforms (Borchers, Soroko, Tavanapour, et al., 2024) and mobile systems (Borchers et al., 2023a) with submission forms, chatbot systems, and more (Borchers et al., 2022; Borchers, Uba, et al., 2026) as described in Section 5.1. Although the studies addressed different technologies, there is substantial overlap in their design principles, leading to four clusters of design knowledge extending the existing theoretical knowledge base (Borchers, Soroko, Tavanapour, et al., 2024; Romberg & Escher, 2024) as described in Section 5.1 and leading to four design clusters. The same approach was followed for the analysis of the publication, which focuses on the support of urban experts, and the process showed, as with the focus on citizens, a huge overlap, as described in Section 5.2, and led to another four clusters specifying the design of an AI-based system to support urban experts. Section 5.3

5.1 Intelligent Assistant Systems for the Smart Utilization of Urban Citizen Participations

This analysis led to the four clusters: (1) *information for citizens*, (2) *functional elements of the interface*, (3) *feedback characteristics and citizen behavior*, and (4) *data*. The first cluster focused on providing citizens with information about the urban project, the participation process, decision-making procedures, project progress, and contextual knowledge required to formulate informed contributions (cf. Section 5.1.1). The second cluster addressed functional interface elements that enable citizens to interact with the system, explore project-related information, and perform participation-related actions (cf. Section 5.1.2). The third cluster combines design principles that focus on feedback mechanisms and their influence on citizen behavior, including engagement, reflection, motivation, and the quality of contributions (cf. Section 5.1.3). The fourth cluster of design principles addressed the collection, structuring, and processing of citizen-generated data to ensure its usability for subsequent analysis and decision-making (cf. Section 5.1.4). In the following, all four clusters are described, highlighting the theoretical contributions in terms of nascent design knowledge addressing primarily RQ1 and RQ2 (cf. Section 1.2).

5.1.1 Information for Citizens

The first cluster, *information for citizens*, contains design principles aimed at improving citizens' understanding of the participation project and its broader context. These principles emphasize project transparency, communication of progress, provision of contextual information, explanation of AI-supported analyses, and access to supporting information sources. While the concrete implementations differ across studies, they all pursue the common objective of enabling informed participation through improved understanding (Borchers et al., 2023a; Borchers, Soroko, Tavanapour, et al., 2024). A closer examination of the design principles within this cluster revealed two recurring objectives shown in Figure 8.

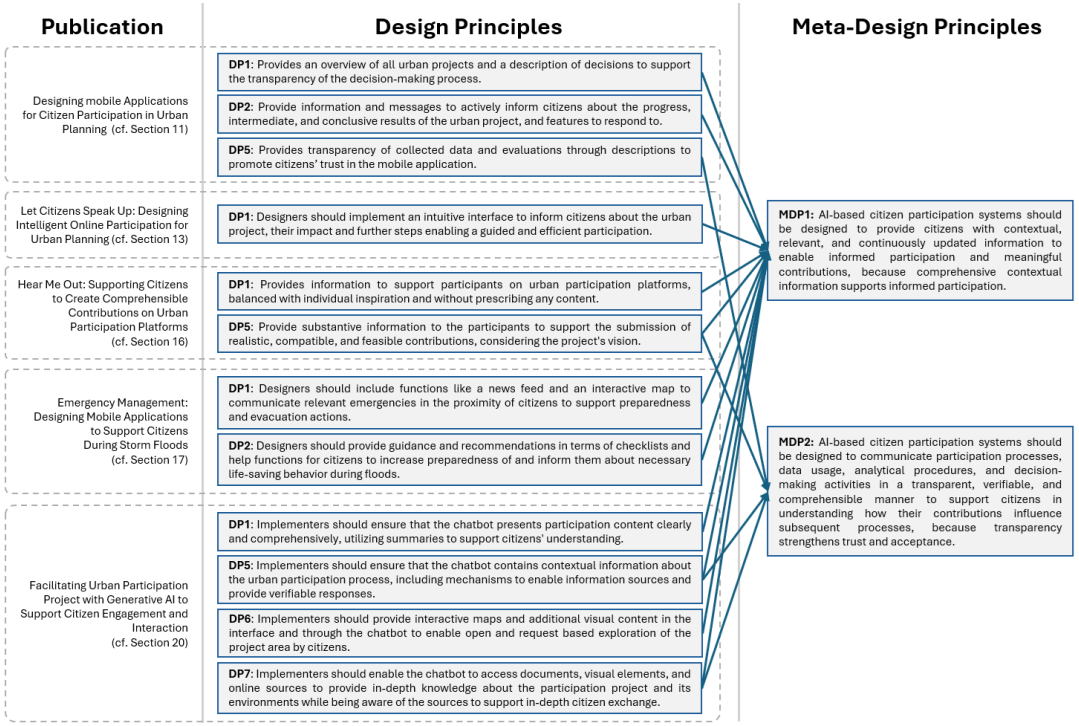


Figure 8. Cluster *Information for Citizens* with the two aggregated Meta-Design Principles, MDP1 and MDP2

The first objective focuses on reducing information asymmetries by providing citizens with sufficient knowledge about the urban project, its objectives, constraints, participation procedures, and progress (Borchers et al., 2022). Across the analyzed studies, this objective is addressed through project descriptions, progress updates, contextual information, explanatory content, and access to supporting documents and sources (Borchers, Uba, et al., 2026). These design principles share a common mechanism that enables citizens to understand the participation context better and formulate informed contributions. Consequently, these were synthesized into the following meta-design principle.

MDP1: AI-based citizen participation systems should be designed to provide citizens with contextual, relevant, and continuously updated

information to enable informed participation and meaningful contributions, because comprehensive contextual information supports informed participation.

The second objective focuses on increasing citizens' trust in the participation process, particularly in digitally mediated and AI-supported environments (Borchers, Soroko, Tavanapour, et al., 2024; Borchers, Uba, et al., 2026). Several design principles (cf. Figure 8) address the transparency of data collection, evaluation procedures, AI-supported analyses, and the communication of participation outcomes (Borchers, Milutzki, Bode, et al., 2025; Borchers, Soroko, Tavanapour, et al., 2024). Rather than merely providing additional information, these principles seek to make the underlying processes comprehensible and verifiable for citizens. Their common mechanism is reducing uncertainty about how contributions are processed and used, thereby increasing trust, legitimacy, and acceptance of participation outcomes (Borchers, Uba, et al., 2026). These design principles were therefore aggregated into the following meta-design principle.

MDP2: AI-based citizen participation systems should be designed to communicate participation processes, data usage, analytical procedures, and decision-making activities in a transparent, verifiable, and comprehensible manner to support citizens in understanding how their contributions influence subsequent processes, because transparency strengthens trust and acceptance.

Together, MDP1 and MDP2 capture the two dominant informational mechanisms identified across the analyzed publications. While MDP1 primarily addresses citizens' understanding of the participation context, MDP2 focuses on the transparency and trustworthiness of the participation process itself. Figure 8 visualizes the relationship between the original DPs and the two resulting meta-design principles and illustrates how the individual contributions from the analyzed studies were synthesized into higher-level design knowledge addressing RQ1.

5.1.2 Functional Elements of the Interface

The second cluster, *functional elements of the interface*, includes design principles that specify the interactive capabilities of urban participation systems. These principles address usability, accessibility, navigation, multilingual support, interactive maps, reporting functions, notification management, and other mechanisms that support interaction with the urban participation system (Borchers et al., 2023a; Borchers, Uba, et al., 2026). In contrast to the information for citizens cluster, which primarily addresses the provision of knowledge (cf. Section 5.1), this cluster focuses on how citizens access information and perform participation-related actions.

The synthesis revealed that the identified design principles pursue two distinct but complementary design objectives. While some principles aim to reduce interaction barriers and accommodate heterogeneous user groups, others seek to enable citizens to explore information and engage with the participation environment actively (Borchers, Soroko, Tavanapour, et al., 2024). As a result, two meta-design principles were derived for this cluster as shown in Figure 9.

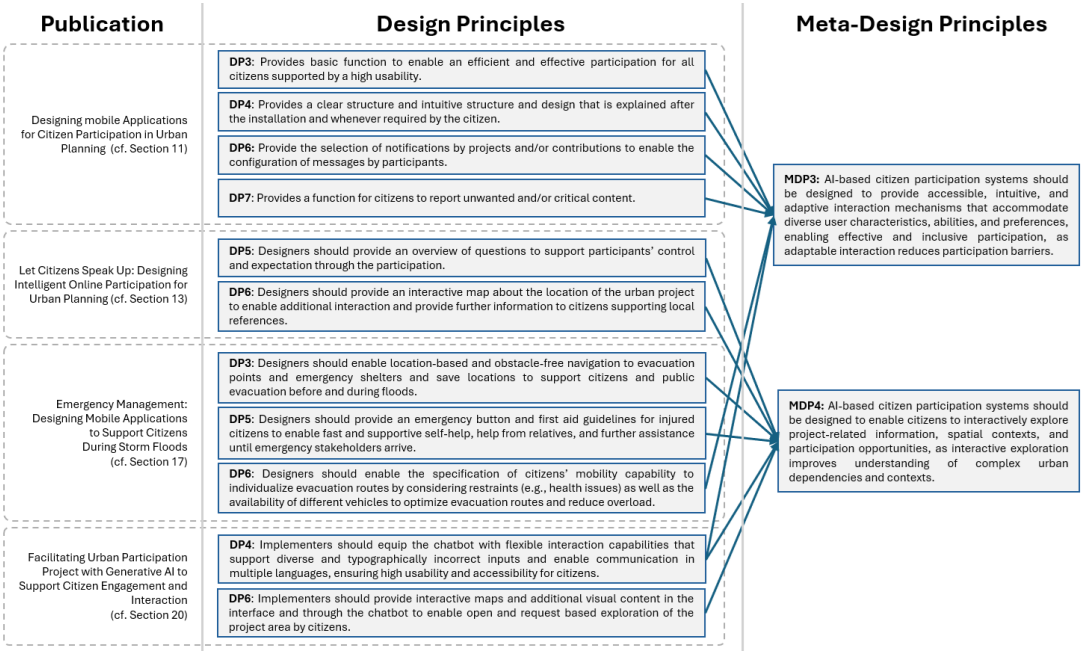


Figure 9. Cluster *Functional Elements of the Interface* with the two aggregated Meta-Design Principles, MDP3 and MDP4

Across the analyzed studies, several design principles highlighted the need for intuitive participation functions, clear interface structures, onboarding mechanisms, configurable notifications, multilingual communication, and personalized system behavior (Borchers et al., 2023a; Borchers, Milutzki, Bode, et al., 2025; Borchers, Uba, et al., 2026). Although these principles were developed in different contexts, ranging from mobile participation applications to AI-supported participation systems and emergency management applications, they address a common challenge. Many urban participation projects involve highly heterogeneous citizen groups with varying levels of digital literacy, language proficiency, technical expertise, and accessibility requirements (Borchers et al., 2023a; Borchers, Milutzki, Bode, et al., 2025; Borchers, Uba, et al., 2026). Consequently, participation systems must minimize interaction barriers and adapt to diverse user needs to enable broad participation. The resulting meta-design principle (MDP3) therefore states that implementers should provide citizens with accessible, intuitive, and adaptive interaction mechanisms that accommodate diverse user characteristics, abilities, preferences, and participation contexts to enable effective participation, as specified with the following:

MDP3: AI-based citizen participation systems should be designed to provide accessible, intuitive, and adaptive interaction mechanisms that accommodate diverse user characteristics, abilities, and preferences, enabling effective and inclusive participation, as adaptable interaction reduces participation barriers.

Three publications emphasized the importance of interactive maps, navigation mechanisms, visual exploration tools, question overviews, and action-oriented functionalities that support citizens in understanding spatial contexts, exploring project-related information, and participating (Borchers, Gierlich-Joas, Tavanapour, et al., 2024; Borchers, Milutzki, Bode, et al., 2025; Borchers, Uba, et al., 2026). Unlike the principles contributing to MDP3, which primarily focus on reducing usability barriers, these design principles address citizens' ability to engage with the participation environment actively and to make informed decisions through interactive exploration (Borchers, Gierlich-Joas, Tavanapour, et al., 2024). A recurring pattern across the studies was that participation systems should not merely serve as channels for information delivery but should empower citizens to investigate, navigate, and act within the participation process. Therefore, these principles were synthesized into MDP4.

MDP4: AI-based citizen participation systems should be designed to enable citizens to interactively explore project-related information, spatial contexts, and participation opportunities, as interactive exploration improves understanding of complex urban dependencies and contexts.

Together, MDP3 and MDP4 represent two dominant design mechanisms that address reducing interaction barriers through accessibility and adaptation (MDP3) and the active exploration and utilization of participation opportunities (MDP4), highlighting functionalities that enable citizens to perform meaningful actions throughout participation (cf. Figure 9), which addresses RQ1.

5.1.3 Feedback Characteristics and Citizen Behavior

The third cluster comprises design principles that focus on how participation systems influence citizens through feedback and interaction mechanisms (Borchers et al., 2022). Across the analyzed studies, feedback emerged as a central mechanism for supporting citizens throughout the participation process (Borchers, Soroko, Tavanapour, et al., 2024).

The synthesis revealed that the identified design principles pursue three distinct but complementary design objectives. While some principles focus on providing timely responses to maintain interaction, others aim to encourage reflection and improve the quality of contributions (Borchers et al., 2022; Borchers, Soroko, Tavanapour, et al., 2024). A third group of principles seeks to motivate citizens, strengthen their

perception of impact, and foster sustained engagement (Borchers, Gierlich-Joas, Tavanapour, et al., 2024; Borchers, Uba, et al., 2026). As a result, three meta-design principles were derived for this cluster as summarized in Figure 10.

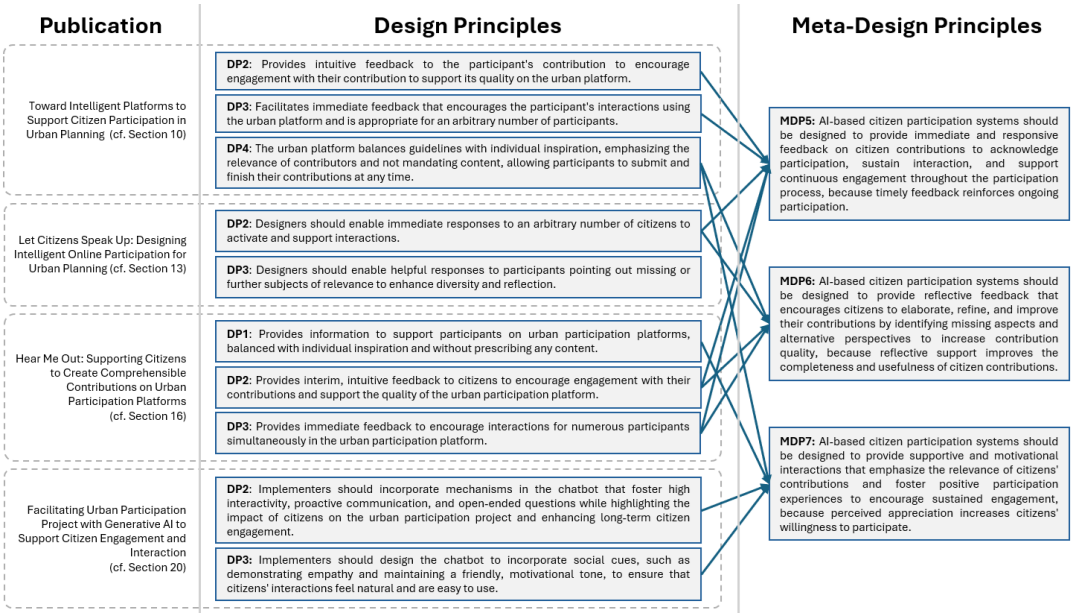


Figure 10. Cluster *Feedback Characteristics and Citizen Behavior* with the three aggregated Meta-Design Principles MDP5, MDP6, and MDP7

A recurring finding across multiple studies was the importance of timely responses to citizen contributions. Several design principles emphasized immediate feedback, direct responses, and scalable interaction mechanisms that could support large numbers of participants simultaneously (Borchers, Gierlich-Joas, Tavanapour, et al., 2024; Borchers, Soroko, Tavanapour, et al., 2024). Traditional participation processes often struggle to provide individualized responses due to limited resources and increasing participation volumes (Borchers et al., 2022). Consequently, digital and AI-supported participation systems offer opportunities to maintain interaction and responsiveness regardless of the number of participants (Borchers, Uba, et al., 2026; Cai, 2021). These principles address the common objective of ensuring that citizens perceive their contributions as acknowledged and processed promptly, resulting in the following meta-design principle.

MDP5: AI-based citizen participation systems should be designed to provide immediate and responsive feedback on citizen contributions to acknowledge participation, sustain interaction, and support continuous engagement throughout the participation process, because timely feedback reinforces ongoing participation.

The design principles underlying MDP5 emphasize that participation systems should not solely collect contributions but also actively respond to them. Immediate and responsive feedback reduces waiting times, strengthens the perception that contributions are valued, and supports continuous interaction between citizens and

the participation system (Borchers et al., 2022; Borchers, Gierlich-Joas, Tavanapour, et al., 2024; Borchers, Soroko, Tavanapour, et al., 2024). As illustrated in Figure 10, the contributing design principles consistently highlight responsiveness as a key mechanism for maintaining engagement and preventing participation drop-off. Beyond responsiveness, several studies identified feedback as an important mechanism for improving the quality of citizen contributions (Borchers, Soroko, Tavanapour, et al., 2024). Design principles repeatedly emphasized the need for helpful responses that encourage participants to consider missing aspects, alternative perspectives, and project-specific constraints (Borchers, Uba, et al., 2026). Additional principles focused on providing contextual guidance and substantive information that support citizens in developing more comprehensive and feasible contributions. While implemented through different technological solutions, these principles share the objective of supporting citizens in reflecting upon and refining their contributions (Borchers, Soroko, Tavanapour, et al., 2024). Consequently, they were synthesized into the following meta-design principle.

MDP6: AI-based citizen participation systems should be designed to provide reflective feedback that encourages citizens to elaborate, refine, and improve their contributions by identifying missing aspects and alternative perspectives to increase contribution quality, because reflective support improves the completeness and usefulness of citizen contributions.

The resulting meta-design principle recognizes feedback as more than a simple acknowledgment mechanism. Instead, feedback serves as cognitive support, stimulating reflection, broadening perspectives, and encouraging citizens to formulate more comprehensive and understandable contributions (Borchers, Gierlich-Joas, Tavanapour, et al., 2024; Borchers, Soroko, Tavanapour, et al., 2024). Figure 10 illustrates how contributing design principles collectively support the development of MDP6.

A third recurring pattern across the analyzed studies concerned the motivational role of feedback and interaction. Several design principles emphasized highlighting the relevance and impact of citizen contributions, using supportive communication styles, and incorporating social cues such as empathy, friendliness, and encouragement (Borchers, Uba, et al., 2026). These mechanisms aim to strengthen citizens' perception that their participation is meaningful and valued while fostering positive participation experiences. Although implemented in different forms, the underlying objective remains consistent, focusing on motivating citizens to remain engaged and actively participate throughout the process (Borchers et al., 2022; Borchers, Soroko, Tavanapour, et al., 2024; Borchers, Uba, et al., 2026). Therefore, these design principles were synthesized into the following meta-design principle.

MDP7: AI-based citizen participation systems should be designed to provide supportive and motivational interactions that emphasize the relevance of citizens' contributions and foster positive participation experiences to encourage sustained engagement, because perceived appreciation increases citizens' willingness to participate.

The contributing design principles suggest that participation systems should actively support citizens by communicating the value of their participation and reinforcing their sense of efficacy. Rather than focusing on contribution quality, these mechanisms address citizens' willingness to participate and continue engaging with the participation process over time (Borchers et al., 2022; Borchers, Soroko, Tavanapour, et al., 2024; Borchers, Uba, et al., 2026).

Together, MDP5, MDP6, and MDP7 represent three complementary design mechanisms within the *feedback characteristics and citizen behavior* cluster (cf. Figure 10). While MDP5 focuses on maintaining interaction through immediate, responsive feedback, MDP6 addresses improving contribution quality through reflective support. MDP7 extends this perspective by emphasizing motivation, empowerment, and sustained participation. Collectively, these principles highlight that feedback in urban participation systems serves not only as a communication mechanism but also to shape citizen behavior, support learning processes, and foster long-term engagement, consistent with RQ1. Furthermore, examining the feedback mechanism and its impact on citizens' expression of their thoughts also affects the collection of data, which is part of RQ2.

5.1.4 Data

The fourth cluster focuses on the collection and processing of citizen-generated information within urban participation processes. The analysis of the publication's design revealed that the value of participation depends not only on the quantity of contributions but also on their structure and comprehensiveness (Borchers et al., 2022, 2023b; Borchers, Uba, et al., 2026).

The synthesis revealed two areas. While some principles focus on the structured collection of information (Borchers et al., 2022, 2023b; Borchers, Gierlich-Joas, Tavanapour, et al., 2024; Borchers, Milutzki, Fetzer, et al., 2025; Borchers, Soroko, Tavanapour, et al., 2024), others address the scalable, trustworthy processing of this information through analytical and AI-supported mechanisms (Borchers et al., 2023b; Borchers, Soroko, Tavanapour, et al., 2024; Borchers, Uba, et al., 2026). Consequently, two meta-design principles were derived for this cluster as shown in Figure 11.

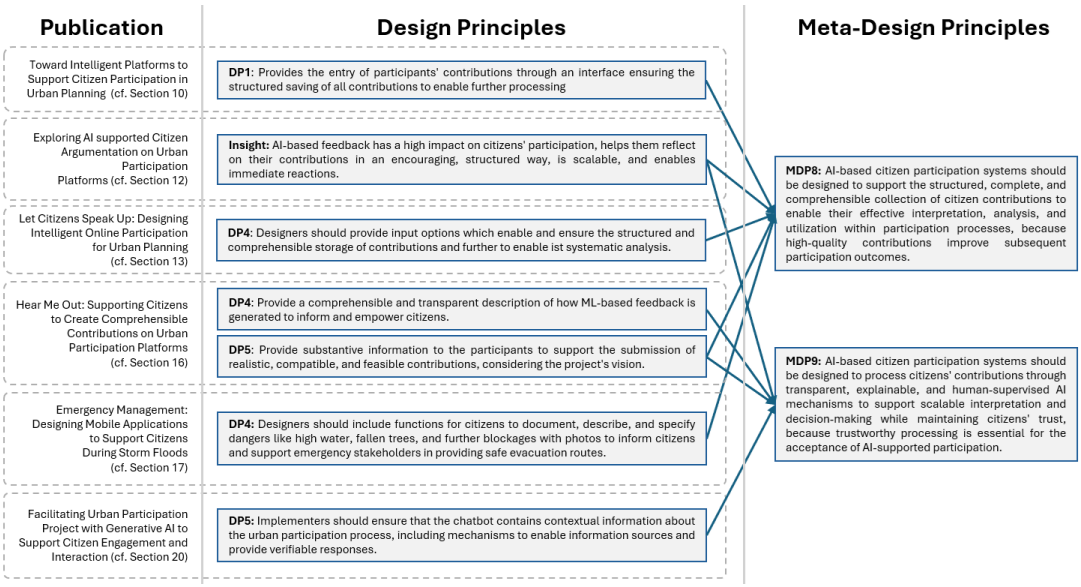


Figure 11. Cluster *Data* with the two aggregated Meta-Design Principles, MDP8 and MDP9

Four publications highlighted the importance of supporting citizens in creating structured, complete, and comprehensible contributions (Borchers, Soroko, Tavanapour, et al., 2024). Design principles repeatedly emphasized the need for structured input mechanisms, comprehensible contribution formats, and functionalities that enable citizens to provide detailed and meaningful information (Borchers et al., 2023b). Poorly structured or incomplete contributions can limit subsequent analysis and reduce the value of participation outcomes for planners and decision-makers, leading to the following meta-design principle.

MDP8: AI-based citizen participation systems should be designed to support the structured, complete, and comprehensible collection of citizen contributions to enable their effective interpretation, analysis, and utilization within participation processes, because high-quality contributions improve subsequent participation outcomes.

The resulting meta-design principles emphasize that participation systems should actively support citizens in creating contributions that can be effectively interpreted and utilized beyond the initial submission process (Borchers, Cao, & Bittner, 2024; Borchers et al., 2023b; Borchers, Gierlich-Joas, Tavanapour, et al., 2024; Borchers, Milutzki, Bode, et al., 2025; Borchers, Soroko, Tavanapour, et al., 2024). Rather than treating participation as a simple data-collection activity, MDP8 recognizes that contribution quality is a prerequisite for generating meaningful participation outcomes (cf. Figure 11).

Multiple studies also emphasized the growing importance of processing citizen-generated information at scale. As digital participation formats increasingly generate large volumes of contributions, manual analysis alone becomes insufficient for

identifying relevant information (Borchers et al., 2023b; Royo et al., 2020). Several design principles therefore highlighted the importance of analytical mechanisms such as categorization, summarization, sentiment analysis, and other AI-supported approaches (Borchers, Uba, et al., 2026). At the same time, the analyzed studies repeatedly emphasized the necessity of transparency, explainability, and human oversight when applying automated analytical methods. Citizens and decision-makers must understand how analytical results are generated and how citizen contributions influence planning outcomes (Borchers et al., 2023b; Borchers, Soroko, Tavanapour, et al., 2024; Borchers, Uba, et al., 2026). Consequently, the identified design principles address the dual challenge of scalability and trustworthiness in data analysis, leading to the following MDP9.

MDP9: AI-based citizen participation systems should be designed to process citizens' contributions through transparent, explainable, and human-supervised AI mechanisms to support scalable interpretation and decision-making while maintaining citizens' trust, because trustworthy processing is essential for the acceptance of AI-supported participation.

MDP9 recognizes that the increasing availability of citizen-generated data requires analytical mechanisms capable of transforming large amounts of information into actionable knowledge (Borchers, Cao, Tavanapour, et al., 2024; Borchers, Uba, et al., 2026). However, the principle simultaneously acknowledges that automated processing should remain transparent and subject to human oversight to ensure legitimacy, accountability, and trust (cf. Figure 11). Together, MDP8 and MDP9 represent the two meta-design principles within the *data* cluster. While MDP8 focuses on improving the quality, structure, and comprehensibility of citizen-generated information, MDP9 addresses the intelligent, transparent processing of this information for planning and decision-making, both laying the foundation as required by RQ3.

5.2 Intelligent Assistant Systems for the Analysis of Urban Participation Data

This analysis of the five publications that focus on the analysis of participation data by experts led to the four clusters: (1) *data acquisition and preparation*, (2) *analysis and knowledge generation*, (3) *information presentation and decision-making,* and (4) *traceability and trust*. The first cluster focused on data acquisition (cf. Section 5.2.1) and is therefore very close to the fourth cluster from the perspective of citizens in Section 5.1.4. The second cluster addressed data analysis and knowledge creation, as AI and ML should increase efficiency and automate manual processes (cf. Section 5.2.2), thereby tackling the described challenge. The third cluster specifies

possibilities for presenting findings and derived information to experts, as these need to be further interpreted so that urban experts can use and create recommendations and reports for participation projects and public or private clients (cf. Section 5.2.3). The fourth and final consideration is that urban experts face the challenges of traceability and trust, which are also connected to transparency and principles to achieve that, as far as possible, in the face of black-box challenges in AI and ML models (cf. Section 5.2.4). In the following, all four clusters are described, highlighting the theoretical contributions in terms of nascent design knowledge addressing the RQ2 and RQ3 (cf. Section 1.2).

5.2.1 Data Acquisition and Preparation

The first cluster, *data acquisition and preparation*, comprises challenges, insights, and design principles that focus on the generation, collection, standardization, and preparation of citizen-generated data for subsequent analysis. Across the analyzed studies, a recurring finding was that the quality of analytical outcomes strongly depends on the quality, consistency, and structure of the underlying data (Borchers, Cao, & Bittner, 2024; Borchers, Habash, et al., 2025; Borchers, Milutzki, Fetzer, et al., 2025). The synthesis revealed two complementary design objectives. While some contributions focus on establishing standardized, structured data-acquisition mechanisms, others emphasize preparing collected data to ensure its suitability for AI-supported analysis. Consequently, two meta-design principles were derived for this cluster, as shown in Figure 12.

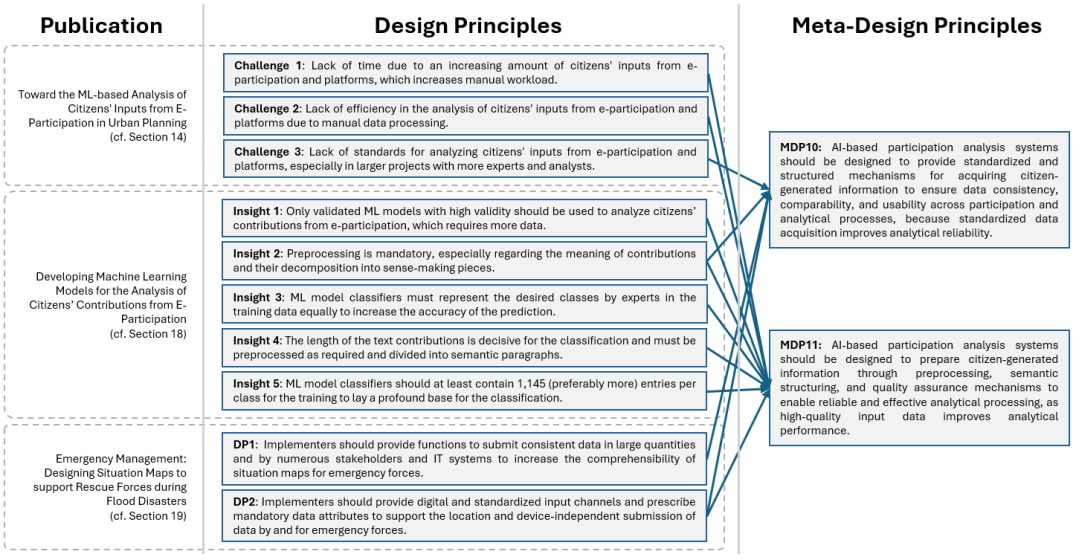


Figure 12. Cluster *Data Acquisition and Preparation* with the aggregated Meta-Design Principles, MDP10 and MDP11

Three studies have highlighted the challenge of collecting citizen-generated information in a consistent, standardized manner (Borchers, Cao, & Bittner, 2024; Borchers, Habash, et al., 2025; Borchers, Milutzki, Fetzer, et al., 2025). The analysis revealed a lack of common standards for collecting and documenting contributions,

particularly in larger projects involving multiple stakeholders and analysts (Borchers, Habash, et al., 2025). Consequently, several design principles emphasized standardized input channels, mandatory data attributes, and mechanisms that ensure consistent data acquisition across different users and systems. Although developed in different application contexts, these principles address the common objective of improving data consistency and comparability (Borchers, Cao, & Bittner, 2024; Borchers, Milutzki, Fetzer, et al., 2025). Therefore, they were synthesized into the following meta-design principle.

MDP10: AI-based participation analysis systems should be designed to provide standardized and structured mechanisms for acquiring citizen-generated information to ensure data consistency, comparability, and usability across participation and analytical processes, because standardized data acquisition improves analytical reliability.

Beyond data acquisition, several studies emphasized that the data collected frequently require substantial preparation before they can be analyzed using ML or other analytical approaches (Borchers, Cao, & Bittner, 2024; Romberg et al., 2022). The findings from the ML studies demonstrated that preprocessing is essential to improve analytical performance and ensure meaningful results (Romberg & Escher, 2024). Insights repeatedly highlighted the importance of sufficient training data, balanced class distributions, semantic decomposition of contributions, and the preparation of textual content into analyzable units (Borchers, Cao, & Bittner, 2024; Borchers, Habash, et al., 2025). While these findings were derived from the development and evaluation of ML models, they reveal a broader design requirement for preparing participation data for analysis. Consequently, these insights were synthesized into the following meta-design principle.

MDP11: AI-based participation analysis systems should be designed to prepare citizen-generated information through preprocessing, semantic structuring, and quality assurance mechanisms to enable reliable and effective analytical processing, as high-quality input data improves analytical performance.

Together, MDP10 and MDP11 represent the two dominant design mechanisms within the *data acquisition and preparation* cluster. While MDP10 focuses on establishing structured and standardized mechanisms for acquiring participation data, MDP11 addresses the preparation and refinement of collected information for analytical purposes (cf. Figure 12). This answers, together with the cluster's *feedback characteristics and citizen behavior* (cf. Section 5.1.3), *data* (cf. Section 5.1.4), RQ2 by specifying design insight for implementers and bridges the citizens' and experts' perspectives through data, as the bot relies on proper submission, to make an impact

on the participation projects and understanding the need to make proper recommendations (cf. Section 2.3).

5.2.2 Analysis and Knowledge Generation

The second expert-oriented cluster, *analysis and knowledge generation*, comprises challenges, insights, and design principles that focus on transforming citizen-generated information into actionable knowledge for urban experts.

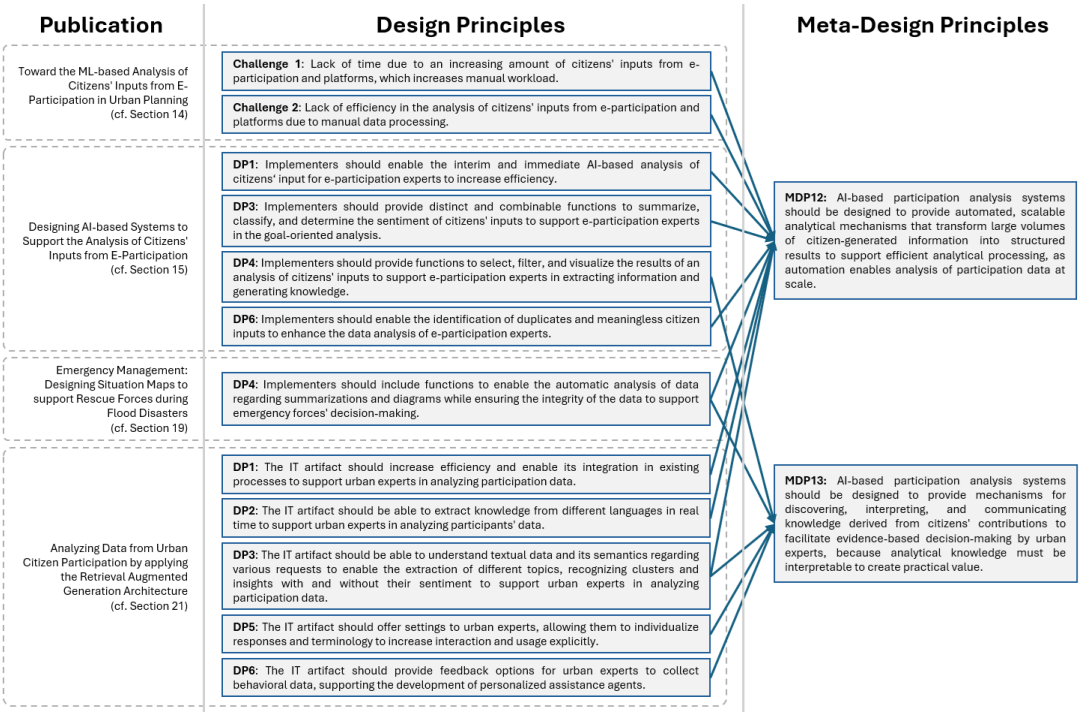


Figure 13. Cluster *Analysis and Knowledge Generation* with the aggregated Meta-Design Principles, MDP12 and MDP13

Across the included studies, focusing on urban experts, the increasing volume and complexity of citizen contributions emerged as a recurring challenge that exceeds the capabilities of purely manual analysis approaches (Borchers, Cao, & Bittner, 2024; Borchers, Cao, Tavanapour, et al., 2024; Borchers, Milutzki, et al., 2026; Borchers, Milutzki, Fetzer, et al., 2025). The synthesis revealed two complementary design objectives. While some principles focus on automating analytical tasks to improve efficiency and scalability, others aim to support experts in extracting knowledge and deriving insights from analytical results, as shown in Figure 13.

Several studies emphasized the need to automate analytical tasks that traditionally require substantial manual effort. The identified challenges highlighted increasing workloads and decreased efficiency resulting from the growing number of citizen contributions (Borchers, Cao, Tavanapour, et al., 2024; Royo et al., 2024). To address these challenges, multiple design principles proposed mechanisms such as automated classification, sentiment analysis, summarization, duplicate detection, multilingual processing, and semantic analysis (Abel et al., 2022; Borchers, Cao, Tavanapour, et

al., 2024; Borchers, Milutzki, et al., 2026). These principles pursue a common objective, which is to enable experts to process large volumes of citizen-generated information efficiently and at scale, leading to the following MDP12.

MDP12: AI-based participation analysis systems should be designed to provide automated, scalable analytical mechanisms that transform large volumes of citizen-generated information into structured results to support efficient analytical processing, as automation enables analysis of participation data at scale.

The resulting meta-design-principle recognizes that the increasing scale of digital participation requires analytical approaches and mechanisms to enable experts to process large datasets while maintaining consistency and reducing workload (cf. Figure 12). Complementary to MDP12, MDP13 focuses on supporting experts in interpreting analytical outcomes and transforming them into actionable knowledge, a challenge well described in the literature (Cai, 2021; Romberg & Escher, 2024). The derived design principles of the included publications repeatedly emphasized filtering mechanisms, visual representations, topic extraction, cluster identification, summarization, and personalized analytical support (Borchers, Cao, Tavanapour, et al., 2024; Borchers, Milutzki, et al., 2026; Borchers, Milutzki, Fetzer, et al., 2025). These principles aim to help experts identify relevant patterns, derive insights, and support evidence-based decision-making, leading to the following meta-design principle.

MDP13: AI-based participation analysis systems should be designed to provide mechanisms for discovering, interpreting, and communicating knowledge derived from citizens' contributions to facilitate evidence-based decision-making by urban experts, because analytical knowledge must be interpretable to create practical value.

Figure 12 illustrates how the contributing design principles collectively support the development of MDP13 and highlight knowledge generation as a central objective of AI-supported participation analysis. Together, MDP12 and MDP13 represent the two design mechanisms focusing on automating and scaling analytical processes (MDP12) and the transformation of analytical outputs into actionable knowledge and decision support (MDP13). Combined, these principles extend the theoretical foundation for the sense-making of citizens' contributions, addressing RQ3 (Hevner et al., 2004).

5.2.3 Information Presentation and Decision Support

The third expert-oriented cluster, *information presentation and decision support*, comprises design principles that focus on how analytical results and generated

knowledge are presented to experts and integrated into their decision-making processes (Borchers, Cao, Tavanapour, et al., 2024; Romberg & Escher, 2024).

Across the analyzed studies, it became apparent that analytical capabilities alone are insufficient if the resulting information cannot be effectively communicated, contextualized, and utilized (Pitogo & Ramos, 2020). The synthesis revealed two complementary design objectives, focusing on presenting information in a role-specific and understandable manner and the transformation of analytical results into actionable decision support, as shown in Figure 14.

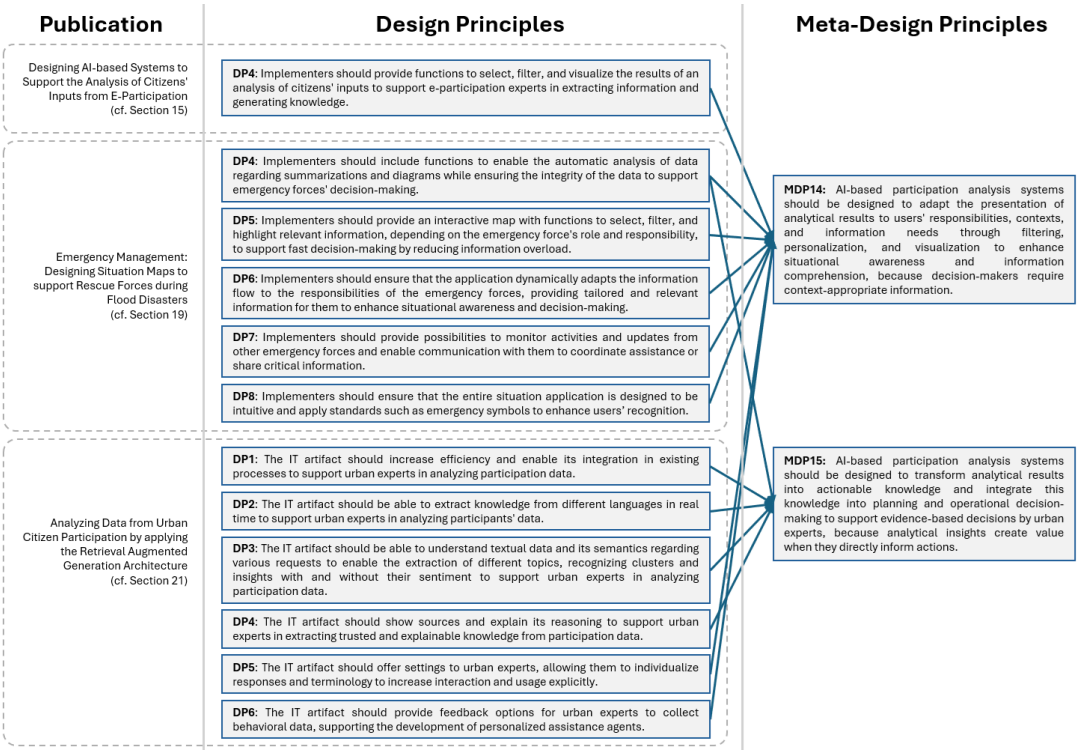


Figure 14. Cluster *Information Presentation and Decision Support* with the aggregated Meta-Design Principles, MDP14 and MDP15

Several studies highlighted that experts often face large amounts of information originating from different stakeholders, analytical systems, and data sources (Borchers, Cao, Tavanapour, et al., 2024; Borchers, Milutzki, Fetzer, et al., 2025; Royo et al., 2020). Consequently, multiple design principles emphasized the importance of filtering, selecting, visualizing, and adapting information to users' responsibilities and information needs (Borchers, Cao, Tavanapour, et al., 2024). Interactive maps, personalized information flows, monitoring mechanisms, adaptive interfaces, and configurable analytical responses emerged as recurring design mechanisms (Borchers, Milutzki, Fetzer, et al., 2025). They address the common challenge of reducing information overload while maintaining situational awareness, leading to the following.

MDP14: AI-based participation analysis systems should be designed to adapt the presentation of analytical results to users' responsibilities, contexts,

and information needs through filtering, personalization, and visualization to enhance situational awareness and information comprehension, because decision-makers require context-appropriate information.

The resulting meta-design principle recognizes that experts require different information depending on their tasks, responsibilities, and decision-making contexts (Borchers, Cao, Tavanapour, et al., 2024). Rather than presenting all available information simultaneously, systems should support users through adaptive filtering, personalized information presentation, intuitive visualizations, and context-sensitive interfaces (Bono Rossello et al., 2025; Borchers, Cao, Tavanapour, et al., 2024). While MDP14 focuses on presenting information effectively, several studies emphasized the need to transform analytical outputs into actionable knowledge that directly supports decision-making. Many derived design principles in the conducted studies (cf. Section 4.2) highlight knowledge extraction, multilingual information access, summarization, clustering, insight generation, and process integration as mechanisms for supporting experts in deriving decisions from large volumes of data (Borchers, Cao, Tavanapour, et al., 2024; Borchers, Milutzki, et al., 2026; Borchers, Milutzki, Fetzer, et al., 2025). These principles share the common objective of enabling experts to move beyond information consumption toward evidence-based action, as summarized by MDP15.

MDP15: AI-based participation analysis systems should be designed to transform analytical results into actionable knowledge and integrate this knowledge into planning and operational decision-making to support evidence-based decisions by urban experts, because analytical insights create value when they directly inform actions.

Together, MDP14 and MDP15 represent the design mechanisms within the *information presentation and decision support* cluster addressing RQ3. While MDP14 focuses on presenting analytical information in a role-specific, adaptive, and comprehensible manner, MDP15 addresses transforming analytical outputs into actionable knowledge that supports decision-making.

5.2.4 Traceability and Trust

The fourth expert-oriented cluster, *traceability and trust*, comprises challenges, insights, and design principles that enable experts to understand, verify, and trust AI-supported analytical processes and results. Across the studies included in this dissertation that focus on data analysis by urban experts and similar work, the two aspects of traceability and trust emerged as critical requirements for the successful adoption of AI-supported analysis systems (Borchers, Cao, Tavanapour, et al., 2024). The synthesis revealed two complementary design objectives. While some principles focus on ensuring that analytical processes remain traceable, others emphasize the

trustworthiness of analytical models and results. Consequently, two meta-design principles were derived for this cluster (Borchers, Cao, & Bittner, 2024; Borchers, Cao, Tavanapour, et al., 2024; Borchers, Habash, et al., 2025; Borchers, Milutzki, et al., 2026; Borchers, Milutzki, Fetzer, et al., 2025).

Several studies identified a lack of traceability as a significant challenge in analyzing citizen-generated information. During analysis, manual data processing is enabled, as it is known which expert or assistant analyzed what kind of data, and the findings are usually discussed together (Küstermann & Bittner, 2022; Stelzle et al., 2017). With AI, this is more challenging, as the input can be inspected, and the output, but the processing step between aren't, which is why experts frequently reported difficulties in understanding how analytical results were generated, which data sources were used, how and when, and which processing steps contributed to specific outcomes (Borchers, Cao, Tavanapour, et al., 2024; Romberg & Escher, 2024).

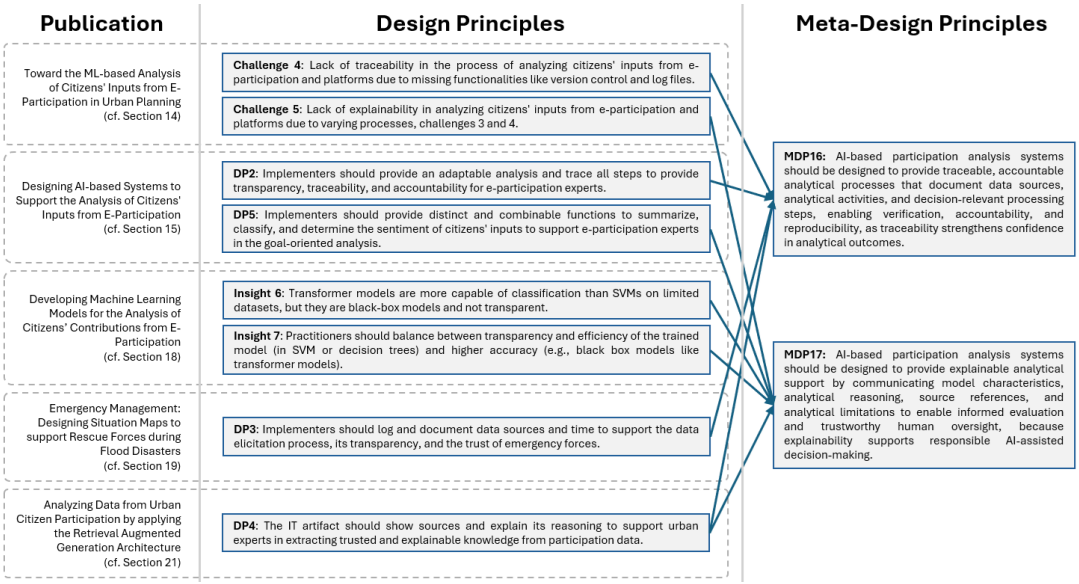


Figure 15. Cluster *Traceability and Trust* with the aggregated Meta-Design Principles, MDP16 and MDP17

To address these challenges, multiple design principles emphasized the importance of logging analytical activities, documenting data sources, recording timestamps, and maintaining transparent records of analytical workflows to enable accountability. This affects the use of different AI and ML models, and, in the case of LLMs, also the information about their pattern activation, as far as possible (Borchers, Cao, & Bittner, 2024; Borchers, Habash, et al., 2025; Borchers, Milutzki, et al., 2026), leading to MDP16 as shown in the following and Figure 15.

MDP16: AI-based participation analysis systems should be designed to provide traceable, accountable analytical processes that document data sources, analytical activities, and decision-relevant processing steps,

enabling verification, accountability, and reproducibility, as traceability strengthens confidence in analytical outcomes.

MDP16 emphasizes that analytical systems should provide more than final results and enable experts to understand how those results inform their recommendations to politicians and other clients (Borchers, Cao, Tavanapour, et al., 2024; Stelzle et al., 2017). Beyond that, several studies emphasized the need for experts to understand and evaluate the underlying analytical models themselves. Challenges and insights repeatedly highlighted the limited transparency of complex ML approaches (Borchers, Milutzki, et al., 2026), particularly black-box models such as transformer-based architectures (Vaswani et al., 2017). Additional derived design principles, insights, and identified challenges (cf. Figure 15) emphasized the importance of providing information about model behavior, analytical confidence, source references, and explanations of generated results (Borchers, Cao, & Bittner, 2024; Borchers, Cao, Tavanapour, et al., 2024; Borchers, Habash, et al., 2025; Borchers, Milutzki, et al., 2026). These findings suggest that experts need mechanisms to assess the reliability and limitations of analytical outputs. Consequently, these were synthesized into the following MDP17.

MDP17: AI-based participation analysis systems should be designed to provide explainable analytical support by communicating model characteristics, analytical reasoning, source references, and analytical limitations to enable informed evaluation and trustworthy human oversight, because explainability supports responsible AI-assisted decision-making.

MDP17 acknowledges that trust in analytical systems depends not only on predictive performance but also on users' ability to understand how results are generated and to assess their reliability. Explainability mechanisms, source transparency, and model information help experts critically evaluate analytical outputs and make informed decisions (cf. Figure 15).

Together, MDP16 and MDP17 represent the cluster of traceability and trust, by first documenting and providing information about the overall processing process which also enable accountability, as in manual data analysis and secondly, by providing information about the ML models itself and their data processing, which is especially challenging with neural networks and LLM and addresses an major deign implication which resulting from RQ3 (Borchers, Milutzki, et al., 2026; Romberg & Escher, 2024).

5.3 Overall Theoretical Contribution

The synthesis of the seventeen meta-design principles, nine regarding the interaction with citizens (cf. Section 5.1) and eight regarding the interaction with experts (cf.

Section 5.2), demonstrates that the theoretical contribution of this cumulative dissertation extends beyond the individual IT artifacts developed in the included DSR projects and empirical works (cf. Section 4.2). While each publication proposed and evaluated design principles within a specific technological context, their systematic aggregation revealed recurring design mechanisms that transcend individual systems, technologies, and application scenarios. By abstracting these recurring mechanisms into seventeen meta-design principles, this dissertation contributes generalized prescriptive knowledge for the design of AI-supported urban participation systems.

Following Gregor's conceptualization of *Type V* theories as theories for design and action (Gregor, 2006), the proposed meta-design principles prescribe how digital and AI-supported participation systems should be designed to achieve desired outcomes for both citizens and urban experts (cf. Section 3). Rather than describing or explaining existing phenomena, the resulting initial design theory provides normative guidance for the development of future participation platforms, intelligent assistance systems (cf. Section 5.1), and AI-supported analytical environments (cf. Section 5.2).

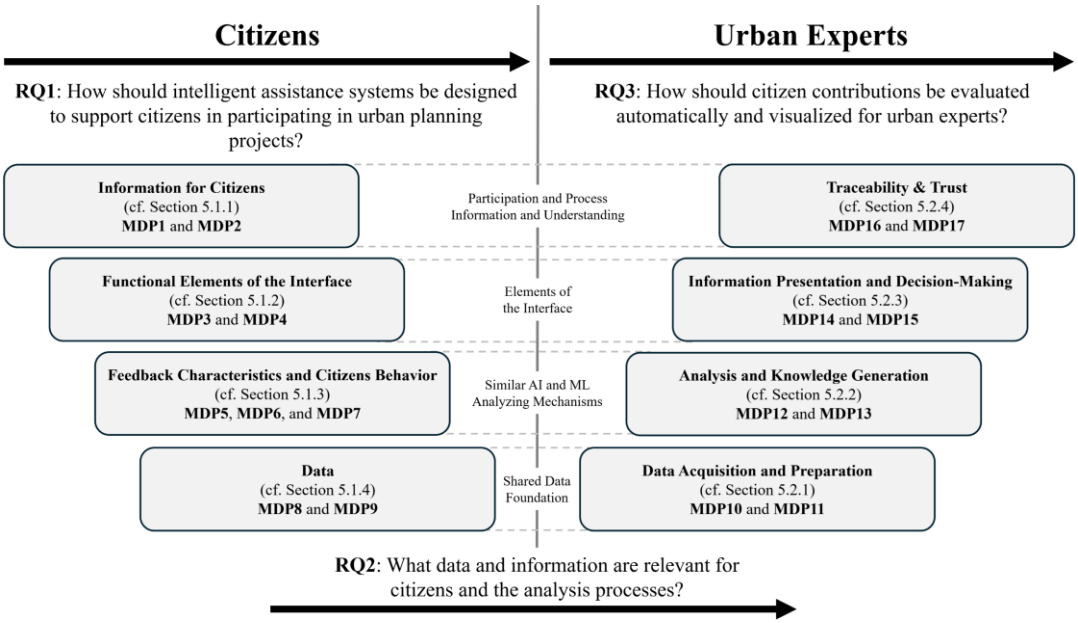


Figure 16. Overview of all Meta-Design-Principles considering the Research Questions and Stakeholders

Figure 16 provides an overview, arranges the meta-design principles by perspective, and highlights overlaps through target-group comparisons. The connection between the meta-design principles becomes evident in relation to the RQs, as the left side primarily addresses RQ1, while the right side primarily addresses RQ3. RQ2 is primarily considered in the clusters' *feedback characteristics and citizen behavior* (cf. Section 5.1.3), *data* (cf. Section 5.1.4), and *data acquisition and preparation* (cf. Section 5.2.1). Building on the existing knowledge base and the inclusion of more than 110 citizens and 120 experts to achieve these meta-design principles, the higher-level design knowledge is approved and transferable, to a reasonable degree, beyond

the individual artifacts and empirical contexts investigated throughout the dissertation.

The synthesis further demonstrates that design knowledge can be organized into two primary stakeholder groups involved in digital participation processes (Küstermann & Bittner, 2022; Stelzle et al., 2017). For citizens, the identified meta-design principles describe how participation systems should provide information, support interaction, facilitate reflective feedback, and ensure the generation of high-quality participation data (Borchers et al., 2023a; Borchers, Gierlich-Joas, Tavanapour, et al., 2024; Borchers, Milutzki, Bode, et al., 2025; Borchers, Soroko, Tavanapour, et al., 2024; Borchers, Uba, et al., 2026). For urban experts, the consolidated meta-design principles specify how citizen-generated data should be acquired, prepared, analyzed, transformed into actionable knowledge, presented effectively, and supported through transparent and trustworthy analytical processes (Borchers, Cao, & Bittner, 2024; Borchers, Cao, Tavanapour, et al., 2024; Borchers, Habash, et al., 2025; Borchers, Milutzki, et al., 2026; Borchers, Milutzki, Fetzer, et al., 2025). Together, these complementary perspectives establish an integrated and initial design theory that covers the full lifecycle of AI-supported urban participation, from the generation of citizens to their analysis and use in planning and decision-making.

The resulting initial *Type V* theory provides a consolidated body of prescriptive design knowledge comprising 17 interrelated meta-design principles (cf. Figure 16) organized into eight coherent design clusters (cf. Sections 5.1 and 5.2). These clusters describe recurring design mechanisms that emerged consistently across multiple research projects and technological implementations (cf. Section 4.2). The proposed theory provides a reusable and extensible foundation for future research and AI-supported urban participation, enabling researchers to refine, evaluate, and extend the identified design mechanisms in designing effective, transparent, and trustworthy participation systems, as summarized in Figure 16.

6 Practical Contributions

Beyond its theoretical contribution in the form of meta-design principles and initial *Type V* design theory (cf. Section 5), this dissertation provides substantial practical contributions through the design, implementation, and evaluation of multiple AI-supported prototypes for urban participation. Following the DSR paradigm, this work's contribution is therefore twofold. While Section 5 synthesized prescriptive design knowledge that is transferable across application contexts, this section focuses on the practical implications for municipalities, planning authorities, software developers, and urban participation practitioners. Rather than proposing abstract design knowledge, the developed artifacts demonstrate how artificial intelligence can be integrated into existing participation processes to address practical challenges faced by both citizens and urban experts. This is done, as described in Section 5, regarding the RQs formulated in Section 1.2, which are also summarized in Figure 7.

6.1 Integration of AI in Urban Participation Processes

As outlined in the holistic participation process (cf. Section 2.3), digital technologies can support several phases of urban participation, particularly the co-design, commenting, and analysis stages, by citizens to lay a foundation of local knowledge (Stelzle et al., 2017). However, existing participation platforms often provide only basic submission mechanisms and limited support for citizens when formulating contributions (Borchers, Soroko, Tavanapour, et al., 2024). Consequently, many contributions remain short, unstructured, or lack sufficient contextual information, reducing their value for subsequent planning activities (Borchers, Cao, Tavanapour, et al., 2024; Romberg & Escher, 2024).

The developed prototypes presented throughout this dissertation demonstrate how AI-based assistance systems can extend existing participation platforms by supporting citizens during contribution creation while simultaneously improving the quality of the resulting participation data (Borchers, Cao, Tavanapour, et al., 2024; Borchers, Soroko, Tavanapour, et al., 2024). To avoid repeating all included publications focusing on citizens and therefore corresponding to RQ1 and RQ2, this dissertation focuses on key examples of prototypes to highlight their practical impact. All prototypes directly influence practices, as they can serve as an orientation for further developing urban participation platforms and similar solutions (Akmentina, 2022a; Borchers et al., 2023b).

Figure 17 demonstrates how lightweight AI-supported interventions can already improve participation outcomes (Borchers, Soroko, Tavanapour, et al., 2024). Instead of interrupting citizens with lengthy dialogues or mandatory forms, the prototype continuously provides visual feedback through simple indicators, which are based on

a scale from *fully considered* to *not considered* that evaluate comprehensibility in terms of the named criteria which represent the smart city dimension (Borchers et al., 2022; Vasudavan & Balakrishnan, 2019), but can be replaces depending on the urban projects and it objective.

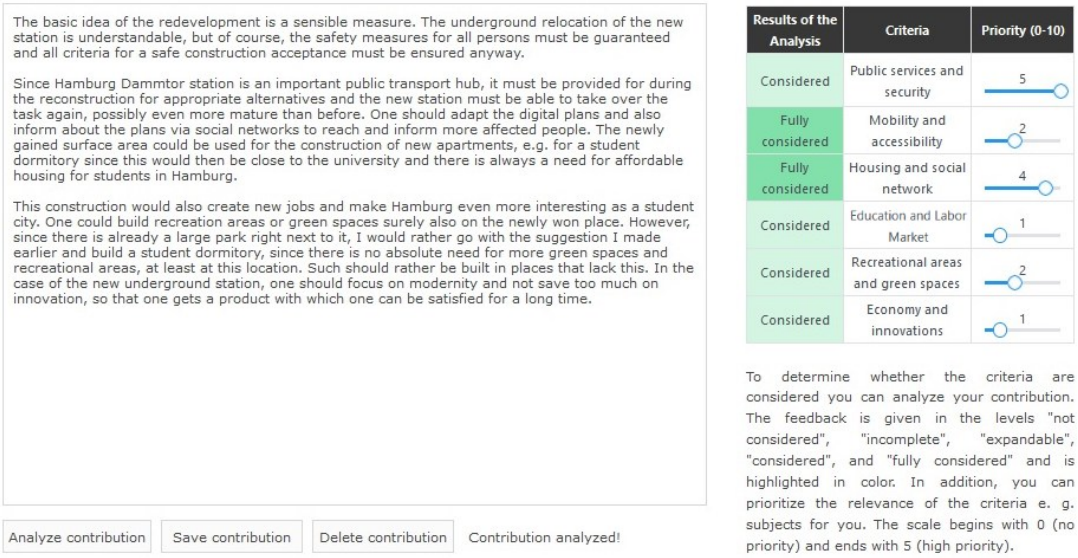


Figure 17. Scale-based Interaction on Urban Participation (Borchers, Soroko, Tavanapour, et al., 2024)

The evaluation described in Section 16.5 showed that even these small stimuli encourage citizens to reflect on their written input, leading to longer, more comprehensible, and more detailed contributions (Borchers, Soroko, Tavanapour, et al., 2024). From a practical perspective, this prototype illustrates that improving contribution quality does not necessarily require complex conversational interfaces but can already be achieved through applying natural language processing techniques which determine the level of comprehensibility by comparing vectors with the cosine similarity (Lieven et al., 2021; Penningtin et al., 2014) leading to more interaction and more elaborate citizens submissions in urban participation platforms (Borchers, Soroko, Tavanapour, et al., 2024).

Building on this concept, the second prototype example shown in Figure 18 introduces a more advanced, question-based approach (Borchers, Gierlich-Joas, Tavanapour, et al., 2024). The objective remains the same as before, but the motivation for citizens, or stimulus, is different and presented as a question. These are shown on the right side, where, in Figure 18, "Are there enough areas to rest and relax?" is placed. However, these questions are predefined by practitioners, depending on the kind of project (Vasudavan & Balakrishnan, 2019). They can also be formulated openly, e.g., to collect further information that cannot be answered with a simple yes or no. Rather than providing only quality indicators, the system analyzes the semantic content of citizens' contributions, compares them with predefined questions, and then selects the next unasked question (Borchers, Gierlich-

Joas, Tavanapour, et al., 2024). These questions encourage citizens to consider additional aspects of the urban project, reflect on their own needs, elaborate on missing arguments or perspectives, and ensure a natural end to the interaction, as, to some degree, all questions were asked of the citizens.



Figure 18. Question-based Citizen Interaction in Urban Planning (Borchers, Gierlich-Joas, Tavanapour, et al., 2024)

Consequently, the prototype shown in Figure 18 supports citizens during the co-design phase of the participation process by fostering deeper reflection and enabling more comprehensive and balanced contributions (Borchers, Gierlich-Joas, Tavanapour, et al., 2024). Compared with traditional participation platforms that primarily collect textual input, this approach transforms participation into an interactive dialogue between citizens and the participation system (Borchers, Gierlich-Joas, Tavanapour, et al., 2024; Borchers, Soroko, Tavanapour, et al., 2024).

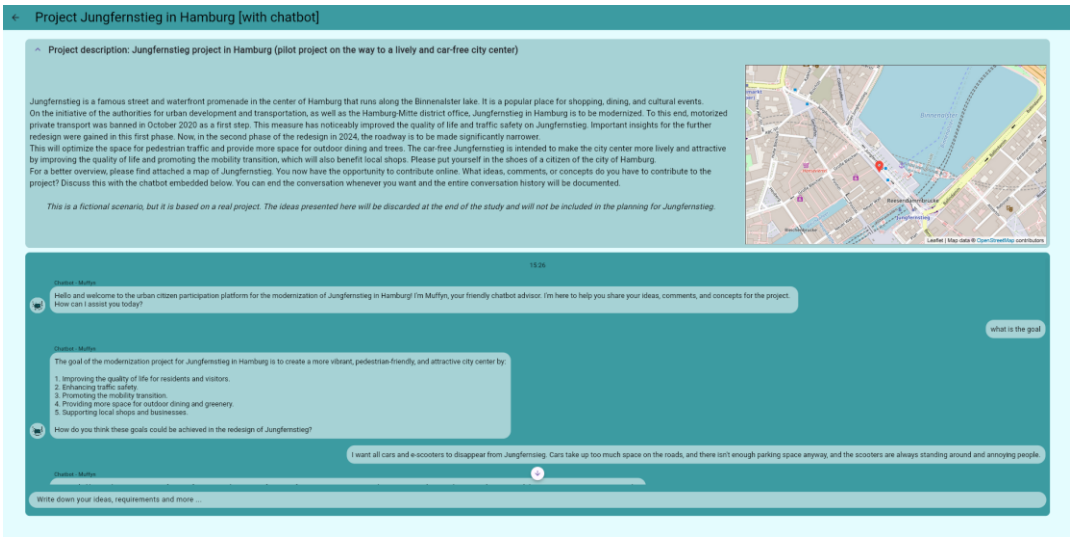


Figure 19. Large Language Model-based Citizen Participation in Urban Planning (Borchers, Uba, et al., 2026)

Recent advances in LLMs further extend the capabilities of the prototype shown in Figure 18 and enhance how citizens can interact with urban participation systems. The third prototype, shown in Figure 19, demonstrates how an LLM organized by the Retrieval-Augmented Generation (RAG) architecture can be integrated into urban participation systems to provide context-aware assistance grounded in project-specific knowledge (Borchers, Uba, et al., 2026). In contrast to earlier AI components that primarily focused on contribution quality or reflective feedback, the prototype enables citizens to interact with planning documents, regulations, project descriptions, maps, and additional domain-specific knowledge through natural language (Borchers, Uba, et al., 2026; Cai, 2021). By grounding generated responses in retrieved project-specific information, the system provides more reliable, explainable, and contextually appropriate answers while reducing hallucinations commonly associated with standalone LLMs. Furthermore, RAG enables the continuous incorporation of newly available project information without retraining the underlying LLM, making the system particularly useful for in-depth and long interactions (Borchers, Uba, et al., 2026). Nevertheless, practitioners should be aware that extended conversations with LLMs also introduce challenges. As interaction histories grow longer, LLMs may lose contextual information or place less emphasis on earlier parts of the dialogue due to limited context windows (Borchers, Hallmann, et al., 2026). Consequently, long-term conversational support requires mechanisms such as retrieval, contextual memory management, and transparent source integration to ensure that relevant project information remains consistently available throughout the interaction. The prototype in Figure 19 demonstrates that modern generative AI technologies can evolve beyond isolated assistance functions toward comprehensive intelligent participation assistants that accompany citizens throughout the co-design phase (Stelzle et al., 2017) while simultaneously illustrating the importance of

combining LLMs with retrieval-based architectures to ensure robustness, transparency, and sustained interaction (Borchers, Uba, et al., 2026).

Overall, the developed prototypes, as well as further findings described in Sections 9, 11, 12, 13, 16, 17, and 20, demonstrate a continuous evolution of AI-supported citizen participation, ranging from lightweight feedback mechanisms to intelligent conversational assistants and, finally, to RAG-based participation systems (Borchers, Uba, et al., 2026). While the first prototype shows that even simple AI-generated stimuli can encourage citizens to produce longer, more comprehensible, and more detailed contributions (Borchers, Soroko, Tavanapour, et al., 2024), the second prototype extends this concept by introducing question-based interactions that actively stimulate reflection and help citizens consider additional aspects of urban planning projects (Borchers, Gierlich-Joas, Tavanapour, et al., 2024). The third prototype illustrates how modern LLMs, combined with RAG, enable context-aware, sustained dialogue by integrating project-specific documents, planning regulations, maps, and other knowledge sources into the participation process (Borchers, Uba, et al., 2026). These practical IT artifacts directly correspond to RQ1. The evaluations demonstrate that intelligent assistance systems should not merely provide static information or collect textual input, but actively support citizens throughout the participation process by providing adaptive feedback, stimulating reflection, facilitating dialogue, and enabling natural language interaction grounded in project-specific knowledge (Borchers et al., 2022, 2023a, 2023b; Borchers, Gierlich-Joas, Tavanapour, et al., 2024; Borchers, Milutzki, Bode, et al., 2025; Borchers, Soroko, Tavanapour, et al., 2024; Borchers, Uba, et al., 2026), guiding practitioners and implementers. The prototypes simultaneously address RQ2, as the findings show that effective participation requires considerably more than citizens' textual contributions alone. Project descriptions, planning objectives, regulations, maps, local contextual information, previously submitted contributions, and continuously updated project documentation are essential sources of information that enable informed participation (Borchers et al., 2022, 2023a, 2023b; Borchers, Gierlich-Joas, Tavanapour, et al., 2024; Borchers, Milutzki, Bode, et al., 2025; Borchers, Soroko, Tavanapour, et al., 2024; Borchers, Uba, et al., 2026). Furthermore, the generated citizen contributions themselves specify that textual information is submitted. However, in terms of context, comprehensibility, and citizens' rationale, many aspects can and should be included to support subsequent processes that create real-world value (Borchers, Soroko, Tavanapour, et al., 2024).

6.2 Applying AI in Analyzing Participation Data

This section addresses the contribution and impact of the findings on the subsequent analysis of the participation data generated by urban experts. As described in the holistic participation process (cf. Section 2.3), the co-design phase (Stelzle et al.,

2017) produces the foundation of local knowledge through citizens' ideas, opinions, concerns, and proposals, as also specified in Section 6.1. However, these contributions only create value if they can be systematically analyzed, interpreted, and incorporated into subsequent planning and decision-making activities (Borchers, Cao, & Bittner, 2024; Borchers, Cao, Tavanapour, et al., 2024; Borchers, Habash, et al., 2025; Borchers, Milutzki, et al., 2026; Borchers, Milutzki, Fetzer, et al., 2025). Consequently, the transition from contribution generation to contribution analysis represents one of the most critical phases within the urban participation process. Traditionally, participation data has been analyzed manually through qualitative coding and thematic analysis (Romberg et al., 2022). While these approaches ensure human processing and accountability, they also increase costs and become increasingly infeasible as participation projects scale, as Royo et al. (2020) describe. These challenges were systematically examined across multiple publications, and the findings offer, in addition to the theoretical contribution (cf. Section 5.2), direct practical guidance regarding the prototypes and developed processes. AI offers different opportunities to overcome limitations in data analysis. Many restrictions and concerns regarding its quality exist. AI should primarily be used to automate analytical workflows and repetitive tasks, enabling and supporting experts to focus on interpretation and decision-making rather than manual data processing (Borchers, Cao, Tavanapour, et al., 2024). Depending on the analytical objective, different AI approaches provide complementary capabilities.

One of the most fundamental analytical tasks in urban participation projects is classifying citizen contributions into predefined categories (Borchers, Cao, Tavanapour, et al., 2024; Borchers, Habash, et al., 2025). Such classifications allow urban planners to quantify recurring concerns by building predefined categories or dimensions relevant to urban projects, as used in the prototype shown in Figure 20. In combination with sentiment analysis, classification provides an overview of topics and their relevance, including quantifying how many citizens are for or against a specific development. As manual classification is time-intensive and experts sometimes classify identical contributions differently, even when juniors or students are used for manual tasks, this can lead to inconsistent analytical outcomes (Borchers, Cao, Tavanapour, et al., 2024; Borchers, Habash, et al., 2025; Cai, 2021; Romberg & Escher, 2024).

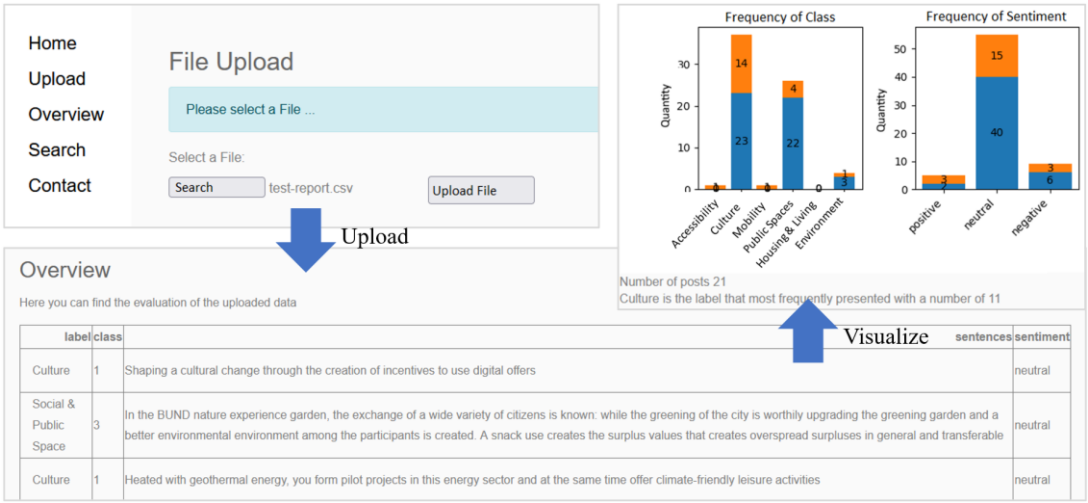


Figure 20. Classification of Citizens' Inputs embedded in a Web Prototype for Urban Experts (Borchers, Cao, Tavanapour, et al., 2024)

As illustrated in Figure 20, the developed prototype combines automated ML classification with an interactive analytical interface. Rather than presenting AI predictions as immutable results, the system enables experts to inspect classifications, search contributions, apply filters, compare categories, review sentiment analyses, and validate automatically generated outputs (Borchers, Cao, Tavanapour, et al., 2024). In doing this, the prototype supports existing real-world processes and allows AI to perform repetitive classification tasks while maintaining expert oversight and responsibility for final interpretations. The analytical functionality extends beyond simple topic assignment. The prototype shows how multiple complementary analytical functions, including automatic classification, sentiment analysis, duplicate detection, summarization, filtering, and visualization of participation results (Borchers, Cao, Tavanapour, et al., 2024). By combining these functionalities within a single interface, urban experts can iteratively explore participation data from different analytical perspectives while maintaining a consistent analytical workflow, which is particularly valuable in large-scale participation projects (Hofmann et al., 2020; Royo et al., 2020).

The underlying ML models required for the solutions, as shown in Figure 20, were investigated in the publications included in Sections 14, 15, 18, 19, and 21. The studies demonstrated that the predictive performance of ML models depends not only on algorithm selection but also heavily on the quality of the training data, which is a major issue, as data quality is very limited in the domain of citizen participation (Borchers, Habash, et al., 2025). This can be explained by the fact that many participation platforms publish only the results of participation, not the raw data submitted by citizens. For this, they have to agree, which can also prevent citizens from participating if trust issues exist (Borchers, Habash, et al., 2025; Romberg et al., 2022). The findings show that comprehensive preprocessing is an essential prerequisite, including semantic decomposition of long textual contributions,

normalization of textual content, balanced representation of planning categories in the training data, and enough training examples per class (Borchers, Habash, et al., 2025). Consequently, practitioners should select analytical models based on the specific requirements of the participation project and consider explainability a challenge when trust and the possibility to argue in detail how the analysis is conducted are required by the cities or other contractors (Borchers, Cao, Tavanapour, et al., 2024; Borchers, Habash, et al., 2025).

While classification assigns contributions to predefined planning categories, clustering addresses fundamentally different analytical objectives. Usually, urban participation projects have a specific interest and a clear goal (Stelzle et al., 2017). However, unexpected findings are possible, and it is not possible to know all dimensions in which citizens think in advance, which is why clustering can be used as an extension to classification, e.g., as a counterpart to the deductive approach (Borchers, Habash, et al., 2025).

Figure 21 illustrates the proposed analytical process supporting AI-based clustering of participation data guiding practitioners. Clustering algorithms subsequently identify semantically related groups of contributions without requiring manually predefined categories or annotated training datasets (Borchers, Cao, & Bittner, 2024; Pattnaik & Nayak, 2019). The resulting clusters are then interpreted by urban experts, who can specify the number of clusters and subclusters, assign meaningful semantic labels, and manually process the findings forward. Clustering therefore enables a more exploratory analytical process to identify emerging topics and can reduce analytical biases introduced by experts, which is a practical benefit, as citizens' contributions themselves determine the thematic structure of the resulting clusters (Borchers, Cao, & Bittner, 2024). Nevertheless, clustering does not replace expert interpretation. The identified clusters must still be evaluated regarding their semantic coherence, practical relevance, and implications for urban planning decisions.

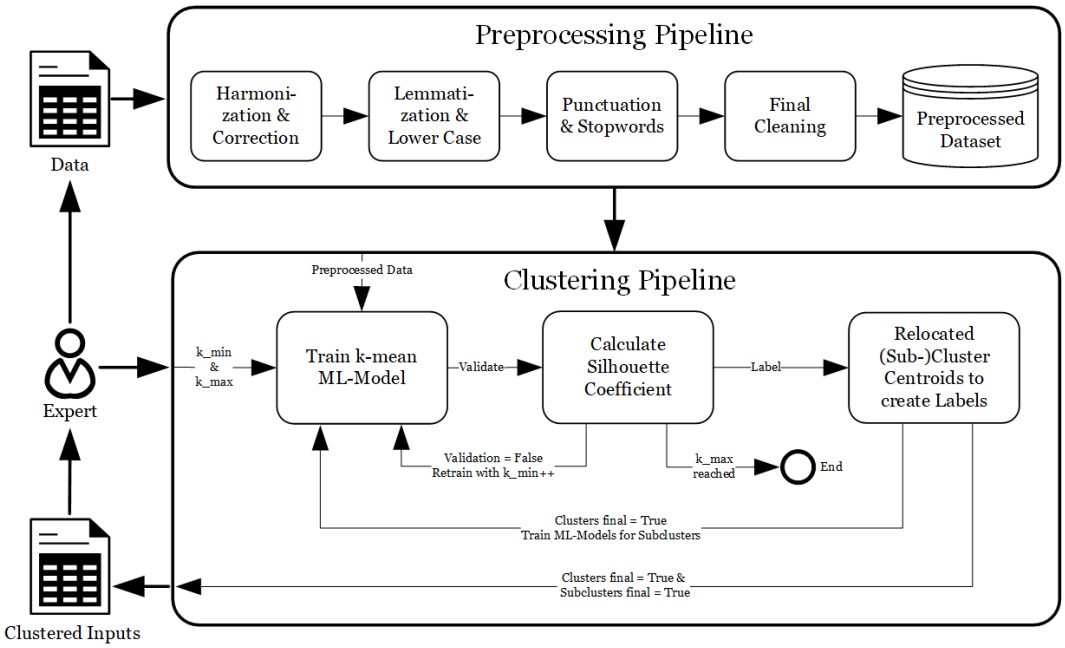


Figure 21. Process Model for Clustering of Citizens' Inputs from E-Participation ((Borchers, Cao, & Bittner, 2024)

Besides traditional ML models, recent developments in LLMs and RAGs not only affect how citizens interact with AI but also how experts use and explore data. LLMs enable experts to formulate analytical requests using natural language (Borchers, Hallmann, et al., 2026; Gao et al., 2024). Consequently, interaction with participation data shifts from operating analytical software toward engaging in conversational knowledge exploration (Borchers, Milutzki, et al., 2026).

The research presented in the publication in Section 21 and the Prototype shown in Figure 22 followed this path. It explored how conventional analytical systems operate on citizen contributions when these are incorporated in accordance with the RAG architecture, along with additional information about the role and the urban project, including planning regulations, project descriptions, geographic information, and other project-specific knowledge sources (Borchers, Milutzki, et al., 2026). This extends the analytical possibilities available to practitioners, as experts can now not only create quantifiable information and plots, but also immediately generate textual descriptions about the content. However, practitioners should be aware that LLMs and RAGs are pattern-activation models, and experts may tend to request results rather than consider the recommended depth directly (Borchers, Hallmann, et al., 2026; Sharma, 2025). This is why traditional ML approaches like classification and clustering remain highly important, and quantifying accuracy is much easier, which is a huge benefit when trust, explainability, and accountability are required (Borchers, Cao, Tavanapour, et al., 2024).

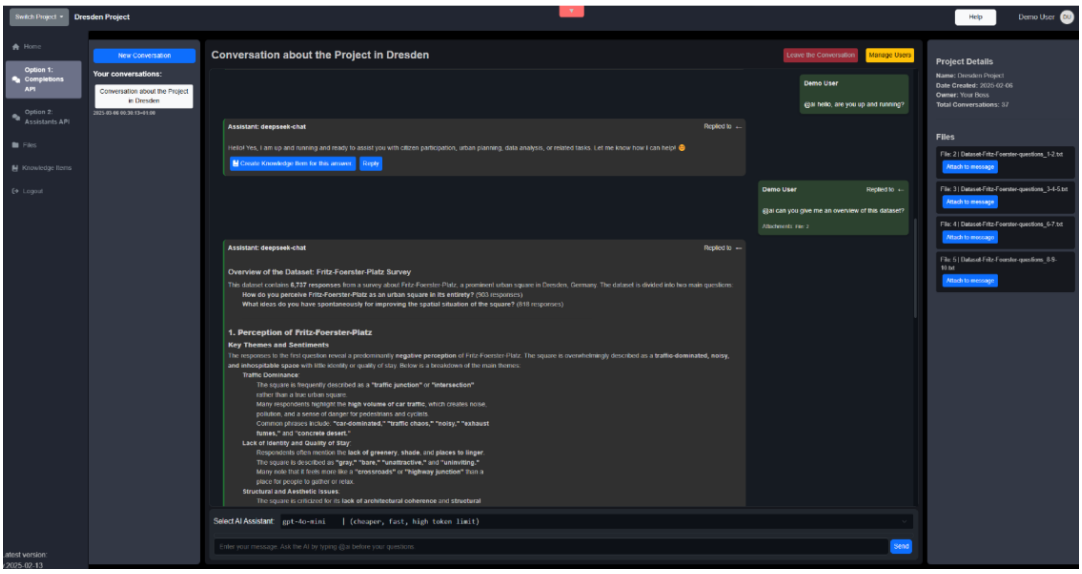


Figure 22. RAG-based Prototype to support the Analysis of Citizens' Contributions by urban Experts (Borchers, Milutzki, et al., 2026)

Another practical advantage concerns the flexibility of analytical exploration. Traditional ML pipelines require separate analytical modules for classification, clustering, summarization, keyword extraction, or sentiment analysis (Borchers, Cao, & Bittner, 2024; Borchers, Cao, Tavanapour, et al., 2024; Borchers, Habash, et al., 2025). RAG-based LLM systems unify these functionalities within a single conversational interface, allowing experts to iteratively refine analytical questions, request alternative perspectives, explore unexpected findings, and investigate participation data interactively without requiring technical expertise (Borchers, Milutzki, et al., 2026). Despite these advantages, applying LLMs to participation analysis also introduces new practical challenges. Analytical conversations frequently become considerably longer than citizen interactions because experts iteratively refine hypotheses, compare analytical results, and request increasingly detailed explanations. As conversation histories grow, LLMs may gradually lose contextual information or assign less importance to earlier parts of the interaction due to finite context windows (Borchers, Hallmann, et al., 2026). Furthermore, experts must remain aware that LLM-generated analyses serve as decision support rather than decision-making. Final interpretations, planning judgments, and policy decisions should remain under human responsibility (Borchers, Cao, Tavanapour, et al., 2024).

Across all three approaches, the final interpretation of the data by urban experts should include contextual information on infrastructure, environmental conditions, demographic characteristics, transportation networks, and spatial relationships, which can also be presented in interactive maps (cf. Section 19) with more advanced functionalities than those available to citizens (Borchers, Milutzki, et al., 2026; Borchers, Milutzki, Fetzer, et al., 2025). The interviews conducted and data collection showed that citizen contributions rarely include explicit references to streets or other

names. In map-based approaches, the location can be specified by adding a note, and as part of the project's context, urban experts should consider the results of semantic analysis with spatial information to make proper and profound decisions (Borchers, Cao, & Bittner, 2024; Borchers, Cao, Tavanapour, et al., 2024; Borchers, Habash, et al., 2025; Borchers, Milutzki, et al., 2026; Borchers, Milutzki, Fetzer, et al., 2025).

6.3 Overall Practical Contribution

The practical contribution of this dissertation goes beyond the individual AI-supported prototypes presented throughout the included publications. While Section 6.1 demonstrates how artificial intelligence can support citizens during participation (RQ1) and Section 6.2 how urban experts can be supported (RQ3), both connected by the elicitation and usage of data (RQ2), the combined findings are illustrated in Figure 23 to visualize how AI can be integrated across the entire process. The practical contribution, therefore, does not remain in isolated technological solutions but also in operationalizing knowledge building upon Section 5, demonstrating how intelligent assistance systems can support multiple stakeholder groups throughout digital urban participation projects (RG).

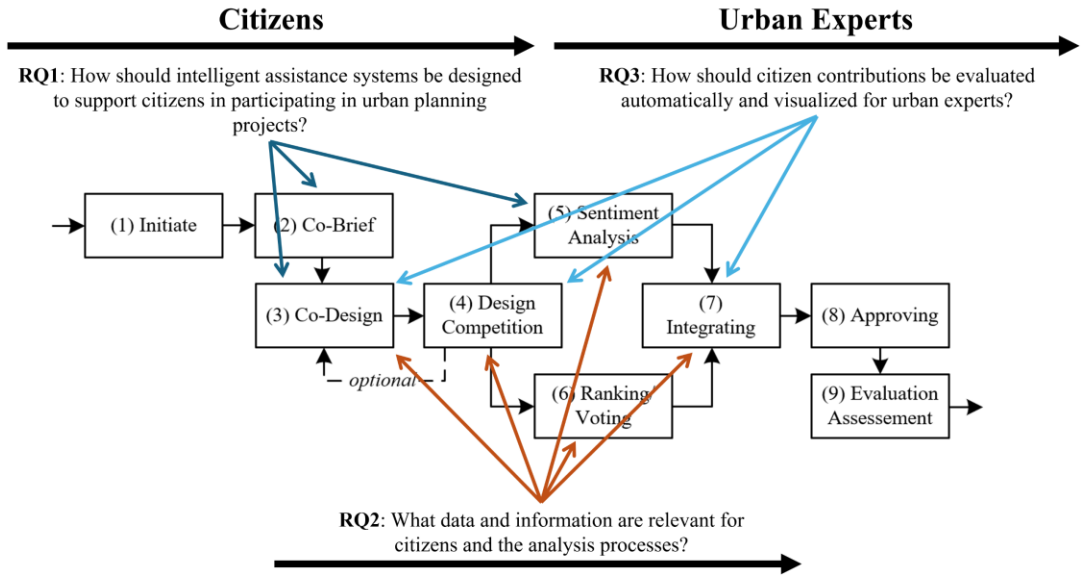


Figure 23. Overview of the Practical Contribution to the overall Urban Participation Process and RQs

Consequently, this dissertation contributes validated implementation examples that can guide and support cities, planning authorities, software providers, and further practitioners in integrating AI into participation processes (Borchers, Cao, Tavanapour, et al., 2024). Considering the DSR paradigm, the practical contribution complements the theoretical contribution by demonstrating the feasibility and applicability of the proposed design knowledge within real-world settings (cf. Section 5). In doing so, it should be highlighted that across the conducted evaluations, more

than 110 citizens and 120 urban experts were included, underlining the consideration of practical thoughts and the solutions' impact (Borchers, Cao, & Bittner, 2024; Borchers, Cao, Tavanapour, et al., 2024; Borchers et al., 2022, 2023a, 2023b; Borchers, Gierlich-Joas, Tavanapour, et al., 2024; Borchers, Habash, et al., 2025; Borchers, Milutzki, Bode, et al., 2025; Borchers, Milutzki, et al., 2026; Borchers, Milutzki, Fetzer, et al., 2025; Borchers, Soroko, Tavanapour, et al., 2024; Borchers, Uba, et al., 2026).

The practical findings directly address RQ1, as shown in Figure 23 regarding process steps 2, 3, and 5, where qualitative data is elicited (cf. Section 2.3). The developed citizen-oriented prototypes demonstrate the integration of AI and show that lightweight AI-supported feedback can already improve the quality and comprehensibility of citizen contributions through subtle behavioral stimuli (Borchers et al., 2022, 2023a, 2023b; Borchers, Gierlich-Joas, Tavanapour, et al., 2024; Borchers, Milutzki, Bode, et al., 2025; Borchers, Milutzki, et al., 2026; Borchers, Soroko, Tavanapour, et al., 2024). Building upon these findings, conversational assistance systems introduced adaptive, question-based interactions that actively stimulate reflection, broaden perspectives, and encourage citizens to elaborate on their needs and ideas. The developed artifacts also provide a practical answer to RQ2**.** The findings demonstrate that successful participation depends on rich contextual information and textual contributions (Borchers, Milutzki, Bode, et al., 2025; Borchers, Soroko, Tavanapour, et al., 2024).

Throughout the co-design phase (cf. Figure 23), citizens require access to project descriptions, planning objectives, regulations, contextual information, and maps to formulate informed contributions. At the same time, the findings show that the quality of subsequent analytical processes depend heavily on the quality, structure, and contextual richness of the generated participation data, leading to RQ3. The analytical prototypes demonstrate how AI can support urban experts through automated classification, clustering, semantic analysis, and natural-language interactions via LLMs and RAGs. Rather than replacing expert judgment, these systems automate repetitive analytical tasks, support exploratory knowledge discovery, and facilitate evidence-based planning decisions (Borchers, Cao, & Bittner, 2024; Borchers, Cao, Tavanapour, et al., 2024; Borchers, Habash, et al., 2025; Borchers, Milutzki, Fetzer, et al., 2025; Borchers, Uba, et al., 2026). Furthermore, the findings show the practical importance of combining different AI approaches, as traditional ML methods provide transparent, reproducible, and quantifiable analytical results. At the same time, LLMs offer flexible conversational access to participation data and project-specific knowledge.

Together, the developed IT artifacts offer substantial knowledge, orientation, and guidelines considering the complete process of urban citizen participation. Figure 23 illustrates this holistic perspective by showing the connection between the RQs and

process steps, which were all part of the examination and included publications of this work. Consequently, the practical contribution of this dissertation extends beyond individual software artifacts by providing validated implementation concepts that support practitioners in incrementally adopting artificial intelligence for transparent, scalable, and citizen-centered urban participation.

7 Limitations

Throughout this dissertation, the development of intelligent solutions to support citizens during urban participation and urban experts during the subsequent analysis of participation data was investigated across the included publications (cf. Section 4.2). As demonstrated in Sections 5 and 6, the dissertation contributes both generalized design knowledge in the form of seventeen meta-design principles and multiple practically evaluated AI-supported artifacts. Although the included studies are characterized by extensive collaboration with citizens, urban experts, and other stakeholders, some limitations should be considered in interpreting, transferring, and applying the presented findings.

The findings presented throughout this dissertation exhibit a high degree of practical relevance. Rather than deriving RQs solely from literature, most publications were motivated by concrete challenges identified in collaboration with citizens and urban experts from planning authorities, public administration, and companies (cf. Sections 5 and 6). This close collaboration substantially enhances the relevance of the developed IT artifacts to all three RQs. The qualitative evaluations strengthen the validity of the findings, and the repeated evaluation cycles increased confidence that the identified design requirements and resulting design principles address practically relevant problems rather than isolated observations (Borchers, Cao, Tavanapour, et al., 2024; Borchers et al., 2022, 2023a, 2023b; Borchers, Gierlich-Joas, Tavanapour, et al., 2024; Borchers, Milutzki, Bode, et al., 2025; Borchers, Milutzki, et al., 2026; Borchers, Milutzki, Fetzer, et al., 2025; Borchers, Soroko, Tavanapour, et al., 2024; Borchers, Uba, et al., 2026). However, nearly all practice-oriented elicitations and evaluations were qualitative, and some interpretation variance exists. To reduce that, as far as possible, all included publications were developed collaboratively with multiple co-authors possessing complementary expertise in information systems, as summarized in Section 4.2. Furthermore, the DSR publications consistently followed established methodological guidelines for deriving design principles from empirically identified issues and meta-requirements (Gregor et al., 2020). Most publications explicitly document this derivation process through conceptual figures illustrating how identified issues were translated into meta-requirements and subsequently synthesized into design principles. Therefore, the reasoning underlying the developed IT artifacts remains transparent and reproducible (Hevner et al., 2004).

Another limitation concerning the predominantly qualitative nature of the evaluations is the limited statistical generalizability of the reported findings. Although the conducted evaluations consistently demonstrated positive effects regarding interaction, usability, contribution quality, and analytical support, they do not allow precise quantification of effect sizes or direct statistical comparison between alternative design solutions. Closely related to this limitation is the absence of long-

term evaluations. The developed prototypes were evaluated across multiple iterative development cycles and demonstrated promising results in terms of usability and stakeholder acceptance (cf. Sections 5 and 6). Nevertheless, none of the developed artifacts were investigated over extended periods or in real-world settings covering complete urban planning projects lasting several months or years. Consequently, the presented evaluations primarily capture immediate user perceptions, interaction behavior, and prototype acceptance rather than long-term adoption, sustained usage, organizational integration, or behavioral changes over time (Peffers et al., 2012; Pries-Heje et al., 2008).

Beyond the methodological limitations, the transferability of the developed design knowledge should be considered. The meta-design principles (cf. Section 5) and their elaboration regarding the overall process of citizen participation (cf. Section 6) are based on publications that were mainly conducted within relatively homogeneous geographical and cultural settings. Approximately half of the citizens participating in the interviews, workshops, and prototype evaluations originated from Germany, with a substantial proportion living in or around the metropolitan region of Hamburg (Borchers et al., 2023a, 2023b; Borchers, Soroko, Tavanapour, et al., 2024). Consequently, the investigated participation behavior primarily reflects citizens operating within German administrative structures, planning procedures, and cultural contexts. This limitation is particularly relevant for RQ1, which investigates how intelligent assistance systems should be designed to support citizens in urban planning projects. A similar limitation applies to the participating urban experts investigated throughout this dissertation. Although the experts originated from different municipalities, public authorities, research institutions, and software companies across Germany, they nevertheless represent a relatively homogeneous professional environment in terms of planning procedures, legal frameworks, and administrative structures (Borchers, Cao, Tavanapour, et al., 2024; Borchers, Milutzki, et al., 2026; Borchers, Milutzki, Fetzer, et al., 2025). Cultural and political differences, as well as existing data protection, planning regulations (Akmentina, 2022b; Stelzle et al., 2017), and construction laws, can also affect the practical implementation and, in turn, the findings of RQ1 and RQ3. The transferability of the identified information requirements addressed in RQ2 should also be interpreted within this context.

The applicability of the findings should also be interpreted with respect to the investigated domains. While the primary focus of this dissertation is AI-supported urban participation (cf. Section 1), two of the included publications were conducted within the domain of emergency management (Borchers, Milutzki, Bode, et al., 2025; Borchers, Milutzki, Fetzer, et al., 2025). At first glance, these application areas differ substantially, as emergency management primarily focuses on supporting rapid operational decision-making, whereas urban participation addresses collaborative

planning processes over extended periods. Transferring findings between both domains requires careful consideration. Nevertheless, both domains exhibit considerable similarities in how citizens interact with digital platforms to obtain information, contribute data, and support decision-making (Borchers, Milutzki, Bode, et al., 2025). This also applies to urban experts, who require contextual information on infrastructure, mobility, public services, environmental conditions, and project objectives to understand and analyze citizens' contributions and to make decisions about creating urban project solutions and a vision (Borchers, Milutzki, Fetzer, et al., 2025).

Further limitations arise from the development and application of ML models. Two of the included publications followed the KDD framework to investigate ML approaches supporting urban experts in analyzing citizen-generated participation data, thereby primarily contributing to RQ2 and RQ3 (Borchers, Cao, & Bittner, 2024; Borchers, Habash, et al., 2025). Although these studies established a solid methodological foundation for AI-supported participation analysis, they investigated only a subset of the extensive landscape of available ML techniques (Arana-Catania et al., 2021b; Küstermann & Bittner, 2022). ML is rapidly evolving, and new algorithms, preprocessing techniques, feature engineering approaches, vector representations, and optimization strategies are published (C. Li, 2019; Penningtin et al., 2014). This also applies to LLM-based systems and RAG studies that support both citizens (RQ1) and urban experts (RQ3). New foundation models, retrieval strategies, prompt engineering techniques, memory architectures, reasoning mechanisms, and agent-based systems are introduced continuously, often within intervals of only a few months, which is why the findings do not provide a definitive implementation (Borchers, Hallmann, et al., 2026; Gao et al., 2024).

Overall, these limitations define the boundaries within which the findings of this dissertation should be interpreted. They do not diminish the theoretical and practical contributions presented throughout Sections 5 and 6 but should be considered in future research and practical application.

8 Implications for Future Research

The findings presented throughout this dissertation establish a comprehensive foundation for future research on AI-supported urban participation. While the developed artifacts, synthesized meta-design principles, and resulting initial *Type V* design theory provide validated design knowledge to support both citizens and urban experts, the rapid evolution of AI, changing participation practices, and the increasing digitalization of urban planning continuously create new research opportunities (Gregor, 2006). Building on the limitations identified in Section 7, future research should further investigate intelligent assistance systems from technological, methodological, organizational, and societal perspectives (Ruohonen & Hjerppe, 2025). While this dissertation demonstrated that AI-generated feedback, adaptive questioning, and RAG improve contribution quality and support citizen interaction (cf. Sections 5 and 6), further questions remain, and further research is required to consolidate and extend the findings.

Besides the (3) co-design, (4) design competition, and (5) sentiment analysis steps described in Section 2.3 in Figure 2, future systems should also address (2) co-brief, (6) voting/ranking, (7) integrating, and (8) approving/assessment steps, to include the whole process in an overarching IT artifact, e.g., participation platforms. Such comprehensive development would cover the entire process, with greater consideration of existing regulations and client decision-making at the city and political levels (Borchers, Milutzki, et al., 2026; Panori et al., 2021; Royo et al., 2024). This can enhance the existing co-design process, leading to the development of a new socio-technical system that can be enabled and supported by a single, overarching platform or product with a high practical impact (Stelzle et al., 2017). The theoretical contribution would then lie in extending the design principles and increasing the focus.

Another promising research direction is to further deep dive into increasingly personalized participation assistants, especially in the (3) co-design step (cf. Section 2.3, Figure 2). Future systems could dynamically adapt their interaction behavior based on citizens' prior participation experience, digital literacy, personal preferences, accessibility requirements, or communication styles (Hatami et al., 2025; Stelzle & Noennig, 2017). Adaptive assistance could determine the appropriate level of explanation, the complexity of follow-up questions, or the amount of contextual information provided during interactions. Such personalization may further reduce participation barriers while improving both usability and citizen satisfaction and should also increasingly consider the different levels of citizen participation, as explained in Section 2.2 (Arnstein, 1969; Stelzle & Noennig, 2019). This also affects the rapid development of LLMs and large multimodal models (LMM), which additionally create opportunities for multimodal participation. Future

intelligent participation systems may combine textual interaction with speech, images, videos, sketches, maps, augmented reality, or virtual reality environments (Fegert et al., 2020), rather than describing planning ideas solely through text, annotating maps, or uploading photos (Borchers et al., 2023a; Borchers, Milutzki, Fetzer, et al., 2025; Borchers, Soroko, Tavanapour, et al., 2024). Such multimodal participation environments could further increase accessibility for citizens with varying communication preferences while simultaneously supporting richer participation data.

Addressing the limitations of the evaluation, future research should also investigate long-term human-AI interaction within urban participation, recognizing that this is hardly possible from an organizational perspective, as well as from the participants' perspective, as cities must agree to a prototype operation. Citizens need to be found who want to participate regularly and are willing to participate in a study. However, such investigations may also reveal whether citizens develop reliance on AI recommendations, ignore repetitive feedback mechanisms, or expect increasingly proactive assistance from intelligent participation systems, and whether they trust AI (Borchers, Milutzki, et al., 2026), but also participation and political processes (Stelzle et al., 2017).

Another dimension is the integration of urban data. Many cities have data platforms with infrastructure information (Lieven et al., 2021) that can be used for participation projects and for simulating citizens' behavior and environmental conditions (López Baeza et al., 2021). Moreover, future research should investigate data governance, privacy, and ethical considerations associated with AI-supported participation and above. This is of special interest, as cities like Madrid have already considered connecting participation to the resident office to ensure that only inhabitants of an affected area can participate (Royo et al., 2020).

Considering the organizational aspect and urban experts, future research should also investigate how AI-supported analytical systems influence organizational processes within cities and planning authorities (Borchers, Cao, Tavanapour, et al., 2024; Borchers, Habash, et al., 2025). Questions regarding organizational acceptance, changing work practices, required competencies, governance structures, accountability, and institutional trust were not explicitly explored in the context of the IT artifacts developed (cf. Section 3.3). Understanding these organizational dimensions will become increasingly important as AI technologies transition from experimental prototypes toward productive planning environments (Cai, 2021; Romberg & Escher, 2024).

Consequently, this dissertation not only provides solutions to current research challenges as required by the problem space and offers innovative solutions considering the solutions space, but it also identifies further research areas to support

the development of the next generation of intelligent, transparent, trustworthy, and citizen-centered urban participation systems.

9 Conclusion

Citizen participation has become an essential component of contemporary urban planning by enabling cities to incorporate local knowledge, strengthen democratic legitimacy, and improve the quality and acceptance of planning decisions (Borchers, Soroko, Tavanapour, et al., 2024; Stelzle et al., 2017). At the same time, the increasing digitalization of participation processes has generated new challenges. While digital participation platforms facilitate broad citizen engagement, they often provide limited support during participation and generate large volumes of data that are difficult for urban experts to analyze efficiently (Borchers et al., 2023b; Borchers, Gierlich-Joas, Tavanapour, et al., 2024). Against this background, this dissertation investigated how artificial intelligence can support both citizens and urban experts throughout the urban participation process (cf. Section 1). Following the DSR paradigm, this cumulative dissertation combined twelve scientific publications to develop, implement, and evaluate AI-supported IT artifacts while synthesizing the resulting knowledge into generalized design knowledge (cf. Section 3). The findings provide answers to the three RQs addressing citizen interaction, relevant participation data, and AI-supported analysis by urban experts (cf. Sections 5 and 6).

Regarding RQ1, the developed prototypes demonstrate that intelligent assistance systems should actively support citizens rather than merely collecting contributions (Borchers et al., 2022; Borchers, Soroko, Tavanapour, et al., 2024). AI-supported feedback, adaptive questioning, and conversational assistants encourage reflection, improve the comprehensibility and completeness of contributions, and reduce barriers to participation (Borchers, Gierlich-Joas, Tavanapour, et al., 2024; Borchers, Uba, et al., 2026). Concerning RQ2, the dissertation shows that successful participation depends on the availability of contextual and project-specific information (Borchers, Milutzki, et al., 2026; Borchers, Soroko, Tavanapour, et al., 2024; Borchers, Uba, et al., 2026). Project descriptions, planning objectives, regulations, maps, infrastructure information, and citizen-generated contributions together establish the foundation for informed participation and subsequent analytical processes (Borchers, Cao, Tavanapour, et al., 2024; Borchers, Milutzki, Fetzer, et al., 2025). For RQ3, the developed analytical artifacts demonstrate how ML, clustering techniques, and LLM can support urban experts in processing large volumes of participation data. Rather than replacing experts, these technologies automate repetitive analytical tasks, support knowledge discovery, and improve evidence-based decision-making while maintaining transparency and human oversight (Borchers, Cao, & Bittner, 2024; Borchers, Cao, Tavanapour, et al., 2024; Borchers, Habash, et al., 2025; Borchers, Milutzki, et al., 2026).

Beyond answering the individual RQs, the dissertation contributes to research and practice. The synthesis of the included publications yielded 17 meta-design principles

organized into 8 design clusters, forming an initial *Type V* theory for the design of AI-supported urban participation systems (cf. Section 5). Practically, the developed prototypes demonstrate how AI can be integrated into existing participation processes to support both citizens and urban experts without fundamentally changing established planning procedures (cf. Section 6).

Overall, this dissertation demonstrates that AI can significantly enhance urban participation by improving citizen engagement, enhancing citizens' contributions, and supporting scalable analytical processes (Borchers, Cao, & Bittner, 2024; Borchers, Cao, Tavanapour, et al., 2024; Borchers et al., 2022, 2023a, 2023b; Borchers, Gierlich-Joas, Tavanapour, et al., 2024; Borchers, Habash, et al., 2025; Borchers, Milutzki, Bode, et al., 2025; Borchers, Milutzki, et al., 2026; Borchers, Milutzki, Fetzer, et al., 2025; Borchers, Soroko, Tavanapour, et al., 2024; Borchers, Uba, et al., 2026). As AI technologies continue to evolve rapidly, the presented design knowledge and validated IT artifacts require further research about the personalization of AI interactions as well as the holistic participation (cf. Section 7), but provide a solid foundation for future research (cf. Section 8) and for practitioners seeking to develop intelligent, trustworthy, and citizen-centered urban participation systems.

10 Publication C1: Toward Intelligent Platforms to Support Citizen Participation in Urban Planning

Pacific Asia Conference on Information Systems (PACIS)

Track: Crowds, Social Media, and Digital
Research in Progress
Ranking: C

Research Question

How to design IT artifacts to support citizen participation on urban participation platforms?

Contribution to the Dissertation

This publication contributes to the overall RG, especially RQ1, by describing the design of a web prototype that supports citizens in submitting their contributions by adding an interactive feedback mechanism. In doing so, the publication also contributes to RQ2, as the feedback considers six content dimensions of interest to both citizens and urban experts. Furthermore, the publication describes 12 issues, ten meta-requirements, and four design principles within the design science research paradigm.

Citation

Borchers, Marten; Tavanapour, Navid; & Bittner, Eva (2022). Toward Intelligent Platforms to Support Citizen Participation in Urban Planning. In: *Proceedings of the Pacific Asia Conference on Information Systems* (PACIS). https://aisel.aisnet.org/pacis2022/82. Research in Progress.

Abstract: *Urbanization has resulted in substantial growth of cities and metropolitan regions creating new and intensifying existing conflicts. In response, many governments are utilizing citizen participation to identify and examine local requirements to develop citizen-centered solutions. Urban participation platforms are increasingly used to expand the range and enable asynchronous discussions. However, online discussions are not comparable to offline discussions due to e. g. a lack of exchange and interaction. Furthermore, the potential of AI and natural language processing are not being exploited to support citizens' participation. To do so, we initiated a design science research project and developed design principles for IT artifacts that support citizen participation. In this paper, we describe the intermediate results of the ongoing project including the identified issues, meta-requirements, and condensation to design principles. Furthermore, we developed a prototype using an AI-Model, to show one possible instantiation of the design principles.*

Keywords: Urban Planning, (e-)Participation, Design Science Research, Artificial Intelligence, Machine Learning

10.1 Introduction

Urban planning has historically been a top-down non-participatory process and has become increasingly crucial as cities have grown (Stelze et al., 2017). This can be explained by the increasing urbanization, as a result of which 54 % of the world's population lives in urban areas and is forecast to 70 % in 2050 (Mohsin et al., 2019). In growing cities building land and residential areas are highly demanded and should be managed sustainably, and e.g. recreational, and leisure spaces should be considered, to support urban life and society (Caragliu et al., 2011). In top-down approaches, architects and planners implement the requirements of the project owner (e. g. investors, government) within their ideas and concepts. Local stakeholders can be consulted, but in the past, this costly and time-consuming process has often been avoided (Simonofski et al., 2017). In the case of construction projects, such as the redesign of train stations or entire city districts, the past has shown that this can have fatal consequences (Müller-Seitz et al., 2016). If citizens' requirements are not considered, citizens' initiatives can significantly extend the planning and construction phases by delaying them via protests and (legal) complaints. This increases construction costs and, due to a later completion also postpones revenue streams (Ceballos and Larios, 2016; Vasudavan and Balakrishnan, 2019). This often applies to extensive construction projects of major public interest (Yazdanpanah Shahabadi and Sajadzadeh, 2020). To prevent this, it is important to include citizens in the planning process. According to Stelzle and Noennig (2017), this works particularly well, if citizens are involved in the design process and are encouraged to contribute their ideas and requirements, which are considered in the project's vision (Recalde et al. 2020).

Citizen participation in urban projects was often facilitated with on-site participation approaches. However, in the past decades, urban participation platforms (UPP) have been increasingly used to enable the participation of thousands of citizens to elicit their requirements, ideas, comments, and proposals, and participate in surveys and pollings (Royo et al. 2020) which was enhanced by the COVID-19 pandemic, as on-site approaches were unavailable (Pantić et al. 2021). However, discussions on online platforms are not comparable with on-site discussions, where an argumentative and also emotional exchange occurs in which ideas are developed and reconsidered. In addition, the quality of citizens' contributions on UPP varies enormously so that contributions and comments might not be comprehensible and/or reasonable for architects and planners to develop a project's vision (Simonofski et al. 2017; Stelzle and Noennig 2017). These challenges need to be analyzed to develop solutions that support content-related arguments and encourage citizens to consider various aspects and project contents. As the possibilities and potentials of artificial intelligence (AI) in particular in natural language processing (NLP) have already been successfully evaluated in other domains, like public service delivery (Hasan et al. 2021) or chatbots (Baha et al. 2022), it is to examine, how these approaches and technologies can be used on UPP to support citizen participation. To do so, we raise the following research question (RQ).

RQ: How to design IT artifacts to support citizen participation on urban participation platforms?

We initiated a design science research (DSR) project to answer the RQ and systematically elicit, evaluate and evolve design requirements by developing an IT artifact as an instantiation of the design principles (Vaishnavi et al., 2004). In this paper, we describe our intermediate results relating to issues, meta-requirement, design principles, and the initial instantiation of the developed IT artifact. Furthermore, we initially describe the planned evaluation to approve our findings and examine further adjustments and extensions.

10.2 Foundations and Related Work

Citizens' requirements are nowadays of high interest to planning authorities and governments. This is reasoned due to the challenge to develop sustainable cities with limited resources to provide e. g. sufficient housing, recreational areas, educational and cultural offerings, and the promotion of innovations and companies to create economic prosperity and jobs to maintain social harmony (Caragliu et al. 2011; Müller-Seitz et al. 2016). Since citizens often have to live with the project's results, many researchers and authorities argue that they should be included in urban projects and contribute their requirements and ideas (Müller-Seitz et al. 2016; Yong and LiYan 2011).

The scientific literature about citizen participation in urban planning describes, that the participation of citizens is commonly executed by professional moderators following different processes (Amado et al. 2010; Koutra et al. 2018; Stelzle et al. 2017). These participation processes generally include the initiation of the urban project, coordination of, and agreement on the (rough) project's requirements, informing the public to promote the participation, the execution of the participation, and its analysis to develop a project's vision (Soneryd and Lindh 2019; Stelzle et al. 2017). Citizen participation in urban planning often contains two steps. First, the elicitation of requirements in which citizen can contribute their requirements without specifying a project's vision, and secondly, the participation in which professionally designed project visions, based on the results of the first step, are presented, to conduct a voting to decide, which vision should be implemented (Steiniger et al. 2016; Stelzle et al. 2017). In this paper we are focusing on the elicitation of requirements, as the RQ suggest.

The participation of citizens and its preparation varies. Many approaches are still based on on-site participation and can be combined with newspaper ads, and social media, to e. g. inform citizens and advertise the participation (Stelzle and Noennig 2017). In on-site approaches, touch tables and VR glasses have already been evaluated so that citizens can express their creativity textually and graphically (Allen et al. 2011; Andrade and Bastos 2019). Depending on the space and duration of on-site events, the number of participants is very limited (Bracken 2014) compared to digital participation, as numerous projects have already shown (Krätzig and Warren-Kretzschmar 2014; Royo et al. 2020; Stratigea et al. 2015).

UPP like CONSUL (Repette et al. 2021) or DECIDIM (Smith and Martín 2021) are already in use and contain functions for submitting applications for projects, changing regulations, laws, public processes, and services, and opportunities to discuss these, as well as surveys and voting systems (Royo et al. 2020). Through an optional connection to the residents' registration office, it is also possible to govern the number of participants, e. g., if a project only affects a selected part of the city or if only the opinions of residents in a specific area should be considered (Repette et al. 2021). The advantages of citizens contributing their requirements, and ideas to become co-authors are significant, because of the high level of knowledge transfer between participants and designers, which especially applies to on-site discussions (Repette et al. 2021). At the same time, it is becoming increasingly apparent that in digital participation many contributions are incomplete, not meaningful, comprehensible, or helpful, and the quality of the debates is not comparable to on-site discussions (Krätzig and Warren-Kretzschmar 2014). This was also enhanced by the COVID-19 pandemic, as on-site participation was unavailable and urban life has changed which affected social interactions and needs and had a sustainable impact on urban planning,

e. g. green infrastructure to support public health and urban resilience (Hanzl 2020; Sharifi and Khavarian-Garmsir 2020).

Therefore, the need for adequate intelligent, interactive, and scalable solutions is high to support citizens in UPP to promote the documentation and completeness of requirements considering prescribed aspects and contents (Recalde et al. 2020). Intelligent solutions such as chatbots have already shown, that they are capable of fostering interaction between humans and machines by answering questions or providing information in other domains (Henk and Nilssen 2021). The technological approaches are promising, which especially applies to NLP which enables the systematical evaluation of natural language as text (Penningtin et al. 2019). This creates new opportunities to extend UPP and some projects have already initially examined NLP in UPP, to summarize discussions for planners and architects (Lieven et al. 2021), but less research was conducted to support citizens in UPP by applying NLP (Nicolas et al. 2021).

10.3 Research Approach

We conducted a Design Science Research project according to Kuechler and Vaishnavi (2008) to design and develop an IT artifact to support citizen engagement in urban planning projects (cf. Figure 1). The DSR approach is iterative and provides a sequence of steps (Kuechler and Vaishnavi 2008). We aim to contribute a nascent design theory and an IT artifact (Thuan et al. 2019). Therefore, in the first cycle, we analyzed the scientific literature about urban planning processes, platforms, and participatory methods to identify issues (I), formulate meta-requirements (MR), and derive initial design principles (DP). We further developed a prototype as an instantiation of the design principles to present one possible solution.

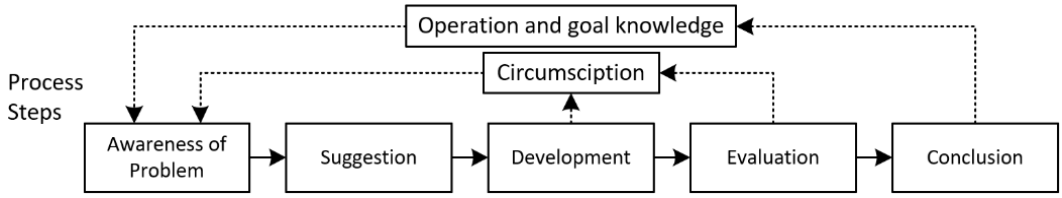


Figure 1. Design Science Research Approach according to Kuechler and Vaishnavi (2012)

10.4 Awareness of the Problem

For the identification of the issues, we reviewed the existing literature about citizen participation in urban planning by using the databases of ScienceDirect, IEEE Xplore, and emerald insight. The focus was on publications that consider citizen participation in urban planning with digital tools and especially UPP, including innovative technologies like NLP (Watson and Webster 2020). The literature analysis revealed, that regardless of whether the participation is project-based or continual, similar

problems arise as soon as citizens are required to participate. In on-site scenarios and urban platforms, participants are invoked to provide requirements by contributing their opinions, needs, and visions and can inform themselves via presented or requested information. The documentation of the contributions is depending on whether the approach is more or less structured, which often results in a lack of documentation and structured data (I1) (Recalde et al. 2020; Schuurman et al. 2012). This especially applies to on-site approaches, where touch displays or virtual environments (e. g. virtual reality) are used (Stratigea et al. 2015) which were already examined by e. g. Lieven (2017) in the DIPAS project. Another issue is the evaluation of contributions, e. g. comments in urban platforms to generate feedback (I2) and to point out missing, inconsistent, or to-be-considered content (Ertiö 2015). This problem is widespread and amplified by high a level of participation, as textual input is often evaluated manually. Therefore, project managers often rely on the number of votes for or against a project or its vision (Steiniger et al. 2016). However, this does not promote an in-depth debate in which information and knowledge are shared (I3). Furthermore, depending on the number of participants the discussion often ends after a few comments, if no response appears (I4) (Royo et al. 2020). An in-depth contribution of requirements and ideas upgrades citizens to co-authors and can create a high interest of citizens in the urban project (I5) (Krätzig and Warren-Kretzschmar 2014). In on-site scenarios, the discussions were generally led by professional moderators, which limits the number of participants due to space and time constraints and creates a lack of scalability (I6) (Hanzl 2020; Stelzle and Noennig 2019). In other words, the issue is, that the quality of an interactive human-to-human exchange is not satisfactorily achieved by human-to-machine interaction. The need for feedback on thematic engagement with the project and requirements is high and should lead to more comprehensible and conclusive citizens' contributions, meaning that missing topics (e. g. accessibility of health care) are pointed out. To enable an open exchange, citizens' creativity should not be constrained, e. g., by purposely prescribing solutions (I7) (Mueller et al. 2018), as this may negatively affect acceptance and is not in line with collaborative approaches, where citizens act as designers and (co-)authors of the project (Recalde et al. 2020).

Due to their investment, the project's financiers have an interest in ensuring that the urban project is successful and not hindered or delayed by local resistance based on a lack of acceptance (I8) (Krätzig and Warren-Kretzschmar 2014). This might correlate with the benefits of a project, which should be supported by the citizens' contribution, to reduce a possible lack of real-world benefit (I9). This especially applies to governments, but also to institutional and private investors who are focusing on sustainability and/or want to increase their reputation and/or image (Ceballos and Larios 2016; Simonofski et al. 2017). After the participation, professional designers develop project visions, based on the elicitated citizens'

contributions and requirements of the projects financiers and responsible. While the requirements of the projects financiers and responsible are usually unambiguous, since the number of people is limited (Palumbo et al. 2021), those of the citizens are more complex. To transfer them into a project vision, it is crucial that the requirements of the citizens are consistent and the intentions and needs behind the contributions are transparent (I10) which does not always apply (Hofmann et al. 2020). This probably also correlates with the length of the contributions and past projects have shown that citizen contributions are sometimes unrealistic (I11) which can lead to the exclusion of their contributions (Stelzle and Noennig 2019). This can be explained by the fact that citizens are non-experts (I12) which is appropriate for urban planning regarding the grassroots approach wisdom of the crowd (Roman and Fellnhofer 2022).

10.5 Suggestions

To determine the meta-requirements, all identified issues and their interrelationships were analyzed and discussed by the authors. Afterward, these were condensed according to the DSR methodology of Gregor et al. (2020) into design principles to be considered for developing IT artifacts, as inquired by the research question. The results are shown in Figure 2.

I1 addresses the documentation of data, which should be facilitated digitally and leads to MR1 and DP1. As a result, DP1 provides that the platform stores all contributions in an assessable format, which is usually fulfilled with textual contributions (Ongsulee 2017). However, graphical approaches have been explored in urban platforms, in which citizens can express their requirements and visions via VR or 3D maps (Lv et al. 2016; Sameeh El halabi et al. 2019). These are not excluded by DP1 if it is ensured that their representation can be systematically and automatically evaluated.

I2, I3, I10, I11, and I12 outline the issues around feedback and response and lead to MR2, MR3, MR8, MR9, and MR10. Thereby DP2 facilitates that an IT artifact should provide helpful feedback to participants, supporting adjustments and enhancements of their contributions. Furthermore, the feedback should be as intuitive as possible to prevent an interruption of the workflow, through e. g. time-consuming reading, which might end the participation (Lieven 2017).

I4 and I5 respond to the lack of interaction and the lack of interest in the urban project or the participation itself (Murphy and Hands 2016). This is a common problem, even if UPP are already reducing many barriers as they can be used at any time via the Internet eliminating all local limitations (Ertiö 2015). However, as communication is often asynchronous, it is difficult to maintain discussions, which can cause a loss of interest during the process. This should be compensated by feedback (MR4). MR5

results from I6, as in many participation approaches, feedback is initiated by moderators and can arise through discussions between participants (Stelzle et al. 2017). However, in low outreach urban projects, this may not occur. Therefore, DP3 provides, that the UPP enables contemporary feedback to support interactions for all participants. It is possible to implement this through moderators and commentators. However, as participation platforms such as CONSUL have already shown that it is possible to implement discussions in urban planning with over 20,000 citizens, moderation by humans is too time-consuming and costly (Royo et al. 2020). Thereby we suggest a technical solution.

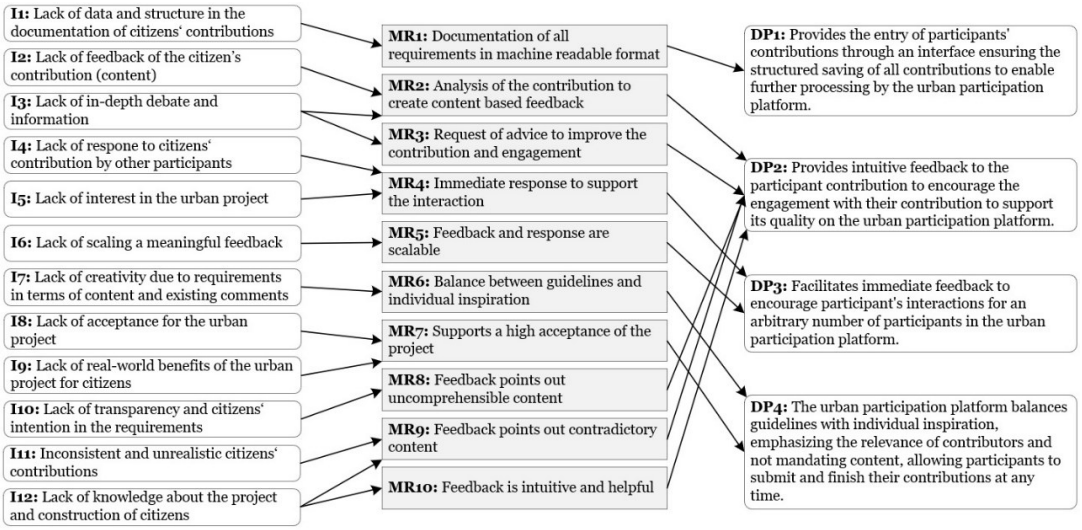


Figure 2. Issues (IS), Meta-Requirements (MR), and Design Principles (DP) for an interactive Urban Planning Platform

The demand in MR6 based on I7 refers to the tension between specifications and individual creativity as every project is aligned to the objective and requirements of the project responsible. In addition, there are regulatory prerequisites, as is the case in social housing, so that visions are always constrained and have to be combined into an implementable concept (Stelzle and Noennig 2019). I8 and I9 are considered by MR7, as both problems relate to the acceptance of urban projects (Schuurman et al. 2012). To develop a feature that supports this, enough information about the project should be provided so that citizens can contribute their requirements concerning what the project can achieve. When providing information, it is important to ensure that no content is forced and solutions are not prescribed to avoid the impression of superficial participation, which may have a counterproductive effect on acceptance. In addition, the participants should be informed about the further processing of their contributions to emphasize their relevance (Krätzig and Warren-Kretzschmar 2014).

10.6 Development

As an instance of the design principles, we developed a web prototype that illustrates one possible implementation and whose evaluation is pending. The design and

functionality can be incorporated into UPPs. The prototype was developed in the programming languages (X)HTML and Java and was hosted with a Glassfish server.

The prototype enables the input of citizens' requirements concerning DP1 via a graphical interface as text and saves all information after each interaction to enable an evaluation of the contribution over time. To provide feedback as described in DP2, different approaches were explored, including the determination of what kind of feedback might be helpful. The feedback is contributed through a color-coded unipolar five-point scale (not considered, incomplete, expandable, considered, and fully considered) due to its intuitive reading (Gosavi 2015; Hartley 2014) and the similarity to the five-point Likert scale, which is widely used (Armstrong 1987). The graphical interface displays the calculated value for each criterion depending on the input of the citizens (cf. Figure 3). The five levels enable, that citizens quickly recognize progress in the feedback, but also do not too quickly reach the highest level, to support the examination with the contribution to extend and adopt it. The six prescribed categories are based on the dimensions of the smart city concept which are crucial for the transformation of cities (Vasudavan and Balakrishnan 2019). The decisive factor for the evaluation is whether and how extensively a category is considered which is automatically determined using NLP. The determination of the scale value for each category is processed by using the unsupervised learning algorithms for training semantic vector representations for text called Global Vectors for Word Representation (GloVe) from Stanford University (Penningtin et al. 2014). Vector models are trained with huge amounts of data using statistical techniques so that each word is computed to determine a position in the vector, known as word embeddings. The position is calculated, for example, using the frequency of the word in the context of other words. The semantic relationship between words is defined by their vectors' position. Particularly adjacent positions (words) represent semantic similarity (Ni and Cao 2020). Therefore, the average vector for each sentence (contribution) overall containing words is calculated, to determine a sentence vector to enable the comparison with each criterion represented by a reference sentence. The comparison is executed by calculating the cosine angular e. g. distance between the vectors (sentences) which determines a value between Zero (semantical similar) and One (semantical different). All values of all sentence comparisons are summed up to calculate how comprehensible each category is considered (Agarwala et al. 2021; Alodadi and Janeja 2015). Due to our approach, all criteria can be exchanged, reduced, or expanded easily to adapt local and project-specific criteria e. g. content. A consideration of position (positive, negative, neutral) is not implemented, as it may influence the outcome in terms of feedback and contradicts DP4. The NLP approach also considers DP3, as this allows immediate feedback for all participants.



Figure 3. Graphical Interface of the initial IT Artefact

Concerning the availability of required computing power, this approach is scalable and supports a human-to-machine interaction. DP4 requires that IT artifacts should find a balance between guidelines and inspiration, which is considered by the roughly described categories. Furthermore, participants can analyze and change their input as often as they wish and can submit it independently of the feedback by using the available button (cf. Figure 3). In addition, all participants receive a short description of the project above, and information about the further process below the input field, which is not shown in Figure 3.

10.7 Outlook and Conclusion

In this paper, we presented the interim results of the ongoing DSR project, in which design principles for IT artifacts to support citizens on UPP are developed to encourage them to contribute comprehensible contributions, e. g. requirements, ideas, and vision, considering prescribed criteria. For this, we applied the DSR methodology of Kuechler and Vaishnavi (2021). We analyzed scientific literature, identified twelve issues that occur in citizen participation and condensed these into ten meta-requirements and derived four design principles that should be considered in the development of IT artifacts to support citizens in UPP.

The results highlight, that many issues relate to the interaction and the incomprehensiveness of citizens' contributions since discussions on UPP differ from on-site approaches due to less interaction between participants and a reduced exchange of requirements and ideas (cf. Awareness of the Problem). Furthermore, the documentation of contributions can be improved, which is reflected in the meta-requirements. The derivated design principles can be implemented differently, as described in chapter Suggestions. The developed IT artifact e. g. web prototype considers the design principles and includes an automated evaluation of citizens' contributions to estimate feedback to whether recommended criteria have been sufficiently addressed or not. For this, NLP is used and with the help of the vector system GloVe, the semantic comparison of sentences and words is enabled and represents an intelligent feature for UPP. The evaluation of the web prototype is pending and will consider if the instantiation and the design principles themselves are

suitable to support citizens on UPP to examine, reconsider and extend their contributions concerning prescribed criteria. It is planned to conduct a qualitative evaluation using focus groups, to evaluate the design (validity), feedback/response (utility), and the technological approach (efficacy) (Gregor and Hevner 2013). To do so, the design of the IT artifact should be tested, and discussed by citizens in a fictional or a real urban project to elicit citizens' contributions. In addition, alternative and further instantiation of the design principles should be examined to increase the validity and e. g. define the maximum and the minimum number of prescribed categories.

Due to the absence of an evaluation, the validity of the design principles is limited. It cannot be ruled out that further issues will be identified during the evaluation, as these are exclusively founded on the scientific literature and may not be complete. Nevertheless, this paper summarizes the advantages, disadvantages, and challenges of on-site participation and UPP and provides an overview for planning authorities, urban designers/architects, and participation experts by highlighting issues, meta-requirements, and initial design principles. The design principles are enhancing UPP with an intelligent feature to automate feedback to encourage citizens to participate and contribute comprehensive contributions. Due to the required evaluation and the lack of NLP approaches in the domain of urban planning to support citizen participation, further research is required, to extend the knowledge base about IT artifacts in this domain, including further visual and technical solutions.

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11 Publication C2: Designing mobile Applications for Citizen Participation in Urban Planning

Hawaii International Conference on System Sciences (HICSS)

Track: Design, Development, and Evaluation of Collaboration Technologies
Completed Research
Ranking: B

Research Question

How to design mobile applications to support citizen participation in urban projects?

Contribution to the Dissertation

This publication contributes to the overall RG, especially RQ1, by describing the design of a mobile prototype that supports citizens in submitting their contributions, including photos, and extending them with visual marks and textual descriptions. Furthermore, the publication contributes to RQ2 by specifying the required data. The publication describes nine issues, nine meta-requirements, and four design principles, which were extended to seven design principles as a result of the evaluation.

Citation

Borchers, Marten; Tavanapour, Navid; & Bittner, Eva (2023). Designing Mobile Applications for Citizen Participation in Urban Planning. In: *Proceedings of the 56th Hawaii International Conference on System Sciences* (HICSS). https://aisel.aisnet.org/hicss-56/cl/design_development_and_evaluation/5.
Completed Research.

Abstract: *As a result of the increasing requirements for urban planning, a paradigm shift towards citizen participation has evolved to collaboratively address enhancing urban challenges and social conflicts. Past projects have examined urban citizen participation processes and methods to support citizen participation. However, the challenges in the domain of informing, encouraging, and enabling participation at any time are not sufficiently examined and less attention was devoted to urban participation through mobile applications, even if required devices are widely used and can enable permanent communication channels between citizens and planning authorities. Therefore, a design science research project was initiated to examine how to design mobile applications to support citizen participation in urban planning projects. In this paper, the findings of the first cycle are presented including issues, meta-requirements, design principles, the development of a mock-up, and its evaluation to provide insight into the design of mobile applications for citizen participation.*

Keywords: Mobile Participation, Urban Planning, Collaboration, Design Science Research

11.1 Introduction

In the past decades, urbanization has led to the continuous growth of cities, and many studies forecast, that this development will continue and enhance urban conflicts (United Nations - Department of Economics and Social Affairs - Population Dynamics 2018) due to increasing demands for livable and affordable space, mobility, sustainable jobs, innovations and recreational areas like parks and community places to support social cohesion and quality of life (Khan et al. 2017; Vasudavan and Balakrishnan 2019).

These challenges are highly complex for urban planners as well as architects, and governments and planning authorities are responding to the changing requirements of citizens via a paradigm shift toward citizen participation to collaboratively design and develop sustainable solutions (Stratigea et al. 2015). Citizen participation enables the elicitation of local knowledge and individual requirements, as well as ideas so that citizens can act as multipliers for urban projects and add civic and social value (Palumbo et al. 2021). Furthermore, citizen participation can reduce costs, because many problems are identified during the design and before the planning and construction phase begins (Repette et al. 2021). The benefits of participatory urban planning have already been considered by various researchers and practitioners and resulted in e.g. a minimum viable process by Stelzle et al. (2017) which describes the implementation of citizen participation on a meta-level and can include different analog and digital tools and techniques like workshops, group discussions, online surveys, and participatory platforms (Stelzle and Noennig 2017). However, until the COVID-19 pandemic, many approaches were on-site approaches, which were not available during the pandemic (Sharifi and Khavarian-Garmsir 2020) which enhanced the usage of urban platforms e.g. in Hamburg (Lieven 2017), Madrid (Royo

et al. 2020), Barcelona (Smith and Martín 2021), and many further cities. However, the existing possibilities are not yet fully exploited, and platforms do not provide continuous communication between citizens and authorities as supported by mobile applications (Schrammeijer et al. 2022). Furthermore, it is important to highlight the value of participants' contributions, and their influence as this is not always apparent due to a lack of transparency. This especially applies to anonymous participation, in which it is not possible to address the participant afterward, to inform about further participation, or present (intermediate) results (Tejedo-Romero et al. 2022).

To support citizen participation and transparency of the planning process and to communicate effectively, the development of mobile applications for citizen participation is considered. Mobile applications are distinguished from existing participation platforms as they are predominantly constructed for anonymous and unregular e.g. project-based participation (Lieven 2017). Mobile applications can enable a permanent and easily accessible communication channel to support an efficient exchange of information and citizens' demands (Royo et al. 2020). In addition, the use of the global positioning system (GPS) enables to inform about nearby participation projects (de Hoop et al. 2022; Schrammeijer et al. 2022) and the majority of the global population possesses a required smartphone (Tenzer 2022), which is why mobile applications can enable effective low-threshold participation.

It is unclear how mobile applications should be designed to support citizen participation in urban planning and what the strength and potentials are, which led to the following research question (RQ).

RQ: How to design mobile applications to support citizen participation in urban projects?

The scope of the RQ lies in the visual implementation of the mobile application to support citizens. Thereby, requirements of other stakeholders like planning authorities are excluded and can be examined after the approval of this approach by citizens. In addition, the word support might be ambiguous and is, in this case, addressing required functionalities for citizens to contribute their requirements and ideas to an urban project. This still can include many kinds of features and will be specified during the project by literature and the exchange with citizens. Due to the user-centered and design-oriented approach a Design Science Research (DSR) project was initiated to iteratively analyze, develop, and evaluate different IT artifacts. For this, the DSR Methodology according to Kuechler and Vaishnavi (Kuechler and Vaishnavi 2012) is applied.

In this paper, the findings of the first cycle are presented and the paper is structured as follows. Section 2 introduces relevant concepts and related work. In Section 3, the research approach and in Section 4, the awareness of the problem including the identified issues are described. Section 5 contains the formulation of meta-

requirements and derivation of the design principles which are used for the development of the mock-up (cf. Section 6) and evaluated as described in Section 7. Finally, the findings are shown in Section 8, discussed in Section 9, and concluded in Section 10.

11.2 Foundation and Related Work

Urbanization is a global phenomenon that creates and enhances challenges around the world and raises the question, of how cities should be designed (Sangawongse et al. 2021). This and the growing belief of governments and planning authorities, that citizens, as they have to live with the results of urban projects should be included in the development and design of the project's vision, led to the increased application of citizen participation in urban planning (Krätzig and Warren-Kretzschmar 2014).

11.2.1 Smart City Concept

The design and development of cities often follow the Smart City concept for which different definitions exist. Caragliu et al. (2011) define a city as “to be smart when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance”. An alternative definition by Vasudavan and Balakrishnan (2019) states, “a smart sustainable city is an innovative city that uses ICTs and other means to improve quality of life, the efficiency of urban operations and services and competitiveness while ensuring that it meets the needs of present and future generations concerning economic, social and environmental aspects”. Both definitions highlight the quality of life. Furthermore, the first definition highlights participatory governance, and the second, that citizens' needs should be considered. Both requirements can be met with citizen participation highlighting the importance of valid participatory approaches to communicate sustainability and strengthen the relationship between citizens and government e.g. planning authorities (Ertiö 2015; Singh and Singla 2021).

11.2.2 Participation Process and Platforms

The literature describes various success factors for citizen participation like well-integrated workflow, transparent communication, commitment to the participatory approach, use of appropriate tools, etc. These should be considered to enable a positive experience and support the trust in participation, planning authorities, and governments (Hofmann et al. 2020; Münster et al. 2017; Stelzle and Noennig 2017). The conduction of citizen participation is described by many scientists and often includes two or more participation phases.

The first participation phase is often called the co-design phase, in which citizens can contribute their requirements, ideas, and vision to an urban project. This phase is defined by the alignment and some meta-requirements to clarify the scope of the project and the participation with none or only a few contextual restrictions, as there is no developed project vision yet (Stelzle et al. 2017). The second participation phase is conducted after the analysis of the received citizen contributions by professional designers, architects, and/or building planners who created different project visions. All visions are presented to the citizen to enable polling to decide, which project vision should be implemented (Münster et al. 2017; Stelzle and Noennig 2017).

To implement the participation different methods and tools like discussions in civil forums, brainstorming, workshops, crowdsourcing platforms surveys, polls interviews, and many more to inform, consult and collaborate with citizens, can be used (Stelzle and Noennig 2017). However, participation by citizens often varies so that different-sized participation groups with varying interests and demands are included, and no permanent communication channel exists, as the exchange is only punctual (Steiniger et al. 2016). To change this and centralize urban planning information and projects, many cities developed participatory platforms to provide a single point of contact for all relevant information and to reduce participation barriers (Lieven 2017; Smith and Martín 2021). Participation platforms, such as Decide Madrid, have reached thousands of citizens through the submission of proposals and projects, discussions, and voting (91,032 participants in 2018) (Royo et al. 2020). However, even if platforms support the participation of numerous citizens, some challenges still exist, as platforms require suitable devices, which are not always available.

11.2.3 Mobile Applications and Participatory Approaches

Mobile applications have not been examined sufficiently yet, even though they might offer significant advantages compared to existing urban platforms, e.g., geolocation and push messages. Mobile applications are classified by Flora (Flora et al. 2014) into four types of applications.

The first type, *browser access mobile applications*, is not installed on the smartphone and can only be used if connected to the internet. In this case, the applications are very often just a responsive website that is opened and used, and the benefits of the smartphone are not utilized, as the approach is comparable to the participation via a laptop, only with smaller display size. The second type is *native mobile applications*, which are installed on the smartphone and can be used without the internet and therefore, never down- or uploaded content and data, which is insufficient for the required communication in urban planning (Kusumastuti et al. 2022). The third type, *online hybrid applications*, are installed on the smartphone but to use them a connection to the internet is required to receive news or provide data. The fourth type,

mixed hybrid applications, can be used with and without a connection to the internet, as data is saved on the smartphone and basic functions can be used. Data might be uploaded later and downloaded if connected, to update e.g. news and discussions (Flora et al. 2014; Francese et al. 2017).

Few projects like MOBISEC and the case study on the PinStreet platforms have examined the implementation of mobile applications to interact with citizens. In the case of MOBISEC, they focused on the development of a mobile application to improve cyclists' safety and urban mobility by analyzing collected data from the participants (Melendreras-Ruiz and García-Collado 2013). In the PinStreet project, the authors analyzed mobile-based participation projects in different cities, to analyze the impact compared to non-mobile-based platforms (Wang et al. 2021). Based on their results, type one and type two are not appropriate for citizen participation in urban planning, as type one, is not extending existing responsive platforms, and type two does not include a connection to the internet, which is mandatory (Akmentina 2022). Thereby, this paper is focusing on type three and type four.

11.3 Research Approach

Design science research (DSR) is a recognized methodology in the field of Information Systems and is used to develop new design theories or contribute to existing ones by developing knowledge about the design of IT artifacts for a specified domain (Kuechler and Vaishnavi 2008). The process is predefined by the DSR methodology and should be further concretized for the development of a solution depending on the problem, and existing scientific literature (Vaishnavi and Kuechler 2004).

In this DSR project, the DSR methodology according to Kuechler and Vaishnavi (2012) is applied. Figure 1 illustrates the methodology and the conducted and specified process step of the first cycle, which is presented in this paper. To identify and specify existing issues (IS) in analog and digital participation approaches, the scientific literature about urban citizen participation was analyzed. This particularly includes initial approaches and projects that already tried and developed mobile applications for citizen participation in urban planning. Afterward, the meta-requirements (MR) were formulated, and the design principles (DP) were derived, by analyzing the associations and relationships of the MR.

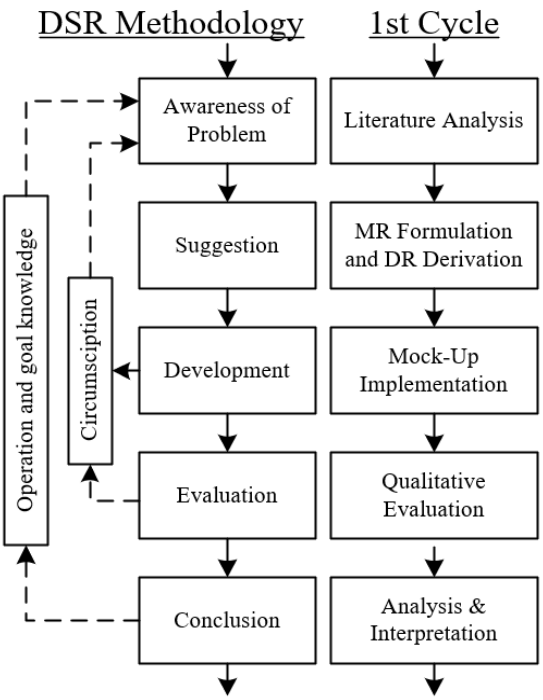


Figure 1. Research Approach

Based on the findings a mock-up as an instantiation of the DP was developed, to enable the evaluation of them. The evaluation was conducted using a focus group including a click-through to the mock-up and a group discussion that resulted in a SWOT analysis. The evaluation is conducted in the described procedure to approve, disprove and/or extend DP and to collect strengths (S) and weaknesses (W) of the design of the mock-up and opportunities (O) and threats (T) considering the usage of the developed solution. The results of the evaluation are analyzed and described concerning the DP.

11.4 Awareness of the Problem

The literature analysis was conducted by using search strings including the words *citizen participation* OR *urban planning* AND *mobile* OR *mobile application* OR *process* OR *platforms* to elicit related work according to the research question (RQ). For the literature research, the databases of Science Direct, IEE Explore, and emerald insight were used and all literature that was published before 2017 was excluded, to focus on contemporary findings. The analysis enabled the identification of nine issues (IS1-9), which are described in the following.

In the scientific literature, approaches to support digital participation via the Internet or on-site are often described. Citizens criticize that the involvement in many participatory approaches is only punctual and that the decision-making process is not transparent (IS1) (Bjørgen et al. 2021; Hofmann et al. 2020). This is enhanced by the lack of effective communication channels (IS2) (Khan et al. 2017), as citizens are

often informed by advertising or have to proactively search for participatory projects, which presuppose an intrinsic interest, motivation, and time (Mueller et al. 2017; Münster et al. 2017). This also relates to the meaningfulness of the projects and the real-world outcome, which some urban projects lack (IS3) (Gutiérrez et al. 2018; Haveri and Anttiroiko 2021; Naranjo-Zolotov et al. 2019). In the literature about on-site participation, a lack of space (IS4) (Royo et al. 2020) and time (IS5) (Steinbach et al. 2019) is described, as on-site participation requires contact point, room, and staff for the administration and moderators or experts to inform citizens and discuss requirements, ideas, and possible vision of the urban project (Akmentina 2022; Stelzle and Noennig 2017). Because of the dependency on the availability of resources, costs, and staff, the time frame for citizen participation is limited which can exclude or reduce the participation of e.g. working citizens and can create a lack of representativity (IS6) (Hofmann et al. 2020; Mueller et al. 2017). This can increase the inhibition threshold and therefore can lead to a lack of participants (IS7) (Kusumastuti et al. 2022; Münster et al. 2017).

In the literature about digital participation, it is differentiated between on-site participation including digital tools like VR-lens or touch-tables, and digital participation via urban platforms (Sameeh El halabi et al. 2019). In both approaches, a possible lack of IT capabilities of participants is described (IS8) (Repette et al. 2021) which can be compensated in on-site participation approaches with professional moderators and experts. However, this can also apply to mobile participation and should be considered. Existing projects have examined how to show 3D building in mobile applications and achieved a proof of concept and are describing the disadvantages of the display size of a smartphone (Rzeszewski and Orylski 2021; Sanaeipoor and Emami 2020), which can create a lack of simplicity and usability (IS9) based on an overcrowded graphical interface (Pantić et al. 2021).

11.5 Meta-Requirements and Design Principles

The issues (IS1-9) were discussed and analyzed by the authors to identify and analyze the relationships and dependencies and formulate a total of nine meta-requirements (MR1-9) and derive four design principles (DP1-4).

IS1 and IS2 led to MR1 which requires, that the mobile application *contains an archive for viewing past projects and decisions*, and lead to DP1, which *provides an overview of all urban projects and description of decisions to support the transparency of the decision-making process*. IS1, IS2, and IS6 require, that the mobile application can *actively inform citizens about the projects' process and decisions* (MR2) to enable a continuous bidirectional communication channel between citizens and urban projects' responsible and/or planning authorities, as the proposed mobile application, as described by type three and four (cf. Section 2.3),

should be installed on the citizens' smartphone (Simonofski et al. 2017). Depending on the available data about the participants, this channel can be used to address certain underrepresented groups (e.g. by age or location) which leads to MR5, based on IS6 (Royo et al. 2020). IS3 and IS4 require that *citizens can contribute requirements, ideas, and visions to urban projects* (MR3) via a graphical user interface. Together MR2, MR3, and MR5 lead to DP2, which describes, that the mobile application *provides information and, messages to actively inform citizens about the progress of the urban project and features to respond* which can be implemented differently and highlights possibilities to strengthen the communication (Nitu et al. 2018) with e.g. surveys and polling (Haveri and Anttiroiko 2021; Royo et al. 2020) to receive efficient feedback. IS3, IS4, and IS5 contribute to MR4 and defines, that a mobile application should enable an exchange between citizens and experts with *sufficient functions to comment on other contribution asynchronously*, which is also supported by IS5 to enable (working) citizen to participate when available. MR6, the intuitive design of the mobile application is founded on IS7, to reduce inhibitions (Steinbach et al. 2019). IS7 also led to MR7, which requires tools to contribute visually to urban projects, as past projects have shown and are supported by IS9. MR8 is founded on IS7 and IS8 and requires *high usability of the mobile application* and result, together with MR3, MR4, MR6, and MR7 in DP3 which *provides a basic function to enable efficient and effective participation for all citizens supported by high usability*. Therefore, DP3 is addressing the use of a mobile application to design it as easy as possible considering necessary functions and simplicity. Furthermore, MR6, MR7, MR8, and MR9 are considering graphical aspects by addressing the usability and result in DP4. DP4 defines, that a mobile application for urban participation should *provide a clear and intuitive structure and design that is explained after the installation and whenever required by the citizens* and distinguishes from DP3, due to the focus on the introduction to the mobile application and self-explainability (Kordts et al. 2021).

11.6 Development

As an instantiation of the design principles (DP1-4), a mock-up was developed. The mock-up was created with the UI Designing Tool Figma, which is an online platform for creating vector-based and clickable graphics, which enables the simulation of mobile applications. The mock-up consists of 32 images to enable the users' interaction using different navigation paths to conduct a simulation of the participation in an urban project.

In the mock-up, users are required to log in to the app and verify their identity by e-mail when they log in for the first time. This is intended to ensure that users can be reached by e-mail and can, for example, reset passwords or receive specific information, as described by DP2. In addition, this supports that citizens only have

one account to participate (MR3), even if verification via e-mail cannot guarantee this, as it is possible to possess several addresses. Alternative verifications are possible as same as a connection to the residents' registration office, which was already evaluated in Spain with urban platforms (Royo et al. 2020). Nevertheless, the communication channels via e-mail and the mobile application enable to inform the users about selected projects, as described in MR2 and MR5.

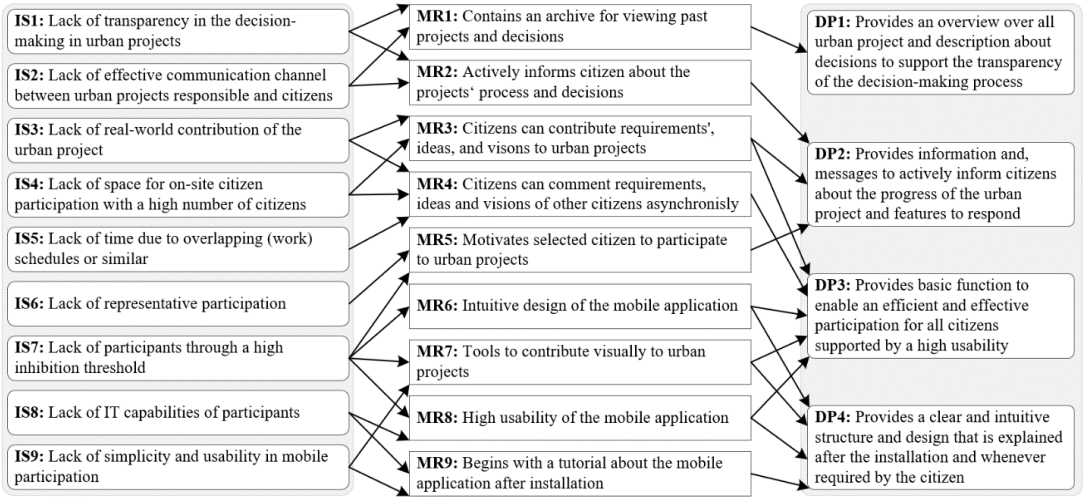


Figure 2. Overview of the Relationship between Issues (IS), Meta-Requirements (MR), and Design Principles (DP)

The first time the mobile application is used, an automated introduction is provided in which the functions and views of the app are briefly explained (DP4). This includes examples and descriptions for the overview of open and closed participation, an overview (DP1) of participated projects as well as the creation and submission of contributions to urban projects (DP3). This is provided with text fields, which users can read and then click away, to ensure that they can participate shortly after installation.



Figure 3. Overview and Projects' Contributions

All open and completed projects are displayed in the overview (cf. left in Figure 3) and can be selected by the user to inform himself about existing comments and responses from other participants or the projects responsible. This highlights the informative nature of the mobile application. In addition, it is possible to specify the projects using categories such as duration, geographic proximity, or project type (e.g., green areas, culture) to individualize the displayed content considering DP2 and DP3.

Submitted contributions are shown in each project's overview (cf. right in Figure 3) and can be filtered (cf. top left in Figure 3) by descending order or date. To participate in a chosen project citizens can contribute their requirements, opinion, and ideas descriptively and/or via Google Street View or comment on existing ones. Google Street View provides an in-depth impression of the environment, as streets, pedestrian walkways, stores, restaurants, etc. can be observed, supporting an exploratory character within the area of interest. To participate, the participant can take a photo (on-site participation) or screenshot/picture (digitally) of the street view, which can then be edited. In addition, the contribution can be textually described to provide further information to document why the proposed changes are important and required by the participant (cf. right in Figure 4). This supports efficient communication, and the combination of graphical and textual information should eliminate the need for detailed time-consuming descriptions (DP3).



Figure 4. Participation and Feedback

In addition, this process is accompanied by professional urban planners since citizen requirements are not always feasible and may violate building regulations (cf. right in Figure 4 bottom comment). This should be identified and communicated as early as possible, to prevent not implementable citizens' requirements and correspond to DP2 too, as citizens can be continuously informed about the development and responses via comments and push messages.

11.7 Evaluation

For the evaluation of the mock-up, a focus group including a digital click-through and a subsequent group discussion was conducted to collect qualitative data to approve/disprove the design principles (DP) and to identify strengths (S) and weaknesses (W) of the design and opportunities (O) and threats (T) considering the usage of the mock-up (SWOT-analysis). The evaluation was conducted using a videoconference due to pandemic constraints and was recorded to allow a systematic evaluation. A link to the mock-up was sent to all participants so that every participant was able to test and experience the mock-up independently of each other.

The focus group was conducted with 10 participants (male=9, female= 1) who were between 18 and 30 years old. The focus was on young and more IT affine citizens to evaluate the functionality excluding challenges based on a lack of IT capabilities. In addition, authors like Rexhepis et. al and Karadimitrou et. al point out the reduced participation of young people, which could be increased with digital approaches to

reach a higher representativeness of citizen (Karadimitriou et al. 2022; Rexhepi et al. 2018). All participants had 10 minutes for the click-through and the subsequent discussion took 20 minutes for which the moderators used questions to approve, disprove, extend, or identify new DP and elicit relevant data considering the SWOT-analysis.

11.8 Findings

The elicited data and discussion about the instantiation approved the derived design principles (DP). In addition, we elicited five strengths (S), three weaknesses (W), two opportunities (O), and two treats (T) (cf. Table 1).

No.	Strength	No.	Weaknesses
S1	Traceable assignments of feedback (n=9)	W1	Limited handling of the tools for design creation and contribution (n=4)
S2	Intuitive use and creation of contributions (n=8)	W2	No transparency about data storage that can be collected by a mobile application (n=4)
S3	Introduction is easy to understand and intuitive (n=7)	W3	No possibility to specify desired messages and reduce them to the desires ones (n=3)
S4	Use of widely available technology (n=6)		
S5	Transparency about the progress of the contribution (n=4)		
No.	**Opportunities**	**No.**	**Threats**
O1	Flexible integration into urban participation processes (n=7)	T1	Lack of experience and motivation of users (n=6)
O2	High range possible due to the installation on the smartphone (n=5)	T2	Abuse through hate messages in submissions possible (n=1)

Table 1. Findings of the SWOT Analysis

The participants particularly appreciate the comprehensibility of the feedback from other users and experts (S1) which is positively emphasized, as it enables an asynchronous, communication between citizens and (urban planning) experts to receive feedback and further information, which according to the participants can increase the reusability of the mobile application and thus supports DP2. The mobile application (mock-up) was described as intuitive (S2) by eight participants as it only contains essential functions and required descriptions (DP4). However, one participant described that the implemented design appears outdated and should be updated to meet contemporary designs and to increase the user experience. The existing functions enable efficient participation and participants can express their requirements and in advance can explore the location of the urban project (DP3).

According to S3, the introduction to the mobile application is also approved as intuitive and supports DP4. However, the possibilities of integrating explanatory videos were also pointed out, which could improve the introduction and may address certain participants better than others. Four participants approved the transparency of public participation (S4) and described the mobile application as it enables a permanent communication channel between participants, planning authorities, moderators, and further experts in which citizens can be informed about responses e.g., feedback and comments at any time via push messages which correspond to DP2.

Concerning the range of functions of the tools for creating contributions, four participants agreed with W1. 3D modeling was mentioned as an addition, as was the possibility of prioritizing contributions to emphasize their relevance. At the same time, it should be ensured that the intuitiveness of the application is supported and that the interfaces are not overcrowded (DP3). W2 describes a non-functional requirement for the mobile application that is also relevant concerning citizens' trust in the mobile application. It should be described transparently which data is used and how it is evaluated. This is particularly relevant in terms of possible connections to civil registers, as this could enable location-based evaluations to measure the activity of participants, and districts or to quantify whether residents in selected streets are sharing similar requirements and may coordinate their participation.

T1 points out, that the usage of mobile applications in urban participation can be challenging due to limited experience as they are quite new and therefore hardly known and used. This applies to citizens and planning authorities, who should ensure that the results of the urban participation can be used for subsequent processes which might require administrative regulatory changes. T2 points out, that the mobile application can also be used for not intended purposes, e.g., to create hate messages or submit and draw unwanted or forbidden symbols.

11.9 Discussion

The findings approved the four initial design principles (DP1-4) and in addition, five strengths (S), three weaknesses (W), two opportunities (O), and two treats (T) were (cf. Section 8) identified.

DP1 was perceived as positive and obligatory and serves as a good introduction to the mobile application after the login. Some participants criticized that the mock-up is not visualizing the results of the urban participation which is desired. Therefore, DP2 is extended to provide information and, messages to actively inform citizens about the progress, intermediate and conclusive results of the urban project, and features to respond to. This includes providing a visual dashboard, which could not be described in detail by the participants and requires further examination. The

objective is to show the results with one view to simplify the accessibility of huge discussion and the communication results. Furthermore, the SWOT-Analysis led to three novel design principles, which are corresponding to the transparency of participants' data and analysis (DP5), the selection of notifications (DP6) to configure e.g., pop-up messages, and a possibility to report critical content (DP7). The possibilities were only discussed initially in the focus group and are not conclusively. However, W2 leads to DP5 and is described as provides transparency of collected data and evaluations through descriptions to promote citizens' trust in the mobile application. DP5 is of high interest as the smartphone is a constant companion of most citizens and there is a high awareness of data collection. Many citizens are skeptical if they should install a mobile application that is developed by or on the order of governments (Babelon 2021). This phenomenon needs further examination, to support the use of mobile applications as it is crucial for the urban participation to install the application on the smartphone as described in Section 2.3 with type 3 and type 4.

W3 addresses a similar issue. The mock-up does consider configurations to specify notifications and to, for example, reduce them to projects and/or contributions of interest by e.g., marking them, which leads to novel DP6 provide the selection of notifications by projects and/or contributions to enable the configuration of messages by participants. Furthermore, even if only one person confirms T2, this leads to DP7, which provides a function for citizens to report unwanted and/or critical content similar to existing applications and social networks to create a safe and trusted environment where citizens can co-create without being offended or condemned.

Further findings such as O2 and T1 occur with the known participation approaches and could not be reduced totally, and it was not possible to determine if these effects are stronger or weaker in comparison to urban platforms or local participation. Based on the evaluation, we assume that at least for younger persons O2 will only be a minor challenge, while T1 will apply to most of the participants and highlight DP4.

11.10 Conclusion and Future Work

In this paper, we presented the findings of the first cycle of the ongoing design science research (DSR) project according to Kuechler and Vaishnavi (2012) to examine how to design mobile applications to support citizen participation in urban projects. To do so, the existing literature about urban participation with mobile applications and related topics was analyzed. We identified nine issues (IS1-9) formulated nine meta-requirements (MR1-9), and initially derived four design principles (DP1-4) (cf. Figure 2). As an instantiation of the DP, we implemented a mock-up which was evaluated with a focus group with ten participants. The focus group approved the initial DP1-4 and led to DP5-7.

In total, the DP describes how to implement a mobile application to enable urban participation considering the requirements of citizens highlighting usability and requirements to configure information, and messages and support transparency. The qualitative approach enabled an in-depth discussion of the design principles, its functions, and potential usage. Nevertheless, the validity of the findings is limited, due to the gender and age bias as we only included participants between 18 and 30 which could influence the findings, as senior participants might be less capable of using mobile applications and/or have other design perceptions. This will be included in the second cycle to extend and/or derive further design principles with the evaluation of a feasible prototype that can be installed on selected devices, to additionally examine technical and organizational requirements, that should be considered by officials e.g., planning authorities. Furthermore, quantitative evaluations like experiments can be used to determine the benefit of selected functions or mobile applications in comparison to existing urban platforms to create further knowledge about the usage of the different approaches in urban planning and how they can be combined.

Overall, this paper contributes to the Smart City concept and digital participation and collaboration in urban planning by providing knowledge about how to design mobile applications to support to enable and support citizen participation with mobile applications for governments, planning authorities, experts, and scientists. In addition, it describes the limitations of the current findings and addresses further research to expand the validity of the findings and the knowledge base of mobile citizen participation in urban planning.

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12 Publication C3: Exploring AI supported Citizen Argumentation on Urban Participation Platforms

Hawaii International Conference on System Sciences (HICSS)

Track: AI in Government
Completed Research
Ranking: B

Research Question

How can AI-based feedback system increase citizens' argumentation on urban participation platforms?

Contribution to the Dissertation

This publication contributes to the overall RG, especially RQ1, by describing the design of a web prototype that supports citizens by providing an interactive feedback mechanism. The publication also contributes to RQ2, as the feedback considers six content dimensions of interest to both citizens and urban experts and follows Toulmin's Argumentation Theory in analyzing the AI impact.

Citation

Borchers, Marten; Tavanapour, Navid; & Bittner, Eva (2023). Exploring AI supported Citizen Argumentation on Urban Participation Platforms. In: *Proceedings of the 56th Hawaii International Conference on System Sciences* (HICSS). https://aisel.aisnet.org/hicss-56/dg/ai/3. Completed Research.

Abstract: *The paradigm shift in urban planning toward citizen participation originates from the Smart City concept, as politicians and scientists argue that citizens should be included in the design of their environment. This led to the development of urban participation platforms and was enhanced by the COVID-19 pandemic as on-site participation was unavailable. Past projects showed that urban participation platforms can reach thousands of citizens, but it became apparent that citizens' contributions vary widely and are sometimes not understandable and comprehensible which limits their value for urban projects. Therefore, we examined how an AI-based feedback system can increase citizens' argumentation on urban platforms. For this, an explorative comparison of two prototypes was conducted by applying Argumentation Theory and Mayring's qualitative content analysis to empirically analyze collected data. The findings highlight that the developed AI-based feedback system supports citizens and leads to more argumentative and comprehensible argumentations on urban participation platforms.*

Keywords: Citizen Participation, Urban Planning Platforms, Argumentation Theory, Artificial Intelligence

12.1 Introduction

The ongoing digitization influences governments, economics, and society and changed the requirements for public service delivery, communication, and politicians (Larsson 2021; Spence 2021). Furthermore, the ongoing urbanization creates and increases new social conflicts in the domain of urban planning and design to which planning authorities and governments need to find solutions (Mohsin et al. 2019; United Nations - Department of Economics and Social Affairs - Population Dynamics 2018) considering the Smart City concept.

The Smart City concept describes future cities as a highly technological, connected, and sustainable with a focus on inclusion and participation to develop citizen-oriented solutions and environments that promote and contribute to society, social cohesion, and quality of life (Simonofski et al. 2017; Stratigea et al. 2015). The Smart City concept contains six dimensions in which urban planning and citizen participation can be seen as an integrated part which especially applies to the Smart Government dimension (Vasudavan and Balakrishnan 2019). To implement the Smart City concept and enable citizen participation, effective governance structures are crucial (Barrutia et al. 2022) to ensure the interconnectedness and security of data, communication channels, and participatory approaches to inclusively concern the demand and requirements of the inhabitants (Singh and Singla 2021). This can affect urban construction projects, social projects, and the development or adaptation of laws and public service delivery (Stelzle et al. 2017). Many cities are already using urban platforms to participate thousands of citizens (Royo et al. 2020; Smith and Martín 2021) and this development was enhanced by the COVID-19 pandemic as on-site participation was not available and e.g. healthcare requirements changed (Pantić et al. 2021).

Past projects have already examined urban participation platforms and are highlighting the benefits (Smith and Martín 2021). However, it is becoming apparent that discussions on urban participation platforms proceed differently compared to on-site participation, as arguments are often conducted asynchronously and anonymously due to the time and location independencies. In addition, textual contributions are often quite short and not comprehensible which aggravates the analysis by architects and urban planners to consider and create public value (Atreja et al. 2018; Haveri and Anttiroiko 2021). Therefore, it endorsed supporting citizens on urban platforms to create comprehensible and more argumentative contributions with intelligent solutions.

In the domain of digital service delivery and help desks, intelligent solutions like chatbots are already explored to e.g. inform or answer questions (Collins et al. 2021; Lee 2020). In the field of urban planning and urban platforms, the use of AI is hardly explored which can be explained by the recent dissemination of urban platforms. Many cities are still developing, testing, and incorporating urban platforms into their administrative processes by adjusting and implementing new and changing existing regulations (Anttiroiko 2016; Frenken and Fuenfschilling 2021). However, past projects have examined approaches to summarize and classify contributions to support planning authorities and architects (Lieven et al. 2021; Nicolas et al. 2021) or to inform citizens about projects of possible interest (Arana-Catania et al. 2021). Some research was conducted about how to support citizens in the process of contribution (Borchers et al. 2022) and less about if these approaches are successfully supporting citizens. Therefore, we examined how an AI-based solution can support citizens with the following research question (RQ).

RQ: How can AI-based feedback system increase citizens' argumentation on urban participation platforms?

To answer the RQ an explorative comparison of two prototypes and two focus groups was conducted. In this paper, we describe our findings including the theoretical foundation (Section 2), the research approach (Section 3), the development of the prototypes (Section 4), the evaluation (Section 5), and the findings (Section 6), which are finally discussed in Section 7 including limitations and future work.

12.2 Theoretical Foundation

Due to urbanization and the development of Smart Cities, participation approaches are increasingly applied in urban planning to include citizens, as they have to live with the project's results, as politicians and scientists argue (Müller-Seitz et al. 2016). This led to the Citizen Design Science Model by Mueller et al. (2017), who combined existing approaches into a three-dimensional model to describe areas and interrelationships in urban participation and design.

12.2.1 Citizen Design Science

Citizen Design Science combines the three dimensions of Citizens Science, Citizen Design, and Design Science and can be used as a toolkit to enable citizen participation in urban planning (Mueller et al. 2017). Each dimension is a combination of two of the areas of citizens, design, and science as these are crucial and induce each other (Torrecilla 2019).

Citizen Science describes how citizens' requirements, needs, and ideas can be elicited in urban planning considering existing frameworks (Nicolas et al. 2021), the urban projects' conditions, and the participation methods (Mueller et al. 2017; Prestopnik and Crowston 2011). This includes on-site/analog and/or digital participation and methods like interviews, workshops, surveys, etc. (Stelzle and Noennig 2017). The scientific literature describes the advantages and disadvantages of the participation approaches, as, for example, digital approaches require a certain IT affinity of the participants. On the other side, they are more time-independent and not limited by space as on-site approaches which are therefore often only temporal and limited concerning the number of participants (Smith and Martín 2021). An overview of Citizen participation methods is provided by Stelzle and Noennig (2017) in the paper *A Database for Participation Methods in Urban Development*.

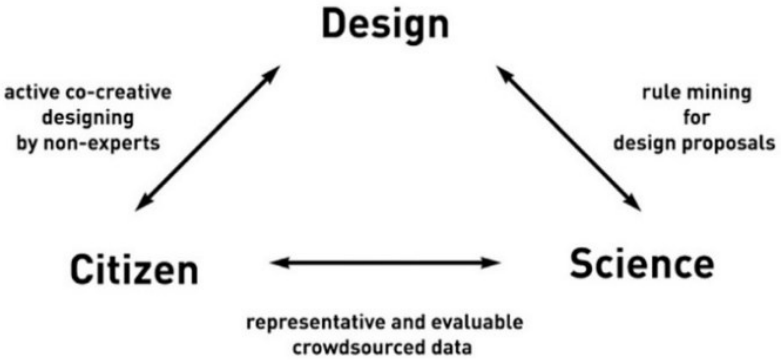


Figure 1. Citizens Design Science Model

Citizen Design determines how citizens actively contribute to the design of an urban project’s vision, e.g. future buildings or parks (Mueller et al. 2017). This can be conducted differently, and the format is affected, by the determined approach (Citizen Science). The contribution of design can be textual and/or visual and was explored in past projects in which participants described parks, buildings, or entire districts on paper, digital whiteboards, mobile and/or stationary devices textually or in 2D or 3D maps (Lieven 2017; Lv et al. 2016).

Design Science describes the process of affiliating design requirements from citizen contributions (Mueller et al. 2017) to support architects and planners to design the project's objective e.g. a park or community place (Altrock 2022). Past projects showed, that transferring the contributions into a specified project’s objective is more advanced than anticipated and that the meta-requirements of the urban projects and

the technical participation approach and analysis of data should be determined before participation, to ensure the feasibility (Repette et al. 2021). These concerns file formats (e.g. Excel, JSON, CSV) in which the contributions are documented and specifications of how collected data should be analyzed, including manual or automatic processes (Cai 2021). Especially for automated approaches, the file format is crucial as visual contributions e.g. 2D (e.g. JPEG or PNG) or 3D maps (e.g. in Unity) are difficult to analyze as these models are stored as vector graphs or individual file formats (Hofmann et al. 2020; Rzeszewski and Orylski 2021).

12.2.2 Urban Participation Platforms

Urban participation platforms enable digital citizen participation and are comparable to social media platforms. They are removing time and space limitations and many cities such as Madrid (Royo et al. 2020), Barcelona (Smith and Martín 2021), Hamburg (Lieven 2017), Dresden (Jannack et al. 2020), etc. are utilizing them. Past projects in Spain, have shown, that it is possible to carry out urban participation projects with thousands of citizens. Furthermore, they upgraded urban platforms to an incorporated part of the public administration by implementing functionalities for citizens to submit applications for example new urban projects, change laws, regulations, and public services, and thus can proactively influence the governments' activity (Royo et al. 2020). During the COVID-19 pandemic, urban platforms were of high relevance to communicate and participate with citizens as urban requirements concerning public health have changed and increased as on-site approaches were unavailable (Sharifi and Khavarian-Garmsir 2020). However, past participation projects have shown that citizen contributions e.g. in discussions, forums, and surveys are not always helpful if they are not comprehensible and/or reasonable (Barrutia et al. 2022; Simonofski et al. 2017). In textual contributions, this often applies as the contributions are quite short, and sometimes only contain bullet points or keywords with less argumentation which would enable architects and designers to understand what and why citizens have certain requirements, ideas, and visions (Poorazizi et al. 2015). This also applies to 2D and 3D models as they often only contain the final contribution, and an extensive argument that would explain and show the development and intermediate steps is missing (Repette et al. 2021). Therefore, it is important to find solutions to support citizens to contribute comprehensible contributions to lay a transparent, and reasonable basement for urban projects and to support subsequent processes and design science (Krätzig and Warren-Kretzschmar 2014).

12.2.3 Argumentation Theory

Argumentations were systematically studied by the British philosopher Toulmin (1922-2009) in the mid-19th century. He focused on spoken words in English and

developed the Argumentation Theory in 1958, which describes the process and properties of argumentation (Smiley 1958).

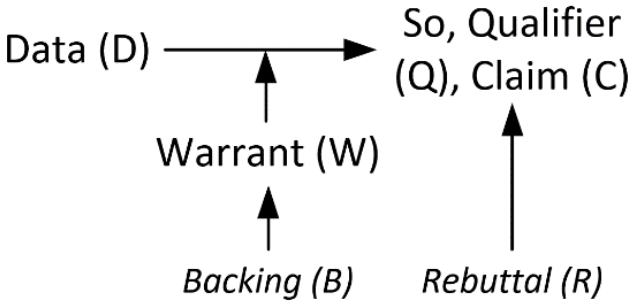


Figure 2. Toulmin Argumentation Theory

Toulmin's Argumentation Theory defines that discussions consist of the components of Data, Warrant, and Claim to be approved as an argumentation (Verheij 2005) (cf. Figure 2). Data describes facts about a certain topic. The warrant represents the derivation from data or facts to a claim. The Claim itself is an assertion or statement. In addition, Toulmin describes the Backing, Rebuttal, and Qualifier. The Backing supports the warrant as it contains further information (Lewiński and Mohammed 2016). The rebuttal constrains the Claim, and the Qualifier is described as an exception. Backing, Rebuttal, and Qualifier are not mandatory for an argument but can increase its quality and reasoning.

An example of argumentation is provided with the following sentence, “Harry was born in Bermuda (D). A man born in Bermuda will generally be a British subject (W). On account of the following statutes and other legal provisions (B). So, presumably (Q), unless his parents were aliens (R) Harry is a British subject (C)” (Lewiński and Mohammed 2016).

Argumentation Theory describes sufficient arguments as coherent and reasoned (Eemeren 1995). In the domain of citizen participation on urban platforms, this can be used as a reference to estimate and encourage citizens to submit comprehensible and transparent contributions to support Design Science (Kusumastuti et al. 2022), as argumentations (contributions) that are not comprehensible and incomplete might only be considered to a limited extent. This should be prevented in crowd-based and participatory approaches (Poorazizi et al. 2015). In on-site participation, argumentation is enabled via face-to-face discussions which are often moderated by professionals. On urban platforms, this is hardly possible as the communication can be asynchronous and depending on the number of participants and discussions, not viable with human moderators (Khan et al. 2017).

12.3 Research Approach

To examine how argumentation on digital platforms can be supported with AI, we conducted an explorative comparison of two prototypes. For this, we synthesized the existing knowledge in the domains of urban planning, Citizen Design Science, urban participation platforms, Argumentation Theory, and AI-based response systems e.g. by Lieven (2017) and Atreja et al. (2018) applied the following research design.

12.3.1 Explorative Design

Due to the lack of results in the area of AI-based feedback systems to support citizens on urban participatory platforms, we decided to follow an empirical approach, to enable an extensive elicitation of qualitative data and an in-depth discussion and analysis (Berger et al. 2018; Tremblay et al. 2010). To collect data and compare citizens' contributions, two groups of different participants who are conducting the same task on two different prototypes as shown in Figure 3, are analyzed.

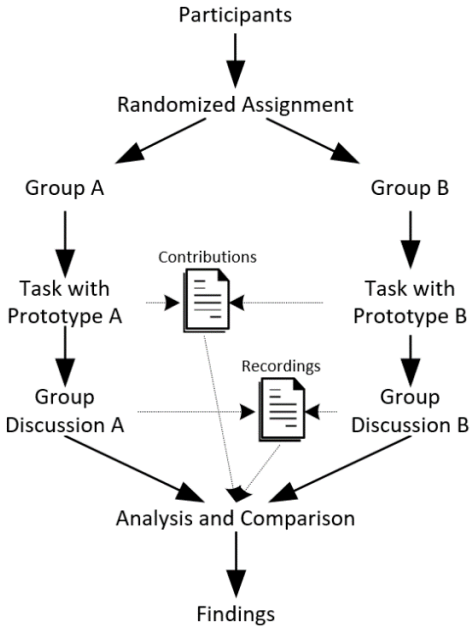


Figure 3. Explorative Design

All participants are randomly assigned to group A or group B by using a web-based program, to prevent arrangements under the participants (Dennis and Valacich 2001). In addition, both groups should contain the same or similar number of participants to prevent data biases (Levy and J. Ellis 2011). After the assignment, both groups receive the same description of a fictional urban project which is comparable to a real urban project containing information about the projects idea, location, and further specifics to define its scope and the objective of the participation (Repette et al. 2021; Stelzle et al. 2017). The prototypes of the groups vary. Both are representing the same part of an urban platform including the mentioned descriptions and guiding criteria, but only prototype A contains an implemented AI-based feedback system as we want

to examine its influence on the contributions (cf. Figure 3). The feedback is a response to the contribution and is intended to increase the interaction between the human and the machine to simulate a content-related exchange. The task of the participants is to participate and contribute their requirements, ideas, and visions as conducted on urban platforms. For this, the participants have up to 20 minutes.

During the processing of the task, all submitted contributions are stored by the prototypes. After the processing of the task, each group discusses the use of the prototype concerning the AI-based feedback system (group A) and a theoretical application (group B) by using guiding questions to examine additional functions, alternative designs, and further feedback systems. Both discussions are recorded to enable a systematic evaluation and analysis in which prototype B is used as a baseline, as it represents the existing participation on urban platforms, while prototype A serves as an extension, to explore the impact and influences of the AI-based feedback system.

12.3.2 Analysis of the Data

The stored participants' contributions and recorded data are systematically analyzed by applying the structured content analysis after Mayring (Mayring and Fenzl 2014). The contributions are examined deductively concerning the components of Argumentation Theory (Lewiński and Mohammed 2016), as described in Section 2.3, by marking all related paragraphs which enables a systematic comparison of the contributions of both groups.

Furthermore, the group discussions are analyzed by applying Maying's summarization as a deductive-inductive approach to reduce the discussion to key statements (Mayring 2014) and to examine the use and perception of the AI system, as well as further adaptions. The deductive categories are specifying the participants' perceptions and are:

1. Impact of (the) feedback on argumentation
2. Perception of the feedback
3. Design of the prototype

Both systematic content analyses are conducted by using the application MAXQDA which is developed and widely used for quantitative analysis with e.g. text, spoken language, and/or videos, and supports systematic comparisons and visualizations of data (Rädiker and Kuckartz 2019).

12.4 Development

Both prototypes were developed as web applications using XHTML for the front-end and Java for the middle-end to implement the AI-based feedback system and to store

all submitted contributions with the session ID and time in a CSV file to enable the evaluation of the contributions over time.

12.4.1 Design of the Prototypes

The front ends were developed concerning existing urban platforms and recent research (Borchers et al. 2022) but do only contain a minimum of the functionalities to focalize the impact of the AI-based feedback system. The contributions are text-based, as it often applies in urban platforms, and are entered in a text field (Steiniger et al. 2016). Prototype A evaluates the participants' contribution by including the six categories Public Services and Safety, Mobility and Accessibility, Living and Social Networks, Education and Labor Market, Recreational Areas and Green Spaces, and Economy and Innovations (Vasudavan and Balakrishnan 2019). Categories or further suggestions are commonly part of urban project description, to inform participants about possibilities, provide orientation, and clarify the scope of the participation (Repette et al. 2021; Stelzle and Noennig 2017). Figure 4 shows the graphical user interface of prototype A including an exemplary participant contribution. The participants of group A can experience the AI-based feedback system by using the Analyze contribution button and can incorporate the feedback into their contributions but are not forced to do so. Therefore, the feedback is not estimated continuously, but immediately whenever a participant requires it. The further buttons can be used at any time to save the contribution, as a minimum length is not required, or to delete it (Ertiö 2015).

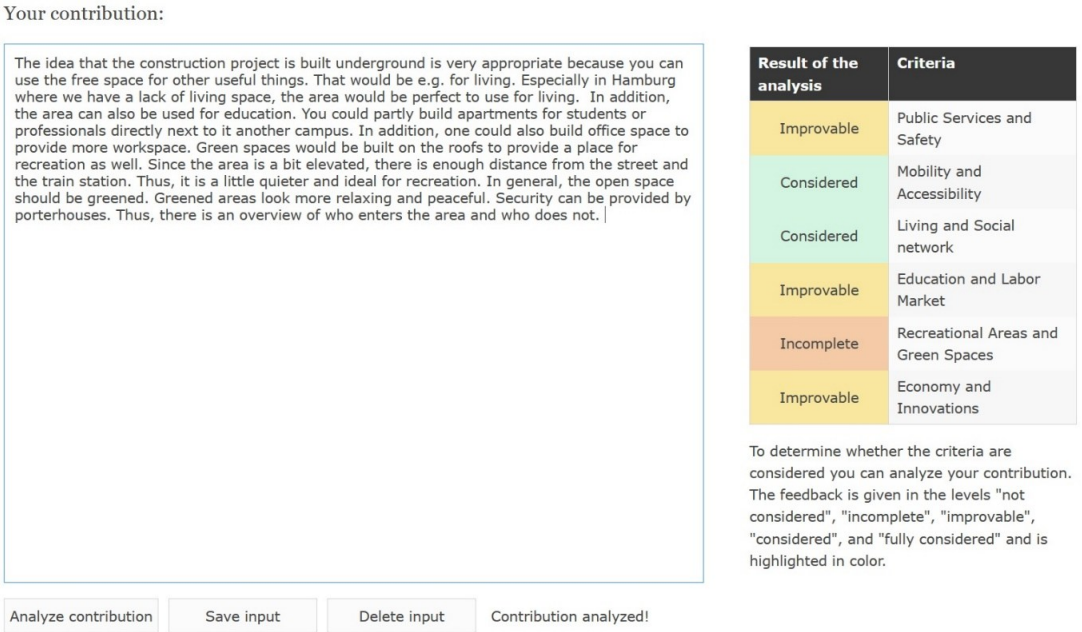


Figure 4. Graphical User Interface of Prototype A

Prototype B for group B is designed similarly to prototype A but does not contain the AI-based feedback system. Therefore, column Results of the analysis, the description below the table, and the Analyze contribution button (cf. Figure 4) are missing. The

categories of column Criteria remain, as this provides orientation and the differences between the prototypes should be as minor as possible to focus on the impact and influence of the AI-based feedback system. Above the input field of both prototypes, the descriptions of the task and fictive urban project are placed. All contributions were stored in a CSV file including the timestamp and session ID whenever a button was used.

12.4.2 AI-based Feedback System

To estimate if a citizen contribution is considering the criteria sufficiently we are using the machine learning model Global Vectors for Word Representations (GloVe) from Stanford University (Penningtin et al. 2019). Therefore, all textual inputs are converted into word embeddings e.g., word vectors, and then compared by an algorithm to six reference sentences that can be easily replaced and of which each is representing the content of one of the six criteria. The comparison is conducted using the cosine similarity and the length of the contribution to estimate, which category was considered to which degree (Lieven et al. 2021). The feedback for each category can be not considered, incomplete, improvable, considered, or fully considered. An extensive argumentation on the content of a category is therefore classified as fully considered as it is addressing the prescribed content and is of sufficient length. The five-stepped feedback was chosen, as it is intuitive and comparable to the widely known Likert scale (Hartley 2014). In addition, this approach supports, that participants do not reach the middle or highest feedback with their first contribution, as it would be possible with a three-stepped scale which could shorten or end the participation as the participant already reached the highest feedback. We suppose that the participant will be encouraged by the feedback to submit more argumentative and comprehensible contributions and that this approach is more intuitive than implementing a feedback system that responds with the elements of the Argumentation Theory, as most participants would not be familiar with it.

12.5 Evaluation

The exploration (cf. Figure 3) was conducted with a total of 16 participants who were asked if they possess a basic or higher level of media capabilities and can operate a laptop with a keyboard without further support. All participants approve that, as required as we wanted to ensure that the results were not affected by a lack of media capabilities.

All participants were between the ages of 18 and 22 and they were randomly divided into two groups of eight participants. The average age in group A was 19,625 (male=6, female=1, divers=1) and in group B 19,75 (male=7, female=1). All participants were from Germany, and we cannot exclude cultural differences due to a lack of diversity which also applies to the age. We consider this to be acceptable

since the focus is on the perception and the influence of the AI-based feedback concerning the argumentation, and possible hypotheses which can be verified later with e.g. quantitative experiments.

Each participant received an equal convertible device to conduct the task, as described in Section 3. The prototypes for the participants in each group were already opened in a web browser. All participants had 5 minutes to read the task and to ask questions for clarification, which was not required. Afterward, all participants had up to 20 minutes to conduct the task and submit their contributions to the fictitious urban project. Afterward, each group discussed their prototype in terms of functionalities and perceptions of the AI system (group A) or a possible feedback functionality (group B) and further supporting elements. The group discussions were moderated by the authors using guiding questions.

We planned 45 minutes for the discussion and required 47 minutes in group A and 40 minutes in group B. The audio was recorded in both groups, transcribed, and analyzed by the authors together with the stored participants' contributions by using MAXQDA. In total, we marked 294 paraphrases according to Mayrings' qualitative content analysis (Mayring 2014). Of these, 56 markers are allocated to the group discussions and 238 to the participants' contributions.

12.6 Findings

The discussion of the prototypes reveals that the opinions of the participants diverge and that the predefined feedback categories can be double-edged. The left side of Figure 5 represents group A and the right-side group B. The numbers indicate the amount of deductively marked paraphrases and are summed up in the hierarchies above (Mayring 2014).

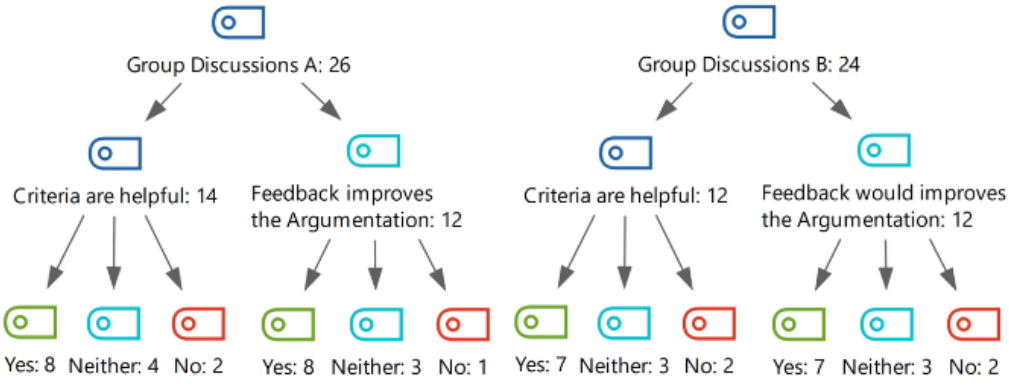


Figure 5. Comparison of Group Discussions

The discussion of whether the *criteria are helpful* was in terms of marked phrases similar, but in terms of content quite diverse. Both groups described the criteria guide as the participants immediately have some thoughts about them in mind which most of the participants also included in their contributions. In addition, both groups

mentioned (A n=4, B n =2), that the criteria are imprecise and thus it is necessary to think about them and to assume what the urban projects responsible had in mind (Stelzle et al. 2017). This promotes argumentation and supports the development of ideas as the criteria are interpreted individually which can support the diversity of the contributions, as citizens consider them from their life perspectives (Caliskan 2012). However, two participants in group A and four in group B mentioned, which was marked with neither, that as the criteria are defined imprecisely, they are not supportive, but as they can be ignored also do not affect the citizen negatively. Furthermore, two participants in group A and two in group B described the criteria as not helpful as they are too unprecise, can confuse participants, and are influencing and pushing the participants in a certain direction, which enables manipulation and could lead to the rejection of the urban project and participatory approaches (Arana-Catania et al. 2021).

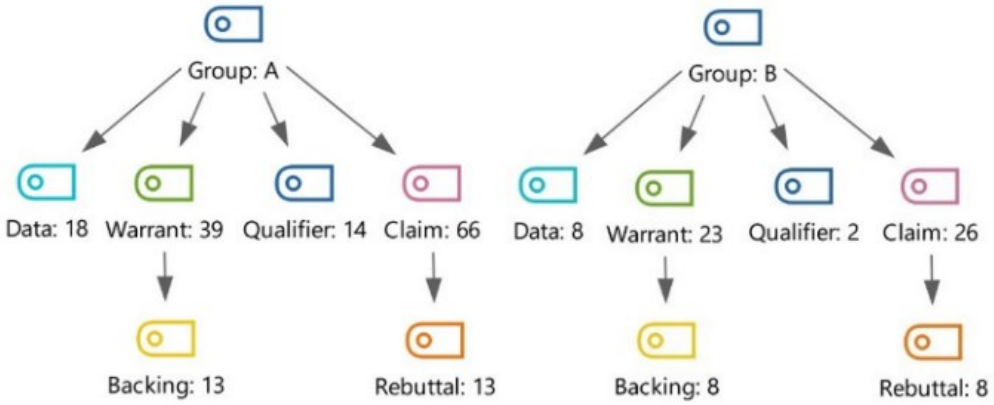


Figure 6. Comparison of Participants' Contributions

The discussion in group A, if the *AI-based feedback is improving the contributions* exhibits, that at the beginning of conducting the task many participants were critical about the feedback system, but as the usage is quite easy and intuitive, have tested it. For this, some participants duplicated text or copied the urban projects and task description, to evaluate how the feedback changed, and the AI model estimates the criteria, as far as possible. Most of the participants in group A tried to reach the highest response and considered this a challenge, as they were curious about what had to be submitted to reach the highest feedback. This encouraged the participants to submit and analyze many contributions. On the other hand, if the feedback is perceived as a challenge, participants may only submit desired content to reach a high response without concerning what they really need and require as citizens and how they can be affected positively or negatively by the urban project. Less participants agreed on that, but all participants confirmed, that it is mandatory to be able to submit contributions at any time independently of the feedback to ensure, that everybody can participate. In addition, this also enables citizens to express their disinterest in certain topics by not considering them. In group A three participants think, that the feedback improves their contributions, two answered neither, and three do not think, that the

feedback positively influenced their contributions. The discussion in group B was similar, and two participants answered with yes, three with neither, and three with no (cf. Figure 7). The participants in group B also describe, that it is important that contributions can be submitted at any time without concerning the feedback, as this otherwise would exclude citizens with fewer requirements and ideas. Furthermore, the feedback should be automated to receive it immediately and group B agreed, that manual feedback by experts would not be sufficient, as they argue that this approach would be too costly and is increasing responding time which could end the participation, as many citizens are not willing to wait (Krätzig and Warren-Kretzschmar 2014). The analysis and visualization of the participant contribution of both groups by applying the elements of Argumentation Theory are shown in Figure 6. In the contributions of group A, 163 phrases were marked, and in group B 75. The average length of a contribution in group A is 217,5 and the total amount of words is 1.740 (71,14 %). In group B the average length is 88,25 and the total amount of words is 706 (28,86 %).

The comparison of the participants' contributions concerning Argumentation Theory (cf. Section 2.3) highlights, that the quality of argumentation in group A is higher than in group B as, the participants submitted more comprehensible contributions with further Data, Warrants Qualifier, and Claims. However, the documentation of Data is still quite low which can be explained, as the participant were non-experts in urban planning and design and therefore are not aware of e.g. studies and would have a higher effort to search, read and mention them in their contributions (Münster et al. 2017).

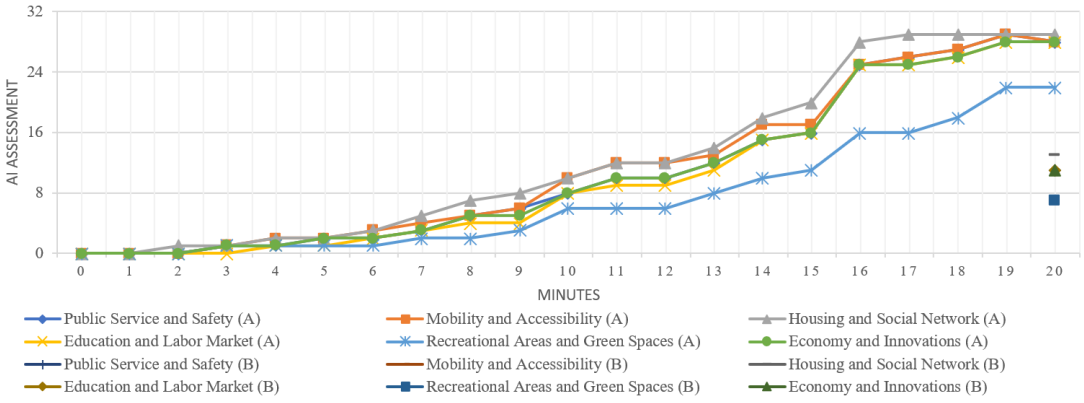


Figure 7. Development of the Argumentation in Participants' Contributions

The analysis of the development of the contribution over time is shown in Figure 7. The vertical axis *AI Assessment* shows the estimation by the implemented AI-based feedback system for each category for all participants of group A and group B. The maximum of the estimation for a category is 32, as the five-stepped scale begins with *not considered*, that is concerned with 0, up to *fully considered*, that is considered with 4, and reach, multiplied by the number of participants a maximum of 32 for each predefined category. The contributions and their estimations in group A were stored

every time a participant used the analyze button (Analyze contribution) to get feedback. This enables the visualization of the development of contributions from group A over time. In group B, the contributions were only stored at the end of the conduction of the task when the participants submitted them. Therefore, Figure 7 shows the development of the contributions of group A and the final contributions of group B, which were evaluated afterward by the AI-based feedback system Figure 7 highlights, that the estimated feedback of the participants is overall continuously increasing, and that this development is enhancing from minute nine. This corresponds to the mentioned evaluating phase of the feedback by the participants which was described in the discussion of group A. In addition, this also applies to the continuous increase after minute nine, as most participants wanted to achieve the highest feedback for all criteria. In the group discussions, the participants were inconclusive about the influence and support of the A-based feedback. The estimated contributions of group B are shown on the left of Figure 7 and emphasize, that the feedback system had a huge impact on the participants' contributions, as the average estimation of all criteria in group A is 21,17 and in group B 10,67. This indicates, that the developed AI-based feedback is supporting the citizen to write more argumentative and comprehensible contributions. This also corresponds to the findings of Figure 6, even if the difference in argumentation is slightly and only deviates strongly considering the number of claims (cf. Figure 7).

12.7 Conclusion

In this paper, we examined how an AI-based feedback system can increase citizens' argumentation on urban participatory platforms. To do so, we implemented two prototypes as a representation of urban platforms and developed an AI-based feedback system corresponding to the Citizen Design Science model, Argumentation Theory, and scientific literature about urban platforms and AI (Arana-Catania et al. 2021).

The systematic comparison of the prototype with (group A) and without (group B) the AI-based feedback system indicates that the AI-based feedback system support citizens to contribute more comprehensible and argumentative contributions which are highlighted by the comparison of the contributions of both groups (cf. Figure 5). The contributions of group A are twice as long as in group B and the argumentation is increased, especially concerning the number of claims (cf. Figure 7). Therefore, we hypothesize that there is a correlation between the developed AI-based feedback and argumentation in citizens' contribution which is advocated by the feedback, and the associated content exchange and reconsideration.

Due to the quantitative approach, the limited number of participants, and the low diffusion of gender and age, we cannot determine the presumed correlation.

Furthermore, alternative and better for example question-based feedback and support systems are possible which could be based on chatbots. However, our findings reinforce the impact of the implemented AI-based feedback system which now should be validated in a quantitative experiment.

With our findings, we contribute and provide initial knowledge about how AI-based feedback systems for urban planning participation should be designed to encourage citizens to contribute more argumentative and comprehensible contributions. In addition, we summarized the benefits and challenges and described the potential for manipulation through criteria (Murphy and Hands 2016). Our findings are of relevance to AI, urban planning researchers, and urban experts like architects and planners and can be used as a baseline to develop extended and alternative systems to enhance citizen contributions on urban planning platforms in comparison to the described system.

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13 Publication C4: Let Citizens Speak Up: Designing Intelligent Online Participation for Urban Planning

International Conference on Design Science Research in Information Systems and Technology (DESRIST)

Track: DSR for a Resilient World
Completed Research
Ranking: B

Research Question

How can AI-based feedback system increase citizens' argumentation on urban participation platforms?

Contribution to the Dissertation

This publication contributes to the overall RG, especially RQ1, by describing the design of a web prototype that supports citizens in submitting their contributions by adding an interactive questioning mechanism. In doing so, the publication also contributes to RQ2, as the feedback analyzes the submission with respect to considered and not considered topics, which are stored in a flexible matrix in the backend. Furthermore, the publication describes ten issues, ten meta-requirements, and four design principles that were extended to six due to the evaluation.

Citation

Borchers, Marten; Gierlich-Joas, Maren; Tavanapour, Navid; & Bittner, Eva (2024). Let Citizens Speak Up: Designing Intelligent Online Participation for Urban Planning. In: *19th International Conference on Design Science Research in Information Systems and Technology* (DESRIST). https://link.springer.com/chapter/10.1007/978-3-031-61175-9_2. Completed Research.

Abstract: *Urbanization and the transformation toward sustainability pose new challenges to governments, leading to an increase in citizen participation in urban planning. Due to the demand for scalability, urban participation is often conducted online. However, past projects showed that the asynchronous and impersonal exchange reduces the value of citizens' submissions as inquiries are omitted. Thus, this study investigates how to design an IT artifact to support citizens in contributing to online participation in urban planning projects. To do so, we initiated a design science research project. We analyzed the literature to define issues, formulate meta-requirements, and derive design principles to develop and qualitatively evaluate an AI-based prototype that enables immediate responses to citizens considering their contributions. This study contributes to the field of information systems with prescriptive knowledge. Furthermore, this study can guide practitioners in citizen participation in urban planning in building and utilizing digital tools to support citizens in contributing to subsequent processes.*

Keywords: Online Citizen Participation, Urban Planning, Artificial Intelligence, Design Science Research

13.1 Introduction

Governments are confronted with enormous challenges like urbanization [62] and the transformation toward sustainability due to climate change [42], which are affecting the way how we build and live [56]. As many authors describe, acceptable and feasible solutions that provide public value are required [48]. To achieve that, many scientists, governments, and citizens argue to include citizens' opinions through participation [56], which led to an increase in online participation during the last decade [1] for urban planning. This and the demand scalability led to the development of urban participation platforms, like Decidim Madrid [52] and CONSUL [55]. Besides the many advantages, online participation is not comparable to on-site face-to-face participation [43, 64]. Due to asynchronous communication, citizens can participate over several weeks, which reduces interactions due to a lack of immediate response and exchange [54, 57], resulting in insufficient and vague contributions [50]. This aggravates public value creation in decision-making processes for urban planners and public authorities if citizens' needs and requirements are difficult to understand and can be misinterpreted [56]. The financial and political consequences of this are high and can result in a loss of trust [33]. Therefore, comprehensive information about the needs and requirements of citizens is crucial for urban planning projects. Few prior works have considered interactive approaches, like conversational agents and recommendation systems based on artificial intelligence (AI) in urban planning [40, 51]. However, the existing solutions do not overcome the described issues, which is why we propose the following research question (RQ).

RQ: How to design IT artifacts to support citizens in contributing in online participation projects in urban planning?

To address the RQ, we initiated a design science research (DSR) project following the framework by Kuechler and Vaishnavi [36] and described the findings of the first cycle in this paper. The related work Section describes the state-of-the-art in citizen participation in urban planning, including the use of AI (cf. Section 2). Next, we emphasize our research approach and specify the first DSR cycle (cf. Section 3). In awareness of the problem, we describe the identified issues (cf. Section 4) followed by the Section suggestions, in which we condense the issues into meta-requirements and derive design principles (cf. Section 5). The instantiation of the design principles in a feasible prototype is described in Section 6 and evaluated as described in Section 7. Afterward, the findings are discussed, considering the theoretical and practical contributions (cf. Section 9) and finally summarized (cf. Section 10).

13.2 Related Work

13.2.1 Online Participation in Urban Planning

Urban planning has historically been a non-participatory process. However, as cities grow in size and complexity, so does the need for participation. Citizen participation in urban planning aims to enable citizens to contribute to urban projects with their opinions, requirements, and ideas [58], further referred to as contributions [12], to develop and shape urban project's visions and subsequent decision-making processes [11]. The approach, strategy, and participation plan depend on the responsible parties, e.g., governments, institutional investors, or private individuals. The impact of citizens on the project varies [7] and often follows predefined objectives [56]. These do not necessarily originate from social responsibility or grassroots democratic ethos and can merely follow economic interests [11], as public or political resistance can delay or prevent urban projects, reducing the return on investment [56]. At the same time, citizen participation can increase the project's value and real-world benefits for locals and whole cities, improving its overall acceptance and reducing risks [9]. Citizen participation can be conducted in analog, digital, or hybrid forms [57]. The last two correspond to electronic participation (e-participation), which the United Nations defines as" the process of engaging citizens through ICTs in policy, decision-making, and service design and delivery to make it participatory, inclusive, and deliberative" [62]. Thus, e-participation can also occur on-site with workshops or town hall meetings if they are enabled and supported with digital tools such as touch tables [40] and virtual or augmented environments [45]. Online participation, on which we focus in this work, is a subset of e-participation, where participation is mediated via the internet [57]. It is often achieved with websites and urban participation platforms [21], especially in the case of extensive citizen participation initiatives with several thousand participants, as described by Royo et al. [52].

13.2.2 Artificial Intelligence in Urban Planning

Online participation omits face-to-face interactions, relies on asynchronous communication, and usually does not have ubiquitous moderators and urban experts [52, 57]. This often reduces the submission of comprehensive and understandable citizen contributions. One approach to address this is to increase information exchange and the elaboration on contributions comparable to human-to-human interaction by utilizing AI [51], by providing immediate responses [13, 51]. Interactive systems and conversational agents like chatbots [68] can replace humans under certain conditions [66]. They must be able to accept inputs and should respond to support interaction and the exchange of content [12]. This requires a procedure for analyzing content and deciding on appropriate responses like questions or hints [60]. Besides this, recent projects have examined how AI can support online discussions in urban planning via content analysis to identify hate speech and conduct fact-checking [30]. This also applies to the possibilities of summaries of citizens' contributions for subsequent processes of urban experts by automatically linking and merging similar content [44]. Bachiller et al. [8] focused on visualization and used clustering to identify citizens' interests connected to specific districts to highlight differences. In Spain, a study has examined the participants' interest in urban projects with AI on the participation platform DECIDIM Madrid to recommend and advertise further projects to increase online participation [22]. Also, chatbot systems were examined to support citizens via dialog flows [68]. Most examples have focused on approaches to automatically analyze citizens' contributions concerning their content to identify specifics, visualize patterns, and support moderators and subsequent processes. However, they do not address the challenge of supporting citizens during their participation and the process of contributing to urban planning projects.

13.3 Research Approach

To answer the **RQ**, we conducted a DSR project according to Kuechler and Vaishnavi [36], as illustrated in Figure 1. For the step awareness of the problems, a structured literature review following the approach by Kitchenham, including the steps of identification of research, study selection, quality assessment, data extraction, and data synthesis [34], was conducted to identify issues, formulate meta-requirements, and derive design principles [35]. We used these to develop a web-based prototype, which we evaluated qualitatively by conducting two focus groups, including guiding questions and a SWOT analysis to identify strengths and weaknesses of the instantiated prototype and the potential and risks of its usage in online citizen participation in urban planning.

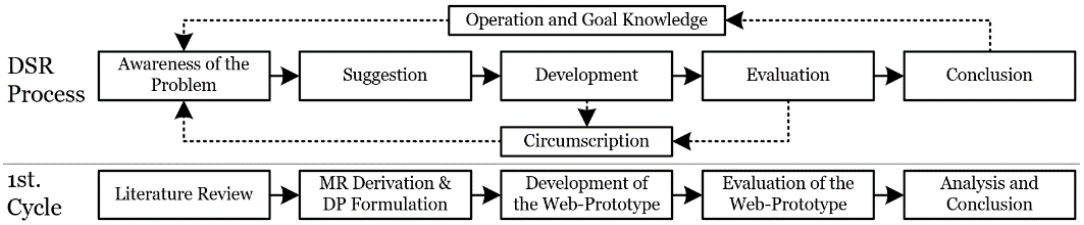


Figure 1. General and conducted Design Science Research Process

13.4 Awareness of the Problem

In the systematic literature review, we focus on the libraries of Springer Link, the Association of Information Systems (AIS), ScienceDirect, and the Association for Computing Machinery (ACM) to consider information systems, computer science, and economics findings. The applied search string is ("challenges") AND ("online citizen participation") AND ("urban planning participation"), and we focused on the recent findings of the last three years [34]. The search provided 410 results, of which 290 originated from Springer Link, 113 from AIS, five from Science Direct, and two from the ACM library. We excluded all publications that were not accessible, duplicates, and unrelated to the RQ. The remaining 35 publications were analyzed to identify issues (ISS), which we inductively clustered as shown in Figure 2).

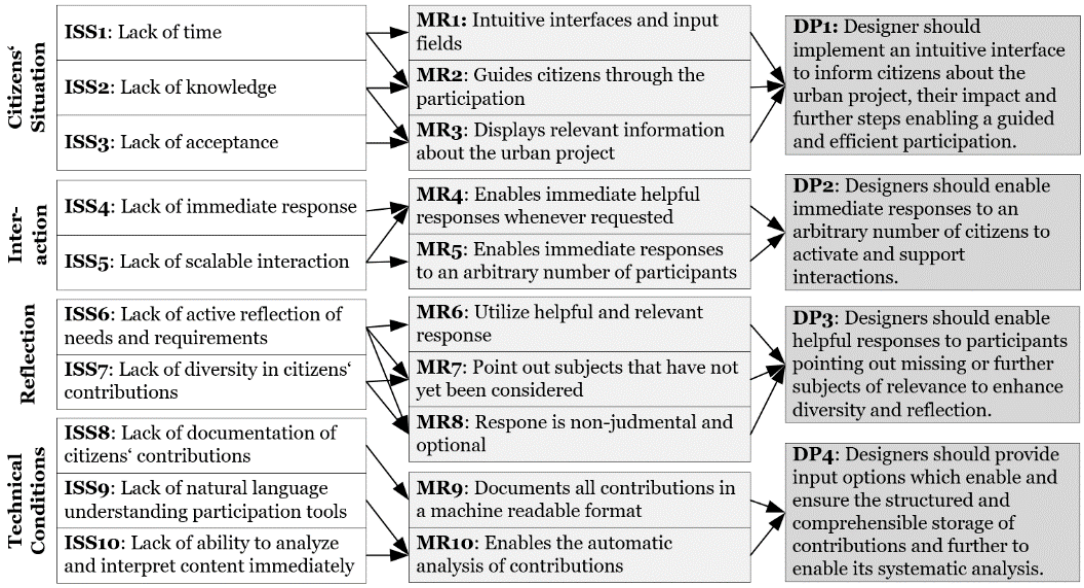


Figure 2. Issues (ISS), Meta-Requirement (MR), and Design Principles (DP)

The cluster citizen's situation shows that many citizens lack the time (ISS1) to be informed and participate [9, 31, 41], even if they are aware of the project and their influence [20]. Another challenge is the lack of expertise and knowledge, as more time would allow participants to inform themselves better and can prevent citizens from participating as they do not feel comfortable submitting meaningful contributions [4, 49]. Therefore, citizens should be informed during the participation about their possibilities and the project to overcome the lack of knowledge (ISS2) [9,

16, 33, 39, 49, 70]. This also affects advertising campaigns before and during the participation, which is attributable to a lack of acceptance of urban projects (ISS3) [9, 24, 28, 33, 43, 49, 69], as citizens are often unaware of their impact and the chance of co-developing their living environment. This is enhanced if the participation objective is unclear or irrelevant for them or if citizens mistrust the initiator due to intransparent processes, which can create the impression that their contributions do not have any influence [6]. The literature describes a lack of immediate responses for the cluster interaction process, as online surveys do not provide any human-to-human interaction. This also applies to participation platforms and is argued with the absence of moderators due to the costs and the not bearable workload in large participation [40] and present participants because of the asynchronous communication and duration of several weeks, which increases waiting times for feedback and comments (ISS4) [3, 10, 12, 20, 23, 25, 64, 67]. This is also affected by the number of participants, which can vary from less than a hundred to thousands and approximates to a lack of scalable interaction (ISS5) [14, 32, 46, 70]. Another challenge is the reflection on and elaboration of citizens on their contributions. In on-site participation, moderators and immediate exchange support the reflection of needs and understanding, which enables compromises. In online participation, responses, if available, often lack this (ISS6) [1, 4, 14, 15, 17, 18, 41, 42, 48], but is highly relevant in one-sided discussions in which a popular opinion is shared without critical questioning and reflecting needs and individual situation (e. g. age, gender, wealth), which can be exhausting and time-consuming. If this is not noticed, discussion and whole participation can lack diversity in opinions and contributions (ISS7) [2, 39, 53], described by the cluster reflection. Considering the technical conditions of participation, the literature states that the lack of documenting citizens' contributions (ISS8) needs to be overcome [3, 19, 47]. However, this mainly applies to on-site participation, in which oral communication dominates. Due to the amount of data, digital participation is often grounded on scale-based queries and yes and no questions. However, to enable automated responses and in-depth text-based exchange to support interaction and reflection, online participation tools have to overcome the lack of natural language understanding (ISS9) [22, 63]. This also is a prerequisite to overcome the lack of analyzing and interpreting content (ISS10) [5, 37] to enable content-based responses, as highlighted in the literature by Romberg et al. [51] and Cai et al. [13].

13.5 Suggestion

All issues were discussed to formulate meta-requirement (MR) and derive design principles (DP) [27], as shown in Figure 2. Together, they initially describe the design of IT artifacts responding to the RQ. ISS1, lack of time, affects information and participation itself. Therefore, digital participation should be intuitive (MR1),

removing settling-in and long reading times. This should be supported with guidance (MR2) and precise, relevant information (MR3). MR1, MR2, and MR3 consider citizens' situation and are reflected in DP1: "Designer should implement an intuitive interface to inform citizens about the urban project, their impact, and further steps enabling a guided and efficient participation". ISS4 and ISS5 address the lack of immediate responses and scalability, which led to MR4, which demands that responses be provided whenever requested to increase interactions. MR5 addresses the scalability of this approach, as this should be applicable to an arbitrary number of participants simultaneously, which led to DP2: "Designers should enable immediate responses by the IT artifact to an arbitrary number of citizens to activate and support interactions". ISS6 and ISS7 address citizens reflecting and elaborating on their contributions, which led to MR6, MR7, and MR8. MR6 specifies that the response should be helpful and is based on ISS6 and ISS7. MR7 specifies that missing subjects of the urban project should be pointed out to support diversity and reflection. Both should be non-judgmental and optional (MR8) to not discourage participants, which leads to DP3: "Designers should enable helpful responses to participants pointing out missing or further subjects of relevance to enhance diversity and reflection". ISS8, ISS9, and ISS10 address technical lacks, leading to MR9 and MR10. MR9 describes that all contributions must be stored in a machine-readable format, which is crucial to enabling scalable and immediate responses (MR10). This leads to DP4: "Designers should provide input options, which enable and ensure the structured and comprehensible storage of contributions and further enable its systematic analysis".

13.6 Development

Figure 3 shows the interface of the developed prototype. It combines the design of existing urban participation platforms [52] and the idea of conversational agents to provide immediate responses to citizens whenever required while creating their contributions [40]. DP1 is instantiated with a simple and clear interface structure. It provides information about the urban project, which can be extended depending on the user's needs and the objective of the urban participation. However, the length of the description should not be too extensive, as a time-consuming familiarization with the project can be discouraging. DP2 is instantiated with the "Get Feedback" button, which participants can use to receive a response [23] (cf. Figure 3). DP3 specifies the subjects of the response by always asking one question that addresses a topic not yet considered. The text field, which can be changed in size, ensures that all data is stored (DP4). To enable content-based responses, as stated by DP2 and DP3, a systematic AI-based analysis and decision-algorithm is required. Considering existing approaches in this domain as described in Section 2.2, we decided to merge urban participation platforms and conversational agents. Urban participations are aligned with the overall project and usually focus on specific topics. Therefore, the responses

should do the same and, e.g., not ask questions about culture if the focus is on mobility. To ensure that and to enable the evaluation, we developed an AI-based prototype that analyses citizens' contributions to identify non-addressed topics to choose responding questions flexibly. To realize this, we used machine learning (ML) algorithms. ML is an AI subcategory that focuses on training models on data to enable predictions and decisions [13]. For our prototype, we used data from an existing urban planning project of a large city with a total of 2006 citizen contributions. The dataset was analyzed to define classes that apply to urban projects, which are public spaces and culture, economy and social affairs, environment and green spaces, and mobility.

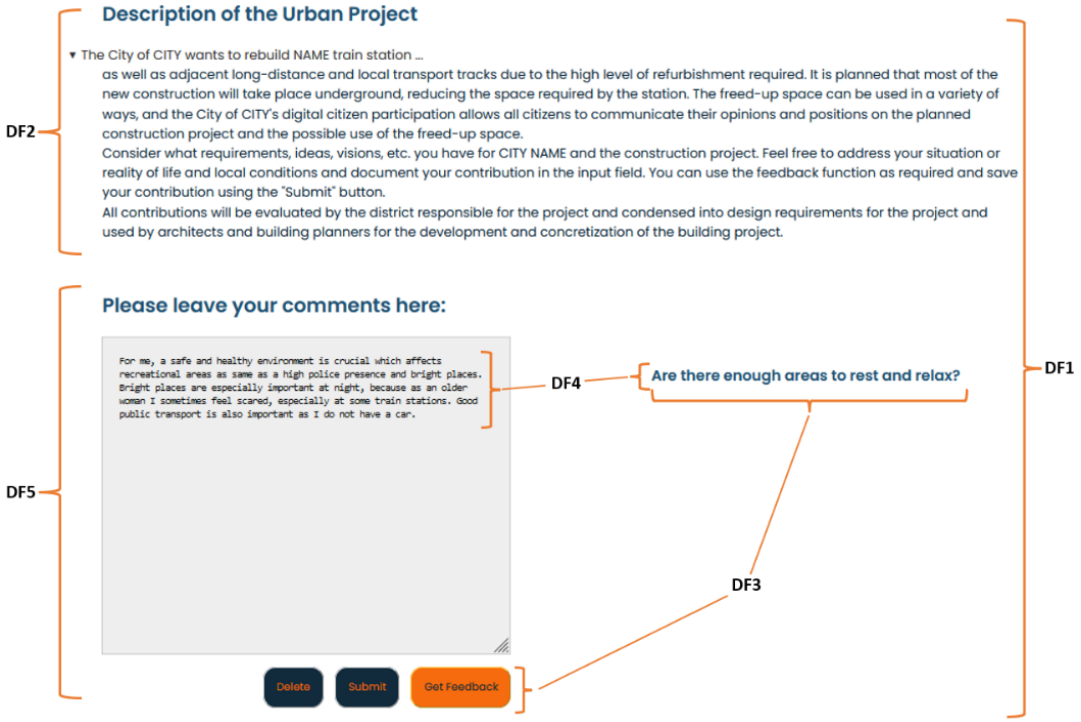


Figure 3. Design of the Prototype

The categories define possible and anticipated content and were labeled by the authors. For the training, we removed meaningless contributions and stopwords and converted these to word embeddings using the natural language processing framework spaCy [26]. For the training, we used 80% of the data and 20% for evaluating [38] and tried different ML algorithms. We reached the highest accuracy of 63% with a long short-term memory (LSTM) neural network. The reliability of the ML model is expandable, but considering the limited number of training data and the purpose of evaluating the prototype's interface, this is sufficient [29]. The ML Model classifies citizens' contributions and stores all results in a class table to determine the response. An algorithm then decides which question from a predefined catalog is chosen as the response. If two categories are equally often considered, the decision is made by chance. In addition, all questions asked are marked to prevent them from being asked more than once, as this would contradict DP3. For the prototype, we defined 24 questions, three for each class, and the prototype asked a maximum of 10

to convey a feeling of completion. If the delete button is pressed (cf. Figure 3), all background savings are deleted, and the participation restarts.

13.7 Evaluation

Following Venable et al.'s guidelines for DSR evaluation [65], the prototype evaluation was conducted qualitatively, including a pretest, to test the functionality of the AI-based response beforehand, as shown in Table 1. The participants were advertised and acquired through the university. They were citizens of an urban region and possessed media competence computers to prevent errors due to a lack of skill. No further capabilities were required as digital citizen participation is usually open to all citizens.

Procedure/Group	Participants	Male	Female	Minutes
Pretest	5	5	-	28
Focus Group (FGI)	6	3	3	56
Focus Group (FGI)	9	5	4	48
Total without Pretest	15	8	7	104

Table 1. Overview of the Evaluation

We facilitated and moderated the focus groups in our media lab [61]. Every participant received a convertible laptop to explore and use the prototype, for which we provided a fictive scenario in which all participants lived close to the urban projects' area, which also applies to a third of the participants. The scenario describes that the city is rebuilding a central overground train station underground and conducts participation to elicit requirements and ideas of how to use the new vacant area above in the future. Further details about the urban planning project were provided to specify the area in and around the train station. The guided evaluation began with the elicitation of participant data, the agreement to record the audio, and the assessment of whether all participants could operate the provided devices. All participants had 15 min to use the prototype, and afterward, we discussed their experiences using guiding questions that leaned toward the design principles and the SWOT analysis (cf. Section 3).

13.8 Findings

We identified seven strengths (S), five weaknesses (W), four opportunities (O), and four threats (T), each with a different degree of approval, which can reach a maximum of 15 (n) (cf. Table 1). The focus groups revealed that feedback in the form of questions is perceived to enhance interactions and diversity of contributions by pointing out further subjects (S1, S2, S3, and S4). The participants also highlighted that open questions are preferred over closed questions (W3), as the prototype

contained both. In addition, the participants emphasized that" the questions are helpful, but [they] are no feedback" (FGII), which supports misleading expectations and should be changed (W2). Besides that, it is still possible that participants' contributions are contrary to others, and citizens have no impression at all whether the requirements and ideas are feasible or floating in the air" (FGII).

No.		n
S1	Questions support the diversity of topics in citizens' contributions	9
S2	Immediate responses support the interaction with the IT artifact	7
S3	Questions point out unconsidered topics in citizens' contributions	7
S4	Questions always change and are never asked twice	6
S5	Large input field for the participant's contribution	4
S6	Responses can be ignored, and it is optional to use them	3
S7	Questions do not determine a specific direction	3
W1	The scenario description does not provide enough information	9
W2	The word "feedback" is misleading, as an assessment is expected	7
W3	The prototype asked some closed questions as a response	5
W4	Lack of motivational functions (gamification)	3
W5	The response button is not highlighted enough in the front-end	2
O1	More comprehensible and diverse ideas are submitted	7
O2	Citizens can contribute time- and location-independent	4
O3	Participation is scalable for an arbitrary number of participants	4
O4	AI analysis enables immediate and arbitrary responses	1
T1	Citizens' demands and ideas might not be feasible	3
T2	Citizens' demands and ideas can converse with each other	2
T3	Responses/questions can be used to influence participants	2
T4	Risk of misinterpretation of keyword-based contributions	2

Table 2. Strength (S), Weaknesses (W), Opportunities (O) and Threats (T)

Furthermore, participants want to have the "possibility to show past questions and suggested that it could be helpful always to provide a cluster of questions" (FGI), but "it should be possible to reach a natural ending of the interaction considering the number of questions" (FGI) not to frustrate participants to conclude. In addition, further information and functions such as a map, images of the project, and more textual descriptions should be provided (W1) to reduce the effort for further research and could also reduce W4.

13.9 Discussion

In the discussion, we first reflect on the evaluation's findings and then embed them in the literature on AI's role in online citizen participation in urban planning. The results of the focus group, and in particular, the strengths, confirm and emphasize the derived design principles. DP1 is supported by S3, S4, and S5, highlighting the

interaction and guidance created by the questions. However, its implementation was also criticized by W1 and W5 as the usability should be considered more extensively to increase the participant's experience, as indicated by W4 (cf. Table 2). The advantages of an increased interaction by an immediate response (DP2) are approved by S2, O1, and O2, which also emphasizes the potential for large-scale participation, which is of particular relevance for larger cities considering moderation cost as described in Sects. 2.1 and 4. DP3 addresses the helpfulness of the responses and that they point out unconsidered topics, which S1, S3, S4, S6, and S7 approve. S1 and S3 address the content of citizens' contributions, which also corresponds to S4, as they always have to differ. S6 and S7 are of minor approval, but considering existing participation platforms and the user experience, are highly relevant, as participation should be perceived as a chance to co-design their living environment in an open discourse without mandating or influencing participants' contributions to a desired direction, as described as non-participation and manipulation by Sherry Arnstein [7]. DP4 addressed the technical condition of the prototype, and its implementation confirmed it. However, alternative and additional approaches to receiving citizen contributions exist and can include pictures and audio, which would aggravate the ML-based analysis (ISS10). The discussions in the focus groups around O4 highlighted the potential for further AI models to support more complex interactions and exchanges between citizens and machines by generating individual questions, including location data and demographics if elicitated. W1 and W4 describe a major point of criticism as the information provided about participation is insufficient and should be more comprehensive, affecting DP3. Whether this also applies outside of experimental settings, where less time is available, cannot be determined conclusively. In addition, four threats were described (cf. Table 2), of which T1 and T2 highlight a fundamental challenge of online participation. Stelzle et al. [59] describe that the feasibility of contributions is challenging to assess at an early stage of urban projects. Furthermore, citizens' requirements can be considered differently by governments and public authorities, and contradicting demands correlate with the diversity of participants depending on different life situations and visions [2, 53]. Contradictions and diversity are acceptable, and their elicitation is part of participation, including the analysis and development of beneficial compromises to create public value for all. Nevertheless, W3 and T1 should be considered and solved with supplemental questions (DP3). Besides the existing design principles, the focus groups revealed the desire for more control, structure, and an overview of the questions, which results in DP5: "Designers should provide an overview of questions to support participants' control and expectation through the participation." In addition, as a result of W1 and W4, DP6 states, "Designers should provide an interactive map about the location of the urban project to enable additional interaction and provide further information to citizens supporting local references" [64]. This also includes further information about building plans, if already available. The

described strengths and weaknesses are inherent to the IT artifact and reflect the users' evaluation of the design principles. Overall, the evaluation was positive. The weaknesses defined further adjustments and will be of special interest in the upcoming design cycle, together with the two new design principles that require further evaluation and validation. Moreover, how the concerns about manipulation (T3) can be reduced needs to be investigated, which affects the IT artifact and the implementation of whole citizen participation projects [25, 39]. Citizen trust in participatory urban planning processes, quite often governmental processes, should be supported, for example, with additional information and transparent subsequent decision-making processes [56]. In addition, further and broader ML models with more categories and higher accuracy should be examined to increase reliability and responses that enable citizens to elaborate on their contributions in depth. Also, further clarification about the possibilities and use of generative AI is of interest to clarify to which degree it could support citizens [13] and if black box models are beneficial as the responses would hardly be comparable and maybe also contradictory, affecting ethical and data privacy aspects. Lastly, it should also be examined whether our findings can be transferred to hybrid and on-site participation to address further citizens and to support moderators [48, 54]. Taking the discussion a step ahead, we want to embed our findings in prior work, as many studies have highlighted the need for e-participation and AI for urban planning in the digital age [9]. They have also investigated the challenges of e-participation that are situated in a lack of interaction, moderation, and data processing [52]. We find fragmented solutions to overcome these burdens, for example, using visualization techniques and clustering [8] and recommender systems for e-participation platforms [48]. Thus, our study builds on prior works that have elaborated on the potential to use AI in e-participation but rarely implemented it. Therefore, we extend the state of literature, as our solution supports the participation phase following an explorative but structured approach. Thus, our study and the prior findings has to be interpreted in the context of interactive support systems [8, 12, 44, 52]. Looking ahead, our design principles should be considered as input knowledge for future design cycles, and we want to encourage the realization of additional and alternative IT artifacts to exploit the described strengths and opportunities and to reduce and avoid the weaknesses and threats (cf. Table 2). Further implementation, extension, and validation of the design principles are necessary to increase validity with qualitative and quantitative research, including the application in real-world projects. However, following the path of developing a novel design theory and a new class of AI-based interaction systems for online citizen participation in urban planning, this paper provides prescriptive knowledge regarding the problem space and a novel prototype that merges the characteristics of online participation platforms and conversational agents contributing to the solution space. We encourage fellow researchers to use and

continue with our findings with quantitative evaluation in the context of a real urban participation project, as they can provide additional insights.

13.10 Conclusion

In this paper, we investigated how to design IT artifacts to support citizens in contributing to online participation projects in urban planning, by applying the DSR methodology [36]. To do so, we conducted a structured literature review that resulted in eleven issues, ten meta-requirements, and four design principles. We used the design principles to develop an AI-based web prototype and qualitatively evaluated it with urban citizens to approve, disprove, and extend them. The evaluation highlighted the strength of our prototype but also underlined the demand for adjustments. This led to adaptions and two new design principles, which state that designers should add further information about the number of questions and the possibility of showing the already received ones, as well as an interactive map to support spatial thinking and the exploration of the area of interest.

The prescriptive knowledge of this paper and novel IT artifact, which combines classical characteristics of online participation in urban planning and conversational agents, contribute to the theory and practice of e-participation and the subfield of online participation in urban planning. The design principles describe a new approach to how citizens can be supported in online participation to increase interactions and content of submitted contributions to support subsequent processes. In addition, the results show that AI can support citizens in documenting and elaborating on their contributions in a scalable and efficient way. The developed design principles guide designers and urban experts in extending online participation and the existing knowledge base [13, 51].

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14 Publication C5: Toward the ML-based Analysis of Citizens' Inputs from E-Participation in Urban Planning

Pacific Asia Conference on Information Systems (PACIS)

Track: Sharing Economy and crowd-based Platforms
Completed Research
Ranking: C

Research Question

How to analyze citizens' inputs from e-participation with machine learning to support participation experts?

Contribution to the Dissertation

This publication contributes to the overall RG, especially RQ2, by describing the structure of collected data from an inductive cluster. Furthermore, the publication contributes to RQ3 by developing and evaluating clustering machine learning models. Based on this, the publication proposes a processing pipeline and a cluster hierarchy.

Citation

Borchers, Marten; Cao, Thu-Bao; & Bittner, Eva (2024). Toward the ML-based Analysis of Citizens' Inputs from E-Participation in Urban Planning. In: *Proceedings of the Pacific Asia Conference on Information Systems* (PACIS). https://aisel.aisnet.org/pacis2024/track16_shareecon/track16_shareecon/6.
Completed Research.

Abstract: *This paper explores the application of machine learning to analyze citizens' inputs from e-participation to support participation and urban experts. Through eleven semi-structured expert interviews, the collection of four datasets from past participation, and the systematic analysis of them according to the knowledge discovery in the database framework, we identified five fundamental challenges in current approaches and developed an ML-based process model for clustering citizens' inputs. To do so, we created a preprocessing and ML model training pipeline, proved its feasibility by its implementation, and described it in detail as a baseline for further research in this domain. However, comparing expert-generated clusters with those from ML models revealed some distinctions due to differing mental models emphasizing the need for further models and expert-friendly interfaces. With the developed process model, this paper contributes to the citizen design science model by offering practitioners a flexible analysis approach and guidance.*

Keywords: E-Participation, Urban Planning, Machine Learning, and Data Analysis

14.1 Introduction

Electronic participation, commonly known as e-participation (Hassan & Hamari, 2020), describes the digital participation of citizens to develop solutions collaboratively (Stelzle & Noennig, 2017). The strength of e-participation lies in its ability to involve a nearly arbitrary number of citizens, time- and location-independent, to identify and specify local challenges and problems like housing shortages, wealth disparities, and low social cohesion and to collect demands, ideas, and visions of how to solve them and to create public value (Repette et al., 2021; Stelzle et al., 2017). In the application, this is often utilized in designing urban areas, districts, neighborhoods, local spaces, and services in a user-centric manner (Falco & Kleinhans, 2018). The advantages of citizen participation and restriction by the COVID-19 pandemic have increased its application sustainably (Pánek et al., 2022) and supported the development of e-participation and urban platforms, which extend and combine digital surveys with polls, forums, wikis, discussions, and panel meetings (Royo et al., 2020).

However, e-participation platforms predominantly collect qualitative data as citizens submit texts (Royo et al., 2020). While this data offers deep insights into citizens' requirements and needs, its manual analysis requires substantial human resources and experience, which are costly and time-consuming (Larsen & Caswell, 2022). Furthermore, the manual evaluation also presents additional challenges. This includes, among other things, the absence of standards and varying levels of expertise and experience among experts, which can lead to inconsistent interpretations (Reynante et al., 2021).

Moreover, the evaluation of data in textual form, or sense-making, is a complex activity (Romberg & Escher, 2023) that should take place in the context of the

participation, its scope, local characteristics, and the demographics of the participants (Romberg & Escher, 2023). In addition, when it comes to urban planning, regulatory aspects must be considered (Steinbach et al., 2019). Nevertheless, the potential for automation and support in preprocessing and aggregating data toward information and visualizations is significant. Therefore, researchers and participation experts endorse the application of artificial intelligence (AI) and machine learning (ML) based solutions to analyze citizens' inputs from e-participations (Bachiller et al., 2021; Cai, 2021), as this could support and automate participation and further experts by increasing their efficiency and standardizing the analyzing process (Arana-Catania et al., 2021).

The domain of analyzing citizens inputs from e-participation with ML-based approaches remains largely unexplored, as indicated by a systematic literature review conducted by Romberg & Escher (2023) and Leible et al. (2022), who underscore the absence of and the need for specialized tools. Developing such tools is non-trivial, as the analysis process and use of AI must be valid and reliable (Romberg et al., 2022), which is of major importance as urban experts and governments incorporate participation results into subsequent decision-making processes, which can include initiating large and costly projects to (re-)construct urban or change governmental services and laws (Correia et al., 2023). Due to the lack of suitable AI- and ML-based solutions to support the analysis of citizens' inputs from e-participation, we examine how this process can be supported with the following research question (RQ):

RQ: How to analyze citizens' inputs from e-participation with machine learning to support participation experts?

To answer the RQ and to contribute to practice and theory, we apply an explorative approach by conducting a series of expert interviews (Meuser & Nagel, 2002) and applying the knowledge discovery framework in databases (KDD) framework. While the expert's interviews allow us to gain in-depth insights from different organizations, which serve as a baseline and support the collection of data, the KDD framework provides a systematic approach to analyze data, e.g., citizens' inputs from past participation to explore and derive new knowledge and ML models (Fayyad et al., 1996).

In this paper, we present the findings of the experts' interviews and analysis of citizens' inputs according to the KDD framework. We continue with the Section on the theoretical foundation, describing the citizen design science model and existing approaches of AI and ML in e-participation. Afterward, the methodology of conducting the expert interviews and KDD framework is described, including information about the collected dataset, their analyses, and the trained ML models. In the findings Section, we document our results. In the discussion Section, we elaborate on the implications, limitations, and future research considering the existing

knowledge base for ML-based systems to analyze citizens' inputs. Finally, we summarize this paper in conclusion.

14.2 Theoretical Foundation

Citizen participation refers to the involvement of citizens in public decision-making processes (Correia et al., 2023) so that planners and citizens attempt to reach agreements on potential projects to create public value (Ludzay & Leible, 2022). By involving citizens, decisions can be enriched with knowledge and legitimacy, and citizens can actively engage in municipal decision-making (Fegert et al., 2020). Compared to non-participatory processes in which citizens can usually only criticize the project after communicating the project vision to the public and during its implementation, participation enables early feedback (Correia et al., 2023). Therefore, negative impacts become apparent quite late, which increases the cost of changes and might reduce political reputations (Münster et al., 2017). In addition, citizens can delay projects with complaints and legal action. Participation can reduce these risks and, in addition, increase the public value and usage in terms of buildings, which is why (e-)participation is beneficial from democratic and economic perspectives (Müller-Seitz et al., 2016).

Conceptualizations and formalizations of participation can be dated back over 60 years to Arnstein's (1969) letter of citizen participation and the nowadays widely used citizen design science model (Mueller et al., 2017), which describes three interdependent dimensions of citizen participation (Mueller et al., 2017).

14.2.1 Citizen Design Science Model

The citizen design science model includes the three aspects of citizen, design, and science, resulting in the dimensions of citizen science, citizen design, and design science. It can be used as a toolkit to plan and implement citizen participation in urban planning (Mueller et al., 2017).

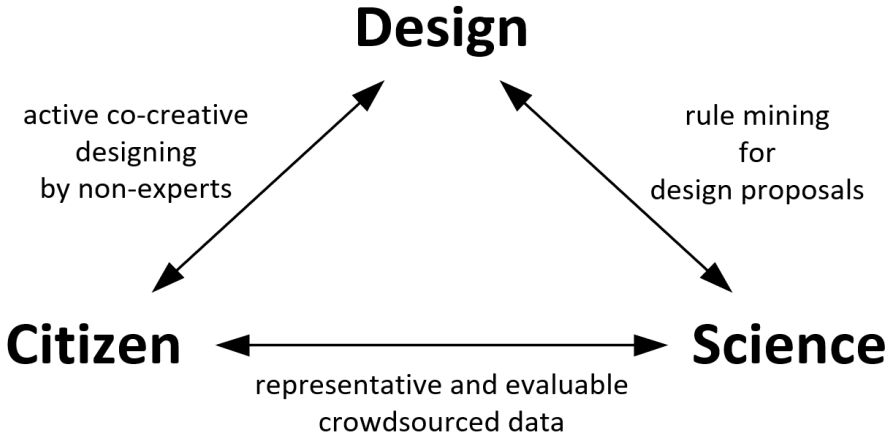


Figure 1. Citizen Design Science Model according to Mueller et al. (2017)

14.2.1.1 Citizen Design

Citizen design determines how citizens actively contribute to a design by being designers and co-authors of a project. In the case of e-participation, this can, for example, address the design of an urban project's vision, e.g., future buildings or parks (Mueller et al., 2017) or public services (Correia et al., 2023). However, design science is not limited to digital approaches and can also be applied in on-site, analog, digital, and hybrid scenarios (Stelzle et al., 2017). The contribution, e.g., citizen inputs can be textual and visual, and various approaches were explored in past projects in which participants described parks, buildings, or entire districts on paper, digital whiteboards, mobile and stationary devices textually or in 2D or 3D maps (Borchers et al., 2023; Falco & Kleinhans, 2018). Therefore, citizen design addresses how citizens contribute to the design in terms of a project outcome and vice versa, in terms of the provided possibilities and functionalities of the co-creative scenario and tool. For this, numerous possibilities exist, as summarized in a database for participation methods in urban development by Stelzle & Noennig (2017) and applied in many projects as described by Becker et al. (2022) and Katmada et al. (2022).

14.2.1.2 Design Science

Design science describes the interface between the aspects of design and science and focuses on extracting knowledge from citizens' inputs to create requirements to support architects and planners in designing the project's objective, e.g., a park or community place (Altrock, 2022). Past projects showed that transferring the contributions into a specified project's objective is more advanced than anticipated and that the meta-requirements of the urban projects and the technical participation approach and data analysis should be determined before participation to ensure feasibility (Repette et al., 2021). However, it is not clear how citizens' inputs from e-participation can be analyzed and translated into the language of designers and how it can be ensured that local knowledge is used and respected (Romberg & Escher, 2023).

Especially in digital participation, this is crucial, as moderators and experts cannot inquire to clarify and elaborate on comments, while in on-site participation, they can do this immediately due to the face-to-face situation (Bjørgen et al., 2021). Therefore, in partly and fully digital participation, where the dialogue is digital and direct communication between designers and moderators is not given, the chosen tools specified by citizen design and the analysis of collected data, as highlighted by design science, needs to be determined and harmonized so that it is possible to make sense from and extract information for the participation from a nearly arbitrary number of citizen inputs (Arana-Catania et al., 2021). These concerns file formats (e.g. Excel,

JSON, CSV) in which citizens' inputs are documented and specifications about how collected data is analyzed, including manual and especially automatic processes (Cai, 2021; Rzeszewski & Orylski, 2021). Therefore, design science is the focus of this paper due to its relevance to analyzing citizens' inputs as described by the **RQ**.

14.2.1.3 Citizen Science

Citizen science describes the interSection between citizens and science, expressing the contribution of individuals to scientific challenges. Historically, this often presented itself as an opportunity to gather information about complex urban challenges that could not be analyzed and simulated due to limited computing power or missing data. In highly modernized cities, this aspect tends to diminish as smart cities collect and provide a wealth of data (Smith & Martín, 2021). Nonetheless, this data is often incomplete, prompting citizens to contribute information through their participation in engagements, such as urban behavior and movement patterns, to inform assumptions and ultimately plan user-oriented land and building use, thus actively contributing to science (Bonney et al., 2009). In architecture and urban planning, this is utilized, for example, to address the unresolved task of describing clear and universal criteria for quality of life in cities. This problem is challenging because there is no clear definition of this term, and it can have different meanings for people from various regions and cultures (Amado et al., 2010). Therefore, citizen science addresses how citizens can contribute to science and vice versa in the context of the project, e.g., participation and its application in urban planning, and further is relevant, as past projects have shown that this can lead to win-win situations (Riesch et al., 2013).

14.2.1.4 Citizen Participation in Urban Planning

The citizen design science model can be instantiated on the process level with the minimum viable process as described by Stelzle et al. (2017) and summarized in Figure 2.

The process begins with (1) initiate the urban project by the project owner. In the (2) co-brief the client's requirements and goals are discussed, documented, and prioritized with various stakeholders, which includes professional designers, planning authorities, and the public. This lays the foundation for the (3) co-design, where citizen participation occurs at different levels (e. g. surveys, contests, dynamic facilitation workshops, visioning, etc.) to raise their requirements and create acceptance for the project (Stelzle & Noennig, 2017). The results are evaluated, synthesized, and used as a baseline for professional designers in a (4) design competition to develop and rank citizen-oriented scenarios. If the results are not satisfying or should be linked back to the citizens, it is possible to repeat step (3) and change or extend the participation approach. In (5) sentiment analysis, the

competition results are professionally evaluated, and in step (6) ranking/voting, citizens can finally vote for the professional designs. Afterward, both results will be integrated (7 integrating) into a comprehensive design. This has to be approved (8 approving) by the project owner and evaluated by the planning authorities (9 evaluation Assessment) to control if all regulations are respected and necessary permits can be granted (Stelzle et al., 2017; Stelzle & Noennig, 2017).

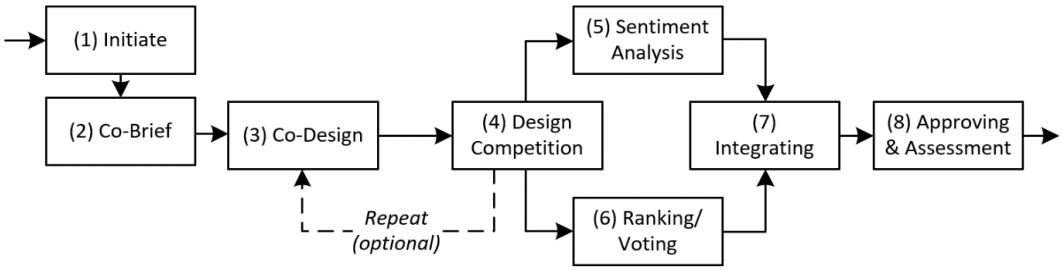


Figure 2. Minimum viable Process for Urban Planning according to Stelzle et al. (2017)

A clear delineation and separation of the dimensions of the citizen design science model is not always feasible. (2) Co-brief can be attributed as a planning step to all dimensions, while (3) co-design is primarily associated with citizen design but also involves design science considering the analysis of the data. The same applies to (5) sentiment analysis and (6) ranking/voting. (4) Design competition and (7) integrating can be classified as design science, while the remaining steps are more organizational and obligatory.

14.2.1.5 Challenges in the Analysis of Citizens' Inputs

Citizens' inputs generated during urban participation must be analyzed and evaluated by experts, as shown in Figure 2, to support subsequent decision-making processes (Balta et al., 2019). Experts are confronted with several challenges in this context as the number of participants in e-participation and on participation platforms has significantly increased over time (Royo et al., 2020).

A large number of participants is beneficial for effective e-participation because it generates broader, more diverse, and more comprehensive knowledge than the experts (Panori et al., 2021; Stelzle & Noennig, 2017). Consequently, the volume and complexity of the generated contributions increase, and experts lack the resources and skills to fully exploit the potential of this knowledge pool. Often, the evaluations of citizen contributions are carried out manually and incompletely afterward, resulting in low-quality e-participation (Arana-Catania et al., 2021). The extensive data volumes pose significant challenges for processing and lead to information overload (Davies et al., 2022; Romberg et al., 2022). Moreover, experts often face many constraints, such as limited budgets, numerous stakeholders with different interests, and short decision-making periods for implementation (Hassan & Hamari,

2020). As a result, findings either come too late or are not immediately relevant to decision-makers (Yang et al., 2022).

Real-time analysis could significantly reduce the time between analysis and decision-making (Romberg et al., 2022). In addition, numerous kinds of participation, including organizational, technical, and urban experts, are involved in large participation, leading to complex interrelationships and more organizational effort (Stelzle et al., 2017). This interrelationship also exists during evaluation, leading to more error-proneness and higher costs (Borchers et al., 2024; Cai, 2021). Another challenge in analyzing citizens' contributions is the individual and qualitative processing (Balta et al., 2019). Evaluators can build on reusable and standardized methods and categories, saving time and financial resources (Hofmann et al., 2020). AI and ML are suitable tools to support evaluators coping with information overload. Automated information processing can increase efficiency and effectiveness by enabling analysis during and after e-participation (Romberg & Escher, 2023)

14.2.1.6 AI and ML for Data Analysis in Urban Planning

AI comprises technical approaches that enable the automatic processing of tasks comparable to human capabilities (Susar & Aquaro, 2019). ML is a subset of AI with the capability of algorithms or models to learn and abstract from data to make decisions or predictions. Natural language processing (NLP) is another subfield of AI and ML that focuses on analyzing and understanding human language (Cai, 2021). Citizen contributions consisting of free texts provide a suitable application field for NLP. Although practical experiences with e-participation using ML and NLP are still scarce, there is growing interest among evaluators and the scientific literature (Romberg & Escher, 2023).

Arana-Catania et al. (2021) addressed the problem of information overload on e-participation platforms. They suggested ML and NLP analyze citizens' interests to promote similar participation and increase the user experience on urban platforms. Lieven et al. (2021) addressed the efficiency and effectiveness of creating and evaluating complex and unstructured citizen contributions to generate summarizations for citizens to support interactions automatically. Pitogo & Ramos (2020) have examined and trained clustering models to analyze data from the social media platform Facebook to determine the sentiment of participants' opinions to support moderators in real-time. This is challenging, especially if participants submit short contributions and only keywords that can be ambiguous and misleading. Romberg et al. (2022) describe something similar while training a classification model with a corpus of citizens' inputs from a mobility project, proposing an initial analysis scheme.

These examples summarize existing approaches and highlight the potential of ML and NLP to support the analysis of citizens' inputs. However, until today, less

emphasis has been placed on analyzing and evaluating citizen contributions, which are crucial tasks for the overall process.

14.3 Methodology

Due to the application-oriented and IT-related RQ, which is crucial for gaining domain knowledge and developing novel AI and ML models, we conduct a series of expert interviews (Meuser & Nagel, 2002) and apply the knowledge discovery in databases (KDD) framework (Fayyad et al., 1996).

The expert interviews aim to gather insights into the current execution of analysis in organizations and companies to specify challenges that can be further investigated. The qualitative approach enables the discussion of different analysis processes considering the limited knowledge and possible differences between organizations, which require an exploratory, in-depth approach (Meuser & Nagel, 2002). The derived insights lay the foundation for the application of the KDD framework and also affect data collection from past participation processes from experts, companies, and organizations, which implicitly or explicitly contain information about their analyzing approaches (Singhal & Sirohi, 2022).

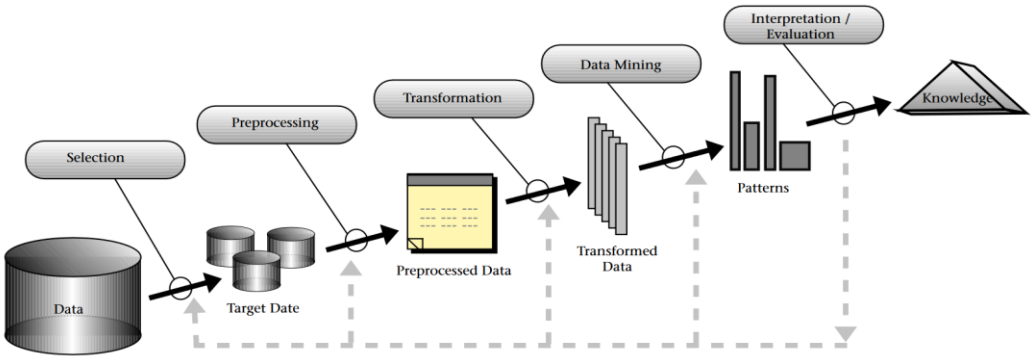


Figure 3. Knowledge Discovery in Database Framework according to Fayyad et al. (1996)

The KDD is a framework that specifies how to iteratively traverse to extract insights or knowledge from data. This follows the argument that when using IT systems, data documenting usage, user behavior, or the result of the usage enables making statements and gaining insights through analyzing this data. In addition, with a sufficient amount of (result) data, it is also possible to train new ML models to automate processes, support users, and further analyze these new ML models to gain further insights such as feature importances and feature dependencies (Maimon & Rokach, 2005). Knowledge created with KDD should be generalizable, non-trivial, novel, useful, and understandable (Fayyad et al., 1996).

KDD is characterized by its systematic approach specified by the KDD process, as depicted in Figure 3, and is of high importance and relevance in a datafied world (Singhal & Sirohi, 2022). KDD distinguishes itself from other approaches by its

rigorous procedure and prescriptions, e.g., data cleansing and standardization, and emphasizes knowledge extraction. This supports the replication and verification of the findings by others and differs from more practical and flexible approaches that focus on solving business problems.

In the initial phase, the goal and domain knowledge are defined. Subsequently, the KDD procedure is traversed in five phases (cf. Figure 3). In the selection phase, the data suitable for the goal are chosen. In the preprocessing phase, the data quality is evaluated and, if necessary, cleaned using appropriate methods. In the transformation phase, the data is converted into a format that ML algorithms can process. In the data mining or machine learning phase, the algorithms are selected to search for patterns or insights in the data (Fayyad et al., 1996). The KDD process focuses on the data, which is why ML or NLP can be employed. In the interpretation and evaluation phase, the results of the ML algorithm are finally analyzed and visualized (Maimon & Rokach, 2005).

14.3.1.1 Expert Interviews

All interviews were semi-structured (Meuser & Nagel, 2002) and planned for 60 minutes. In addition, it was planned to record and transcript the audio afterward to enable a systematic analysis by Mayring (2014) with inductive codes to identify challenges and the possibilities of an ML-based analyzing process as required by the RQ within an explorative approach.

Depending on their role and task descriptions, the experts were selected and contacted via e-mail. This was carried out via publicly available websites of government, public authorities, and companies responsible for conducting participation projects and analyzing data. We contacted over 20 experts and were able to interview eleven experts in different organizations. The experts E5 to E10 allowed us to record the interviews, and for the others, we created memory protocols immediately after the interviews to enable a systematic analysis. Table 1 summarizes the expert interviews conducted, and we perceive this amount as sufficient, as the insight and findings were getting more and more repetitive after four interviews in each type of organization (Baker et al., 2012).

No.	Position	Organization	Duration
E1	Project Leader and Urban Expert	District Office 1.	100 min.
E2	Project Manager	District Office 2.	70 min.
E3	Project Leader and Urban Expert	District Office 3.	110 min.
E4	Project Leader	District Office 4.	80 min.
E5	Project Leader and Urban Planner	Company 1.	22 min.
E6	Research Associate	Company 2.	88 min.
E7	Project Manager	Company 3.	56 min.

E8	Project Leader and Urban Planner	Company 4.	54 min.
E9	Project Manager	Company 5.	63 min.
E10	Sociologist	Company 6.	77 min.
E11	Project Leader and Urban Expert	Company 7.	60 min.

Table 1. Overview of the Expert Interviews

All experts were able to contribute and describe the analyzing process of citizen inputs from their perspective. However, it was getting quite apparent that the district offices and company correspond to different roles. The district offices initiate participation projects for their inhabitants and have a high interest in the approach and results to develop their district and community further to create public value (Ludzay & Leible, 2022) while the companies offer citizen participation in different variations and tools as a service to district offices, other public service departments, and large companies. Quite often, the analysis is conducted by companies as the district offices tend to outsource this work. This can be explained by limited (human) resources, experts, and a lack of skills (Cai, 2021). In addition, the external analysis also supports an objective analysis and elaboration on the findings as it is conducted by an external organization that is not directly affected by the results. This can also increase the trust of citizens and other stakeholders in the analysis process (Pantić et al., 2021). However, as the companies get paid for their work, they, of course, have an interest in satisfying the customer, e.g., the district office with high-quality participation. Besides that, companies are very interested in effective, efficient, and transparent data analysis, as this can reduce their workload and affect revenue and profits.

14.3.1.2 Knowledge Discovery in Database Framework

For the analysis of datasets and development of ML models according to the KDD Framework, the programming language Python version 3.12 was utilized. Python offers extensive standard libraries that can be utilized for data analysis and dataset evaluation. We employed the Pandas library to display the data in data frames for the data selection and exploration phase and visualized them with the libraries Matplotlib, Seaborn, and Plotly. Additionally, we used the spaCy library to preprocess the citizen contributions, e.g., text into vectors, also called word embeddings (Honnibal, 2017), which is crucial to training ML models with natural language, for which we used the Scikit-Learn library (especially from sklearn.cluster import KMeans and from sklearn.metrics import silhouette_score) providing predefined ML algorithms and evaluation methods (Cai, 2021).

14.3.1.3 Data Collection and Selection

The interest of the interviewed experts was huge, as all would benefit from AI- and ML-based tools that support data analysis. During the interviews, we asked if the

experts could provide example data. As this data is not always anonymous and handled discreetly, not all experts agreed to provide real data representing the data analysis, as shown in Table 2.

No.	Received Data	Categories	Subcategory	Entries
E1	Yes	Yes	Yes	2.175
E2 to E8	No	-	-	-
E9	Yes	Yes	Yes	3.547
E10	Yes	Yes	Yes	1.591
E11	Yes	Yes	No	19.259

Table 2. Overview of the Datasets

All datasets, e.g., citizens' contributions, were reviewed by the authors regarding comprehensibility, usefulness, credibility, and consistency. Comprehensibility refers to the structure of the file and the headings it contains. As all datasets were provided in Excel tables and contained headings, they were comprehensible. Regarding answering the RQ, the datasets are useful because they support statements made by the experts in the interviews, the same as the knowledge generation intended by the KDD framework (Fayyad et al., 1996). This, for example, is related to the formulation of categories that are assigned to all citizens' contributions. The credibility check was carried out in comparison with the dataset published by Romberg et al. (2022), and as far as it is possible to compare and evaluate them, the datasets are authentic. There is no systematic procedure for checking the correctness of the data, as the participations from which the data originate are no longer active, and data comparison through inquiries and verification, therefore, is not possible. The consistency of the data was examined using a Python script. It was found that the datasets contain minor inconsistencies, which are characterized by incorrect and confusing category assignments.

14.3.1.4 Data Preprocessing

The data preprocessing was conducted according to the scientific literature on natural language processing and the experts' insights (Cai, 2021; Raina & Krishnamurthy, 2022). In the first step, as depicted in Figure 4 (top), the contributions from citizens were harmonized to ensure consistency in language. The diversity of contributions was evident during the review process, with contributions in other languages being present only in small numbers. Language diversities can happen because e-participation tools and platforms usually accept inputs from all languages, even if the participation is provided in the local language (Lieven et al., 2021).

Furthermore, spelling errors were manually corrected in the contributions to support automated processing and to avoid errors resulting from swapped letters or similar issues. We are aware that manual correction is not scalable. However, tools for spelling and grammar correction, such as Grammarly, GrammarBot, JSpell Checker,

and others, can already do this and can be integrated via API, ensuring that this task can be made scalable. In the second step, all words were automatically lemmatized, translated into their base form, and converted to lowercase to facilitate the recognition of semantically similar statements in different syntaxes (Raina & Krishnamurthy, 2022) via Python (from lingua *import Language, LanguageDetectorBuilder* and *import spacy*). Subsequently, punctuation and stop words were removed via spaCy to emphasize this effect further. Finally, the dataset was cleaned. Empty entries, links, and emojis were removed as they cannot be vectorized correctly with many vector models (Gupta et al., 2023).

14.3.1.5 Data Transformation

The transformation of text for training ML models is extensively described in the literature. All text must be transformed into numerical representations because AI exclusively calculates numbers (Honnibal, 2017). Trivial approaches like *bag of words* exist, but more complex ones such as vector systems or word embeddings have shown better performances. The idea behind these NLP techniques is to represent words or sentences as vectors, with the distance between them expressing syntactic or semantic similarity (Sharma et al., 2017). In our case, we decided to compute the vectors for citizens' inputs for the preprocessed data, which is justified by the fact that many entries only contain a few words and correspond to the elucidations by the experts.

To emphasize distinctions in short citizens' inputs, we calculate the Term Frequency-Inverse Document Frequency (TF-IDF) value to vectorize all data. TF-IDF computes the vectors from the term frequency of each word contained in the contribution. The inverse document frequency measures the frequency of words in the contribution relative to the entire vocabulary, i.e., all data in the dataset (Cantador et al., 2017; Guiao et al., 2017). This considers the frequency of words that quickly become frequent or very rare in the language, which can be crucial, particularly in the latter case, to prevent information from being overlooked in the mass of data. In the end, both vector values are multiplied to obtain one vector per citizen input.

14.3.1.6 Data Mining and Training of the ML Models

Our data mining process was meticulously designed, following clustering approaches corresponding to a category structure that varies from participation to participation, as the dataset from the experts showed. This was done because initial classifications were already examined, as described in Section AI and ML for Data Analysis in Urban Planning, ensuring a comprehensive and detailed analysis. For the clustering, we applied the k-means algorithm, which was chosen for its predominantly good results, stability, traceability, and visualization (Zhang et al., 2019). The k-Means algorithm, belonging to the group of partitioning clustering algorithms, iteratively

divides data points into k clusters (scikit-learn, 2024). The centroid of each cluster is computed as the means of the data points within it, aiming to maximize intra-cluster homogeneity and inter-cluster heterogeneity. The parameter k, which determines the number of clusters to partition, is predefined. The developed algorithm proceeds as follows:

1. K-data points are randomly selected to train the ML models to create clusters.
2. All data points are evaluated for similarity with the silhouette coefficient. If proper clusters are created, step 3 is executed; if not, step 1 is repeated with an increased k.
3. The k-cluster centroids are relocated to create labels for the clusters.
4. Repeat steps 1 and 2 for subclusters until step 2 is determined, and then finally apply step 3 to the subcluster centroids to label the subcategories.

The process was developed to enable categories, e.g., clusters, and identify subclusters, which results in further specific clusters that can be visualized with trees. This requires the iterative application of k-means as defined in the four-step process. However, to decide if a cluster is valid, which means that the identified clusters can be properly distinguished from each other, we calculated the silhouette coefficient, which serves as a metric to evaluate the quality of clustering by computing the similarities of each data point to a cluster and differences to other clusters. To determine the optimal number of clusters, we computed from k_min to k_max, and the number k with the highest silhouette coefficient was selected as the optimal number of clusters. Additionally, for tagging citizen contributions, TF-IDF scores were used to determine tags for each cluster (Guiao et al., 2017). The average TF-IDF scores for each word in the documents within the cluster were computed, and the word with the highest average value was selected as the name for the cluster.

14.3.1.7 Interpretation and Evaluation of the ML Models

To evaluate the developed approach, we compared the automatically extracted clusters based on the determined labels from the ML models with the clusters from the expert's data. However, not all the data contains subcategories, and as we mixed the data to reach enough examples to successfully train k-means-clustering models, this comparison is not conclusive and only serves as a baseline. The evaluation of the clusters itself was conducted with the silhouette coefficient, which we also used as a part of the development processing approach for citizens' inputs from e-participation. The findings are described in the next Section.

14.4 Findings

The conduction of the expert interviews and the receipt of data from four of them, as well as their analysis according to the KDD framework as described in the previous

Section, have led to numerous insights (Fayyad et al., 1996) on which we elaborate in this Section.

We interviewed the experts on the challenges in analyzing citizens' inputs, their experiences with AI, the potential of AI, and the current evaluation process. Nearly all experts mentioned the challenge of an increasing volume of data and citizens' inputs, which encounters limited resources (Stelzle et al., 2017).

Challenge 1: Lack of time due to an increasing amount of citizens' inputs from e-participation and platforms, which increases manual workload.

Time, as stated in *Challenge 1*, also affects the duration between the completion of participation and the presentation of the results to decision-makers (E6 and E10), which could be shortened and reduce overall urban planning cycles. In addition to the time shortage, the experts described the challenges of inefficient (E1 to E11) and non-standardized analyzing processes (E2, E6, E6, E7, and E11). The challenge of efficiency was explained by the limited use of evaluation tools that simplify workflow steps, as most experts rely on Excel as "tools like SPSS are quite expensive and limited in their functionalities, especially for small companies" (E7), which correlates to the findings of the literature (Alahakoon et al., 2023; Pitogo & Ramos, 2020). The lack of standards poses a problem, especially in larger projects where multiple experts and analysts collaborate, possessing varying experiences and expertise that must be coordinated. This can turn linear processes into multifaceted ones, leading to increased organizational efforts.

Challenge 2: Lack of efficiency in the analysis of citizens' inputs from e-participation and platforms due to manual data processing

Challenge 3: Lack of standards for analyzing citizens' inputs from e-participation and platforms, especially in larger projects with more experts and analysts.

Simultaneously, the requirements for the analyzing process are high, as the process should be traceable (E4, E6, E10) and explainable (E1, E2, E, E5, E6, and E10). Traceability mainly considers the process and history of changes, including the accountability by experts. Explainability is of higher relevance and was mentioned equally by district offices and companies, justified by the fact that the results of citizen participation are usually communicated to the public and political decision-makers which consider the results in urban projects, which can be of a structural as well as sociable nature and are often associated with significant financial expenses (Roman & Fellnhofer, 2022). Therefore, it is crucial for the public and political decision-makers to understand and trust participation results (Steinbach et al., 2019), especially when critical, unpopular, and expensive decisions are made, as highlighted by E1, E2, and E5.

Challenge 4: Lack of traceability in the process of analyzing citizens' inputs from e-participation and platforms due to missing functionalities like version control and log files.

Challenge 5: Lack of explainability in analyzing citizens' inputs from e-participation and platforms due to varying processes, challenges 3 and 4.

The descriptions of participation processes are comparable to the process depicted in Figure 2, with some smaller projects skipping steps 4 to 7 (Stelzle et al., 2017). The description of the analyzing process is coherent with these and is carried out manually, leading to and including the described challenges.

To analyze citizens' inputs, experts and analysts review all data following a deductive and inductive approach to create categories. Deductive reasoning is employed when there are already expectations of insights from the project initiators, which were communicated and documented in the initial meetings, as shown in Figure 2. Inductive reasoning is used because of the vastness of citizens' inputs and information diversity, aiming to extract unbiased new knowledge relevant to the project (Mayring, 2014). Therefore, categories vary from participation to participation, especially when local differences in neighborhoods or unique features form their own categories, as they are not transferable. Nevertheless, transferable categories and clusters exist, such as mobility, green spaces, or residential areas (Romberg et al., 2022). Regarding this, all experts emphasized the benefits of supportive AI- or ML-based tools that are reliable and traceable to improve the evaluation and see the potential of these, for instance, "to simplify monotonous and strenuous work by pre-structuring contributions" (E6).

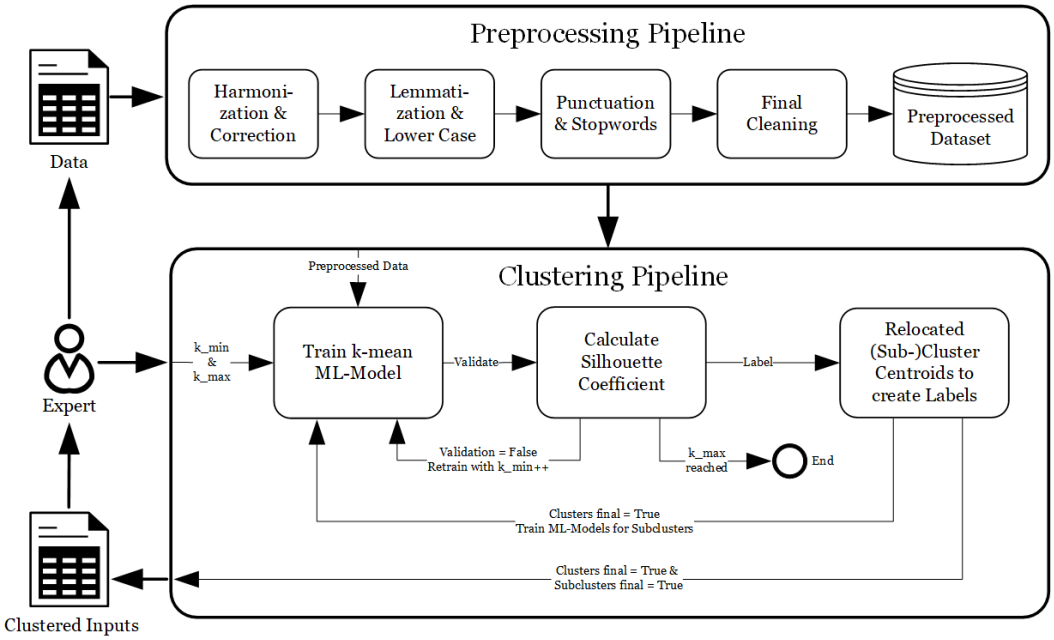


Figure 4. Process Model for Clustering of Citizens' Inputs from E-Participation

The application of the KDD framework enabled us to analyze the process of the experts' organizations to gain an in-depth understanding of the process. However, as described by the Experts, the analyzing processes are not standardized. All received data shares the extraction of knowledge in terms of categories or clusters that are created based on the citizens' inputs. In addition, three of the four datasets also include subcategories. As nearly all experts describe, one of the first steps is to extract misleading or non-understandable citizen input from the collected data (Recalde et al., 2020). This is not executed lightly, as this means that some citizens' opinions are ignored, of course, only if it is not clear what their demands, requirements, ideas, and visions are. It is also not possible to reconstruct this, which is problematic, as described by Akmentina (2022) to support accountability. Afterward, the categories and subcategories are extracted by the manual review of the data, first to create the categories and then, in a second interaction, to create the subcategories. Sometimes, further and finalizing iterations are also required to validate or to reduce variances caused by different knowledge or experience, as implied by *Challenge 2* and *Challenge 3*.

In response to these findings and the existing knowledge base, we propose a novel process model for analyzing citizens' inputs from e-participation, which is shown in Figure 4. We applied the KDD framework to develop the process model and used this insight, as described in the Section Data Preprocessing, to create an automated preprocessing pipeline (Cai, 2021; Raina & Krishnamurthy, 2022). This includes steps required by NLP and those mentioned during the interviews to harmonize and clean the data.

The second and more challenging part is the clustering pipeline. In our case, the preprocessing pipeline receives the data as a CSV file and results in a JSON, while other file formats are possible. Afterward, another Python script is started, which loads the preprocessed data and receives a range of possible clusters. However, it is also possible to set a fixed number of clusters, but considering their semantic distinction, we recommend a more flexible approach. With both, the script trains an initial ML model with k clusters and then validates it with the silhouette coefficient. If the cluster's centroids are distinguishable, the script labels the clusters with a word representing the clusters' topic. If not, another ML model with more clusters is trained, and the steps are repeated until the program successfully creates a cluster or fails to achieve this. If clusters are created, the script continues developing the subclusters, e.g., subcategories, following the same procedure.

Finally, the script determines and stores a CSV file with five columns. The first column contains the original citizen's inputs. The second column contains the clusters, the third the corresponding label, and the fourth the subcluster with the

corresponding label in the fifth column. With the data output of the process models, e.g., scripts, experts can continue to validate the results of the ML models manually. The developed scripts do not visualize the cluster. However, with the content of the columns, it is possible to visualize the output, as shown in Figure 5.

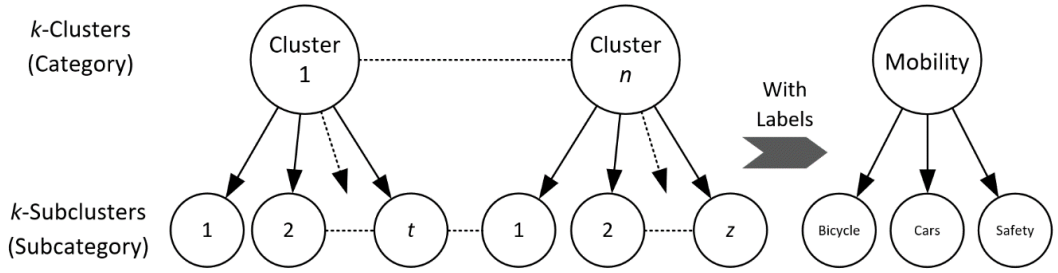


Figure 5. Schematic Structure of the ML-based Clusters

As part of the last step of the KDD framework, we compared the clusters of our approach with the ones included in the expert's datasets based on the determined labels. The comparison showed an overlap but also a difference. For example, the cluster affordable housing was created as a label, including the subcategories of family living, condominium, and community places. While the category by the ML model is understandable, the experts created the category housing. Even if the difference is small, this can have an impact on subsequent processes and highlights that the created cluster does not always correspond to the mental models of the participation and urban experts.

Another example is cluster mobility with the subcluster's bicycle, cars, and safety, and the other cluster traffic created in the same script execution. Further analysis revealed that mobility focused on the different kinds of vehicles and services that can be used to move, while traffic corresponded to noise, traffic jams, and pollution. This shows that both clusters are different but also highlights that the difference is not always obvious and that experts might have created them differently.

14.5 Discussion

In this paper, we present our results corresponding to the proposed RQ, "How to analyze citizens' inputs from e-participation with machine learning to support participation experts?" To do so, we conducted eleven expert interviews, collected four datasets, and applied the KDD framework to gain and derive novel knowledge from them. The developed process model for clustering citizens' inputs from e-participation, as shown in Figure 4, describes a new automated approach and corresponds to the RQ. It enables the ML-based analysis of citizens' inputs considering the five challenges described by the interviewed experts, as elaborated in the Findings Section.

The analysis of the expert interviews' results led to the identification of five challenges: time problems, efficiency, lack of standards, comprehensibility, and explainability of the evaluations (cf. Section Findings). The results confirm the theory-based findings of existing research and emphasize that real-time evaluations of citizens' contributions can shorten entire participation projects (Becker et al., 2022). This could accelerate the completion of urban decision-making, supporting the faster implementation of urban or social changes to create public value (Stelzle et al., 2017). The developed process model is based on the results of the expert interviews and the results of the application of the KDD framework. It represents an automatic approach that is traceable through the application of k-means and can also be visualized. Nevertheless, it remains open whether the clusters are retrained from project to project or whether organizations and companies use reference clusters, as both are possible (Pattnaik & Nayak, 2019).

Regarding the citizen design science model and the minimum viable process (cf. Section Theoretical Foundation), our findings contribute mainly to the dimension of citizen science but could also be applied to the other dimension, as they affect each other bidirectional (Mueller et al., 2017) while the process model primarily considers the aspects originating from design (cf. Figure 1, top). We argue this as citizens contribute to e-participation by submitting inputs, which are then analyzed as we elaborate on our developed approach (cf. Section Findings). The real-time analysis of citizens' input by ML can be used to extract information in clusters representing relevant participation topics immediately (Borchers et al., 2022). The process model itself, thus, can be seen as an approach to rule mining for design proposals in the dimension of design science as the inputs can be used for the design of the participation output as same as to understand the included population better to quantify interest of districts or similar. Additionally, the process model and corresponding results could be used in the dimension of citizen design if used in real-time interactions with citizens to support them with immediate feedback or overviews of discussion or the whole participation. This could reduce reading time and increase the interactivity of e-participation (Ritta Coelho et al., 2018). Therefore, the process model contributes to the citizen design science model with a novel approach that supports data analysis and interaction. Furthermore, the findings of the expert interviews also validated the minimum viable process, as shown in Figure 2, but also identified shorter variations, which are of higher relevance, especially for small e-participations.

Besides the theoretical contribution of this paper, we also want to elaborate on its practical value for participation and urban experts. The five identified challenges that affect many organizations can be used as a guideline in planning participation projects, as otherwise, misplanning can negatively affect participation and data analysis, as insufficient time and resources are available and rough analyzing

approaches are applied (Ullrich, 2022). Moreover, the process model can be used as a baseline for data analysts who want to use AI or ML as the process model provides required steps and follows an interactive approach, which could also be extended with a third cluster level if required.

Despite the profound nature of our findings, some limitations should be considered. First, training the ML model is challenging and requires certain amounts of data. We archived that with the data of E11. However, in practice, training new ML models might not always be possible, and it can also produce misleading clusters and, over time, model shifts. In addition, alternative preprocessing and ML algorithms can be used and could be more reliable (Cai, 2021). Moreover, the expert-based procedure does not ensure that all experts, citizens, and decision-makers who might have less or different knowledge about analyzing processes can understand and trust the developed white box approach in practice and might require further explanations, visualizations, and key performance indicators. In addition, in this paper, we answered the RQ "How to analyze citizens' inputs from e-participation with ML to support participation experts?" focusing on a conceptual solution and contribution based on an information systems perspective. However, alternative and highly precise ML models should be examined and developed in further research to increase the reliability and trust of participation experts in AI- and ML-based tools. Moreover, considering existing classification approaches (Romberg et al., 2022), it could also be possible to merge various approaches to combine deductive and inductive sense-making from citizens' inputs in one tool. As an extension, this could also include creating recommendation reports by generative AI for experts to increase efficiency further. This, as well as the development of an interface that enables intuitive interaction with the MI models, should also be developed and would allow the examination of design elements and the integration of such an application in organizations and expert processes. Nevertheless, we are convinced that the paper is well-founded and that the process model for clustering citizens' inputs from e-participation contributes to citizen design science and practice.

14.6 Conclusion

This paper investigates how to analyze citizens' inputs from e-participation using machine learning to support participation experts. We accomplished this by conducting eleven semi-structured expert interviews and applying the knowledge discovery in the database framework. The expert interviews aimed to gain deep insights into the work practices of participation experts while simultaneously obtaining data from various organizations from past participations. In applying the knowledge discovery in a database framework, the data was processed following the steps of data collection and selection, data preprocessing, data transformation, and data mining, including the development of an ML model and its interpretation, which

led to the process model for clustering of citizens' inputs from e-participation. The evaluation was performed by comparing the information provided by the experts, the obtained data, and the automatically extracted clusters. The results demonstrate that automated generation of clusters for citizen contributions from e-participation with differentiation into category and subcategory is feasible. However, it is crucial that sufficient data is available, which is typically the case with participation on urban platforms.

Furthermore, when comparing the clusters generated by the experts and those generated by the ML model, it was evident that the clusters are distinguishable but not always identical. This can be attributed to different mental models and must be considered, particularly in the processing of clusters in subsequent processes. By utilizing the developed process model, this paper contributes to the citizen design science model by demonstrating a dynamic data evaluation capability. Moreover, the novel process model serves as a guide for practitioners and a baseline for further development, considering complementary ML models as well as the design of a user interface for experts.

14.7 References

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15 Publication C6: Designing AI-based Systems to support the Analysis of Citizens' Inputs from E-Participation

European Conference on Information System (ECIS)

Track: Design Research and Design Methods in Information Systems
Completed Research
Ranking: A

Research Question

How to design IT artifacts to support the AI-based analysis of citizens' inputs from e-participation?

Contribution to the Dissertation

This publication contributes to the overall RG, especially RQ2 and RQ3, by developing and evaluating a web prototype that includes a classification model trained to analyze data. In addition, this was combined with a sentiment model, and for the visualization of findings, plots were automatically generated. To easily find statements, a semantic keyword search was also included. The publication describes eleven issues, nine meta-requirements, and four design principles, which were subsequently extended through a qualitative evaluation with expert interviews into six design principles.

Citation

Borchers, Marten; Cao, Thu-Bao; Tavanapour, Navid; & Bittner, Eva (2024). Designing AI-Based Systems to Support the Analysis of Citizens' Inputs from E-Participation. In: *Proceedings of the 32nd European Conference on Information System* (ECIS). https://aisel.aisnet.org/ecis2024/track23_designresearch/track23_designresearch/7. Completed Research.

Abstract: *E-participation and urban participation platforms have gained significant popularity in addressing thousands of participants. Governments and urban developers utilize them to collect citizens' input to develop user-centric cities and services. Handling these inputs has become increasingly challenging as it requires manual analysis, which is time-consuming, inconsistent, and expensive. Therefore, we examine how to design IT artifacts to support the AI-based analysis of citizens' inputs from e-participation. To do so, we build upon existing literature reviews that highlight the possibilities of AI and apply the design science research paradigm by conducting expert interviews and developing an AI-based prototype, which we evaluated with a focus group. Our initial design theory specifies six design principles addressing the process and AI-based functions to enable the automatized analysis of citizens' inputs, supporting e-participation experts. In addition, we emphasize that further research addressing the explainability of ML, more accurate models, trust, and human-AI interaction is required.*

Keywords: E-Participation, Input Analysis, Artificial Intelligence, Design Science Research

15.1 Introduction

Electronic participation, often referred to as e-participation (Hassan and Hamari, 2020), and urban platforms play a pivotal role in urban planning and service design (Stelzle et al., 2017). Their significance lies in including citizens to shape, develop, and design urban areas, districts, neighborhoods, local spaces, and services in a user-centric way (Falco and Kleinhans, 2018). Over the past years, the utilization and proliferation of e-participation with urban platforms have significantly increased (Royo et al., 2020). This growth is attributed to urbanization, the COVID-19 pandemic, and increasing social conflicts due to lack of housing, wealth gap, low social cohesion, and further (Pánek et al., 2022; United Nations et al., 2018). Participatory approaches are often described as a solution to address these and to support a high quality of life (Repette et al., 2021). E-participation platforms predominantly gather qualitative data, encompassing text and occasionally complemented by figures and images provided by the participation responsible or uploaded by users (Borchers et al., 2023). This data can afford a profound understanding of requirements and needs but demands resource-intensive analysis and evaluation (Romberg and Escher, 2023). However, the existing analyzing approaches for citizens’ inputs do not align with the tremendous increase of qualitative data (Royo et al., 2020) as manual analyses are becoming increasingly expensive, time-intense, and inconsistence as exemplified in metropolises in Spain, France, Denmark, and beyond (Larsen and Caswell, 2022; Royo et al., 2020; Secinaro et al., 2022).

The literature highlights the potential of artificial intelligence (AI) and machine learning (ML) models to analyze and evaluate citizens’ inputs from e-participations, as this can automatize and support experts to increase efficacy (Arana-Catania et al.,

2021). However, this has been identified as uncharted territory in the systematic literature review by Romberg and Escher (2023), who highlight the absence and need for tailored tools. The design of these is not trivial, as they have to be valid and approved, as urban experts and governments are including participation results in subsequent decision-making processes to initialize large and costly projects (Correia et al., 2023). This especially applies if the participation outcome is criticized and politically controversial (Becker et al., 2022). Proper solutions and corresponding decision-making processes are thus of paramount importance, which can be communicated to others and are trusted (Arana-Catania et al., 2021; Cai, 2021; Hofmann et al., 2020). Due to the lack of these, we build upon the existing foundation and examine the design of an expert system by answering the following research question (RQ):

RQ: How to design IT artifacts to support the AI-based analysis of citizens' inputs from e-participation?

To answer the RQ, we followed the design science research (DSR) paradigm proposed by Vaishnavi and Kuechler (2004). DSR provides a structured, cyclic process to systematically develop design principles for IT artifacts, which are prototypically implemented and evaluated to enhance and validate them. Across the cycles, findings are condensed into a novel design theory (Kuechler and Vaishnavi, 2012) with increasing validity and foundation.

In this paper, we present the findings of the first DSR cycle. The paper continues with related work (Section 2), describing fundamentals and existing approaches to evaluate citizens' data. In Section 3, the research approach is specified. In Section 3.1, awareness of the problem and suggestions, we present the findings of the expert interviews and describe issues, meta-requirements, and design principles. In Section 3.2, development, the implementation of a web prototype regarding the design principles is described, including the training and use of machine learning (ML) models. In Section 3.3, we describe the evaluation and in Section 4, findings and implications, we derive further design principles. In the discussion (Section 5), we elaborate on our findings considering the scientific knowledge base for AI-based systems to analyze citizens' inputs and summarize this paper in conclusion (Section 6).

15.2 Related Work

15.2.1 E-Participation and Urban Platforms

The definition of e-participation varies, and for this work, we use terminology from the field of e-government since governments and public authorities are often responsible for initiating and fulfilling urban projects as they shape processes and objectives via guidelines, regulations, urban development strategies, and their

services (Münster et al., 2017; Stelzle et al., 2017). Therefore, "e-participation is a participatory process enabled by modern information and communication technologies, includes stakeholders in the public decision-making processes through active information exchange, and thus fosters fair and representative policy-making" (Wirtz et al., 2018, p. 3). E-participation can be conducted on-site at predefined or organized locations, including IT equipment off-site, which describes digital participation as time and location-independent and often takes several weeks or both (Poser et al., 2019). On-site participation is still applied regularly, ensuring that non-IT affine citizens can participate (Leible et al., 2022).

The shift toward IT-based and fully digital participation is enormous. It can increase interactions and user experience and provide scalability, which increases the amount of elevated information and can lead to more representative data collection and findings (Correia et al., 2023). E-participation communication technologies and computer-supported methods for participation and collaboration are diverse (Stelzle and Noennig, 2017). They can include digital surveys, websites, platforms, and upcoming technologies like virtual and augmented reality lenses (Sameeh El halabi et al., 2019). For fully digital participation, in which the on-site limitations are omitted, e-participation platforms are widely used (Royo et al., 2020). E-participation platforms, also called citizen engagement platforms, urban participation platforms, or just urban platforms like CONSUL DEMOCRACY (employed in over 35 countries), Decidim Madrid (Spain), DIPAS (Germany), CoUrbanize (USA), OSALE (Estonia), and many more (Keramidis and Charalabidis, 2021; Lieven, 2017; Pánek et al., 2022; Royo et al., 2020; Toots, 2019) enable full digital participation and have expanded and emerged into powerful instruments strengthening interactions between citizens, governments, and public authorities (Repette et al., 2021) by enabling continuous and bidirectional exchange (Pallathadka et al., 2022; Stelzle et al., 2017). To enable fully digital participation, urban planning platforms contain functionalities for citizens and public authorities to initiate projects, petitions, forums, discussions, surveys, and polls (Repette et al., 2021).

15.2.2 Challenge of analyzing Citizens' Inputs from E-Participation

The increasing number of participants aggravates the data analysis for governments, public authorities, and all companies that offer the conduction and analyses of e-participation as a service (Verfaillie and Verbrugge, 2021). In the case of polls and voting on participation platforms, the analysis can be conducted automatically due to the numerical representation of how many participants voted for or against a statement, a topic, the project's objective, specifications, or implementation (Stelzle and Noennig, 2017). As soon as a more in-depth exchange is required and the collection of contributions from citizens in the form of text is required, the effort and complexity to analyze and evaluate it increases strongly with the number of

participants and comments (Panori et al., 2021; Reynante et al., 2021). As numerical elicitations are limited and co-creative approaches require a more in-depth and intense exchange, including discussions and forums, the amount of qualitative data has increased (Lieven et al., 2021; Royo et al., 2020).

Besides the increasing amount of data and capacities regarding experts and finances, the analysis with multiple or dozens of persons also creates new risks. This, for example, affects standards and training to ensure that all data, e.g., citizens' inputs, are treated equally, which can be ensured with reviews but again would increase the cost (Jannack et al., 2020). In addition, such an elaborate analysis can require weeks, and sometimes public officials do not or cannot wait so long to continue and present results due to political pressure, tense discussions, and conflicts with relevant stakeholders and citizens (Quintero-Angulo et al., 2020; Romberg and Escher, 2023). Past projects in the USA, Spain, Estonia, Japan, and Germany have shown that participation can reach hundreds and thousands of citizens and even more comments (Consul Democracy, 2023; Lieven et al., 2021; Repette et al., 2021; Smith and Martín, 2021). This is especially underlined by the Decidim Madrid platform, which already had over 90,000 participants in 2018 (Royo et al., 2020). As a response, the attention in science and practice has shifted to automated approaches, which is a characteristic and strength of AI and ML. Both have the potential to increase efficiency and enable real-time analysis (Cai, 2021), which can be used during e-participation to receive early feedback and adapt communication and discussions (Yang et al., 2022).

15.2.3 AI and ML for analyzing Citizens' Inputs

Artificial Intelligence (AI) describes the broad field of computer science dedicated to creating machines, e.g., intelligent agents, capable of performing tasks that typically require human intelligence, such as analyzing citizens' inputs from e-participation to support subsequent decision-making (Al-Besher and Kumar, 2022). Machine learning (ML) is a subfield of AI that involves the development of algorithms and statistical models, which are trained by using large datasets to enable computers, e.g., machines to create models, to predict and determine values, classes, or clusters (Alahakoon et al., 2023).

In scientific literature, findings about e-participation in urban planning and the use of AI and ML to automatize data analysis are rare as this crucial area of increasing interest is underexplored (Romberg and Escher, 2023). Automated content analysis methods based on ML have the potential to support experts by assisting and automatizing part or the complete data analysis in real-time, from which governments, companies, and citizens would benefit (Nicolas et al., 2021; Wirtz et al., 2018). Cai's (2021) work describes the potential of applying different ML approaches to urban projects. The author suggests considering social media to

identify communication gaps, citizens' interest in projects, and their typical use of urban spaces to support urban planning (Cai, 2021). Pitogo and Ramos (2020) have examined e-participation and trained clustering models to analyze data from the social media platform Facebook to determine the sentiment of participants' opinions to support moderators in real-time. Fu et al. (2023) examine pre-trained large language models and describe the potential to support urban experts in extracting data and monitoring discussion in e-participation. They also elaborate on risk and challenges as many large language models are not transparent and explainable, which can increase distrust by participants and complicates the identification wrong prediction by experts, to which Luusua and Ylipulli (2020) agree and at the same time call for further interdisciplinary research in this domain. Bachiller et al. (2021) focused on visualization and used clustering methods to identify citizens' interests in connection to specific districts. They mapped this information to highlight similar and different discussions and opinions to support urban development, and a project described by Lieven et al. (2021) examined the possibility of merging data from the urban platform DIPAS to summarize the content to create further information for architects and planners.

The described research illustrates existing approaches and highlights that many projects focused on supporting citizens during their participation and less on supporting urban experts in analyzing data. However, participation depends on that, as it should support subsequent decision-making processes to create public value. In addition, as stated by Kowalski (2020), data analysis has to focus on the meaning of citizens' inputs to extract their demand, considering the context of the participation and environment, and not only on word frequencies or similar.

15.3 Research Method

Due to the design-oriented RQ, we follow the DSR paradigm. DSR is a widely used approach to (1) create new knowledge by designing novel IT artifacts and (2) analyze the use and performance of IT artifacts through evaluations and reflections (Hevner et al., 2004). DSR contributions can be differentiated into six modes, as vom Brocke et al. (2020) described. The first two modes focus on the creation of prescriptive design knowledge. Building on that, modes 4 and 5 specify the development of design theories considering rules and comprehensive systems, which lays the foundations for modes 5 and 6, e.g., design entities and evolution. Separately and together, these solve relevant challenges and issues for crucial target groups with increasing validity (Kuechler and Vaishnavi, 2012).

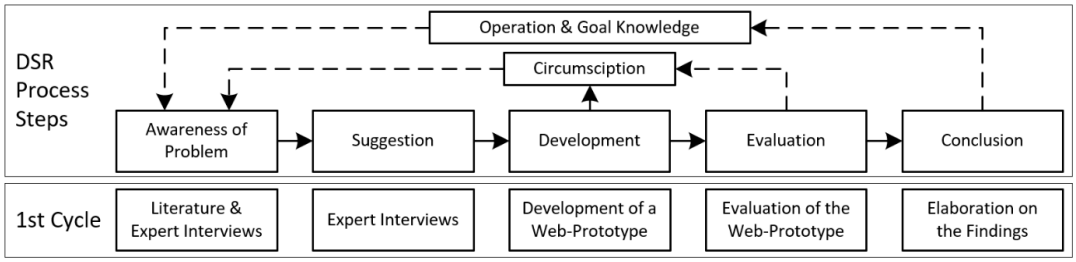


Figure 1. Applied Design Science Research (DSR) Cycle

The DSR paradigm, as described by different authors, involves an iterative or cyclical process that exhibits variations depending on the specific authors and necessitates further elaboration (Kuechler and Vaishnavi, 2012; Peffers et al., 2007). This paper follows the DSR process described by Vaishnavi and Kuechler (2004), who define the five process steps: awareness of the problem, suggestion, development, evaluation, and conclusion, which we applied in the first cycles, as shown in Figure 1.

For awareness of the problem, we build upon the existing literature reviews (cf. Section 2) as described by Cai (2021), Leible et al. (2022), and Romberg and Escher (2023) and conduct expert interviews to identify new and validate known issues and to conduct the DSR step suggestions to formulate meta-requirements and derive design principles describing possible AI-based IT artifacts. The expert interviews follow an explorative and semi-structured approach addressing problems, challenges, requirements, and solution design, as specified by Meuser and Nagel (2002). All expert interviews are documented by audio recording or memory log. All audio records are transcribed and then analyzed with memory logs by applying the nine steps of the qualitative content analysis by Mayring (2014), using MAXQDA and deductive-inductive codes. As deductive codes, we build upon the description of Section 2 and especially 2.3 and apply the codes of process and interface, functions including data analysis, classification, sentiment, clustering, and visualization (Cai, 2021; Romberg and Escher, 2023). This aligns with exploring the rationales for utilizing IT artifacts and understanding the current state of the art, according to Baur and Blasius (2014). As a result of this process, we derive design principles following Gregor's specifications, in specifying the aim, implementer, target group, context, and mechanism or functionalities (Gregor et al., 2020). For the development phase, freely available data from previously conducted citizen participation are collected and preprocessed according to the standards of natural language processing (Cai, 2021; Honnibal, 2017) to train ML models for identified functionalities as specified by the experts. In addition, these functionalities are made accessible through a web prototype, enabling the evaluation of design principles. To do so, we conduct a semi-structured focus group (Tremblay et al., 2010) with additional suitable stakeholders. The focus group is recorded and evaluated according to Mayring (2014), employing

a deductive approach. The codes are assigned based on derived design principles covering potential, challenges, and functionalities using MAXQDA.

15.3.1 Awareness of the Problem and Suggestions

For the steps of awareness of the problem and suggestions, we conducted ten expert interviews from different organizations. Experts are characterized by their active involvement in the field of citizen participation, where they conduct, review, or manage them and the analysis of citizens' inputs. Therefore, they possess detailed knowledge and operative expertise that are relevant to answering the RQ. We used a semi-structured questionnaire to elicit issues in analyzing citizens' inputs. We asked the experts to explain their overall participation and data collection process and, in detail, how they conducted the analysis, including the preparation steps and challenges.

No.	Position	Type	Duration	Planned
E1.	Project Leader and Urban Expert	District Office 1.	100 min.	60 min.
E2.	Project Manager	District Office 2.	70 min.	
E3.	Project Leader and Urban Expert	District Office 3.	110 min.	
E4.	Project Leader	District Office 4.	80 min.	
E5.	Project Leader and Urban Planner	Company 1.	22 min.	
E6.	Research Associate	Company 2.	88 min.	
E7.	Project Manager	Company 3.	56 min.	
E8.	Project Leader and Urban Planner	Company 4.	54 min.	
E9.	Project Manager	Company 5.	63 min.	
E10.	Sociologist	Company 6.	77 min.	

Table 1. Participants Overview of the Expert Interviews

During the analysis of the expert interviews, the deductive codes were extended for additional functions as well as solution ideas for the design of interfaces, such as keyword searches, categories, goals, target groups, standards, and more. In total, we marked more than 400 passages in the documentation of the expert interviews, identified eleven issues, formulated nine meta-requirements, and derived four design principles (cf. Table 1).

The first issue predominantly highlighted by all experts is the lack of time (ISS1) given the temporal pressures imposed by project stakeholders like customers, managers, policymakers, and citizens and pertains to the time between data collection and provision of the analysis (Stelzle et al., 2017). Furthermore, many further processes are contingent upon the results. This correlates with the lack of efficiency (ISS2) mentioned in the literature (Romberg and Escher, 2023) and the experts.

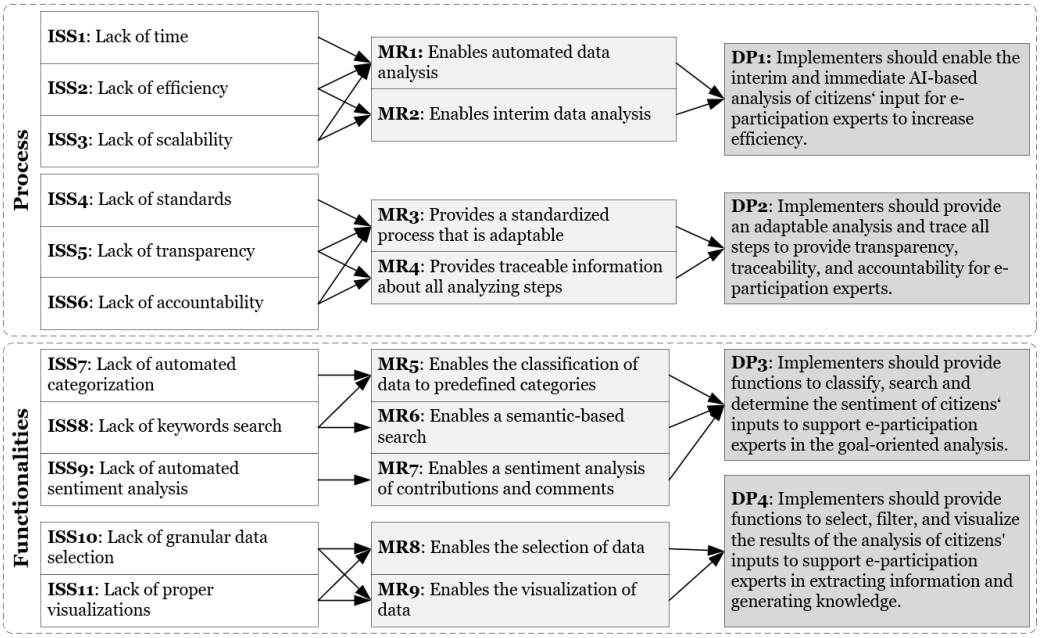


Figure 2. Overview of Issues (ISS), Meta-Requirements (MR), and Design Principles (DP)

Expert E1 stated, "We have this huge pile of 1,000 arguments, and you start to read them and begin to understand the ideas of the citizens. That alone takes time and is incredibly exhausting because it is totally monotonous." (E1), which can also promote mistakes. In addition, the required time correlates to the amount of data, which results in a lack of scalability (ISS3) (Alahakoon et al., 2023). This is particularly problematic in large participatory projects in urban areas and large cities (Royo et al., 2020). ISS1, ISS2, and ISS3 lead to the meta-requirement that enables automated data analysis (MR1), where all experts see a potential for AI, as many of the time-intense analyzing steps are monotonous and recurring. In addition, ISS2 and ISS3 also lead to MR2 enabling interim data analysis, which is currently hardly possible and usually only conducted on numeric data. The idea behind this is to clarify in which direction participations are going and whether they are far from the objective and valuable. Therefore, participation experts can act and communicate additional details to participants and clarify open questions during the participation (E1, E4, E7, and E10). Together, these issues and two meta-requirements lead to the design principle:

DP1: Implementers should enable the interim and immediate AI-based analysis of citizens' input for e-participation experts to increase efficiency.

According to Gregor et al. (2020), design principles should specify the target group. Due to the different roles and expertise that are required for the development of a comprehensible application, we use the term implementers in all design principles. These can be full-stack or specialized developers, such as machine learning experts and interface designers.

The literature and the different descriptions of the data analysis by urban experts have underscored a lack of standards (ISS4) (Pitogo and Ramos, 2020), whereby the approaches overlap to some degree. This is inherent, considering that the analysis depends on the objective and size of the participation. However, the reinvention and adaption of data analyses make it challenging for experts of the same company and novices to work consistently, which can result in deviating interpretations, which also correlates with the described lack of transparency (ISS5) highlighted by E5, E6, and E7. In addition to that, the analyzing process often lacks accountability (ISS6), as the experts told us that they are quite often working with Excel or other simple tools to structure and visualize data, which does not store detailed information about changes and the responsible persons (E4 and E6). Consequently, in practice, senior experts occasionally have to review the results to ensure consistency and correctness, which enhances ISS1, ISS2, and ISS3. ISS4, ISS5, and ISS6 culminate in the need for an adaptable standardized process (MR3) since participation projects require adjustments depending on their focus and size (Stelzle et al., 2017), including traceable information about all analysis steps (MR4). These considerations lead to:

DP2: Implementers should provide an adaptable analysis and trace all steps to provide transparency, traceability, and accountability for e-participation experts.

Besides process-specific requirements, the experts emphasize many issues and a high potential for AI. They revealed that “a first step would be the tagging and categorization of words depending on the content” (E5), which is founded on a lack of automated categorization (ISS7). At the outset of participation or, at the latest, during the analysis phase, urban experts and project stakeholders create categories relating to the areas of interest for subsequent decision-making. These categories are usually content-based and concern topics like car-free zones or mobility, among others. Citizen contributions are assigned to these categories to provide structure and identify their significance based on the frequency of mentions. According to experts, these categories can vary across different participatory projects, although our analysis showed an overlap as themes like mobility and housing are recurring, which should be considered in ISS4. Depending on the context, these themes may be further subdivided, for instance, to distinguish between different modes of transportation. In addition to ISS7, “it would also be helpful to search for examples like citizens who would like to have more bicycle parking lots in the city and to understand the reason strengthen recommendations” (E1), which results in a lack of keyword search which enables the comparison of submitted statement with citizens’ inputs to find phrases of interest (Lieven et al., 2021, E1, E6, E7, E9 & E10).

Furthermore, nearly all experts have described the lack of automated sentiment analysis (ISS9). Currently, they usually conduct these manually as far as possible because citizens' intentions are not always obvious or determinable (Simonofski et

al., 2021), so their contribution is usually marked as neutral. However, “a sentiment analysis would enable us to see if citizens are positively or negatively positioned against a specific topic to find out what is controversial and need further inspections” (E6). ISS7 to ISS9 specify functions for data analysis, which have been transferred into meta-requirements MR5 to MR7 (cf. Figure 2). These meta-requirements are condensed into the third design principle.

DP3: Implementers should provide functions to classify, search, and determine the sentiment of citizens‘ inputs to support e-participation experts in the goal-oriented analysis.

Another further challenge lies in the lack of data selection and filtering, which is described by ISS10 (cf. Table 1). The existing workflows, as described by the experts, do enable manual selections since they do not follow any standards (ISS4). However, this should be achieved with an AI-based tool, as urban experts and analyzers are required to select and filter data to search for similarities, location, or demographic-specific differences. Another substantiated lack is the lack of proper visualization (ISS11). These are often created in Excel or similar, focusing on and representing the main findings, and are used to present the participation, project reports, and supplementary materials (Bachiller et al., 2021). This hinders interim evaluations and exploratory work, which might deepen the analysis and, therefore, should be included in an AI-based approach, as the creation of visualizations is time-intensive and static (E1, E7, and E10). ISS10 and ISS11 lead to MR9, which encompasses precise data selection, including contributions or discussions, and MR10, which aims to automate visualizations (cf. Figure 2). Both are crucial, particularly for knowledge extraction and sense-making (Romberg and Escher, 2023), where experts capture the sentiments and trends of citizens to derive requirements, visions, and recommendations. They interact extensively with the dataset in this context (Hagen et al., 2019). Consequently, these requirements are condensed into the design principle:

DP4: Implementers should provide functions to select, filter, and visualize the results of an analysis of citizens' inputs to support e-participation experts in extracting information and generating knowledge.

15.3.2 Development

To instantiate and later evaluate the derived design principles, we developed a web prototype as the IT artifact. The ML models and web prototype were developed in Python using the IDE PyCharm and are mainly founded on the Python libraries Flask, Haystack, and Scikit-learn. The program was deployed and hosted using one of our university's Linux web servers.

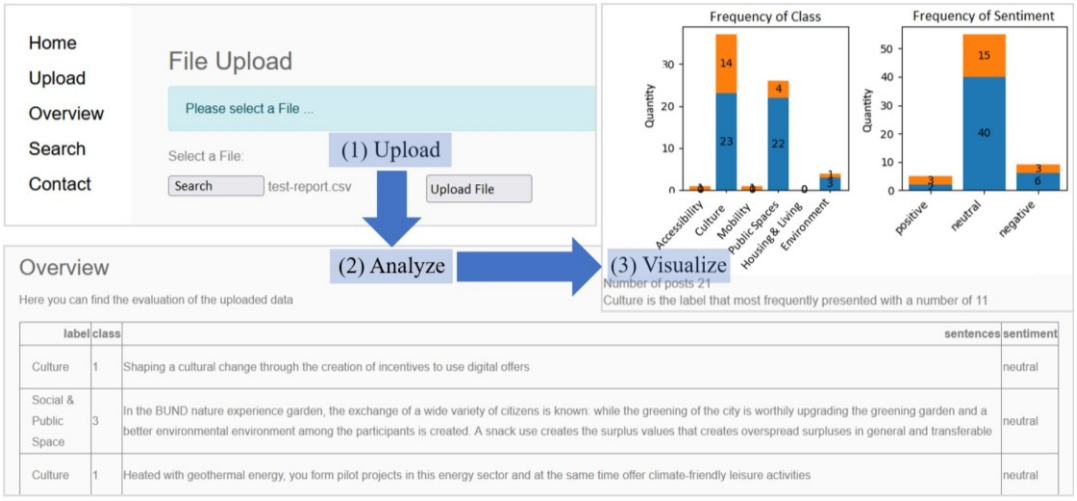


Figure 3. Classification of Citizens' Inputs in the Web-Prototype

According to DP1, an AI-based IT artifact should enable immediate analyses. To achieve that, we rely on ML models. Building upon the work described in Section 2.3, we can develop a new ML model or use existing ones if the required functionalities are available, which did not apply considering DP3 (Alahakoon et al., 2023). DP2 describes the customizable use of the analysis, which the prototype considers as the evaluation functions that can be applied individually to different data sets. Therefore, to analyze citizens' inputs, as shown in Figure 3 (left), experts can upload a dataset in the CSV format regarding a predefined structure, analyze it, and then download the results, again, as a CSV file to further process or evaluated it manually or with further tools. For the classification function, as stated by DP3, we collected data from two public participations from two cities containing 2,008 citizen contributions. To enable the training of an ML classifier, we paid two students who received a manual and short training to label the data according to the six categories of accessibility, culture, mobility, public space, housing & living, and environment (cf. Figure 3, top right). Afterward, the authors manually validated all labeled entries and further reduced them to 1,722 citizen contributions, as some inputs were unassignable, too short, or pointless. For the training of the ML model, we carried out the preprocessing according to the standard in natural language processing (NLP) and applied the widely used vector-based language model SpaCy (Honnibal, 2017), representing words with vectors of 300 dimensions, enabling us to train ML models with text (Jugran et al., 2021). As a classifier, we used a Support Vector Machine (SVM), which is generally more accurate with high-dimensional data representation than decision trees (Pisner and Schnyer, 2020). From the dataset, we used 80% (1,377) of the entries for training and 20% (345) for testing. In addition, cross-validation with a fold of five was used to evaluate whether the selected data or its order influenced the model's reliability (Refaeilzadeh et al., 2009). The standard deviation of the cross-validation is 0.03, which shows that the order of the data had no influence. The best-trained ML model had an accuracy of 0.61 (61%). This

certainly can be improved, but it shows that classifying citizens' inputs is possible with a small amount of data and a limited number of classes, which is sufficient for evaluating DP3 (cf. Figure 2).

For the implementation of the sentiment analysis (DP3), we followed a similar approach. Sentiment analyses are widely used, and many scientific publications have examined different approaches. To enable this, we integrated an existing German sentiment model from hugging face, based on the language model Bert, into our prototype (Jain, 2022), which enables positive, negative, and neutral sentiment analysis, as shown in Figure 3 (right).

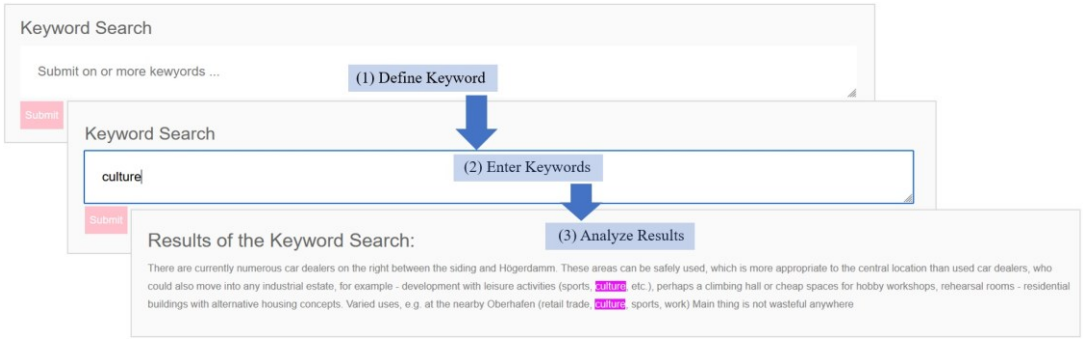


Figure 4. Keyword Search of the Web-Prototype

In addition to the classification and sentiment analysis, DP3 also states that the IT artifact should provide a search function. This is made possible with the help of the Python library Haystack, which we integrated via a Docker container. Haystack can index text to enable a search, for example, for question-answer responses and, in our case, to enable the comparisons of words and sentences (Haystack, 2023).

Finally, DP4 states that proper data selection and filtering are required. This is possible and only depends on the selection of data as described by Arana-Catania et al. (2021), Coenen et al. (2019), and Mariani et al. (2023). We considered that with the upload and download of the data in terms of a CSV file, which can be adjusted, knowing that an extension of the web-web interface with explicit filters might be more efficient but less interoperable.

15.3.3 Evaluation

To evaluate the derived design principles, we conducted a focus group (Tremblay et al., 2010), as described in Section 3, to collect qualitative data about the IT artifact or prototype. This was done with seven experts who differ from the expert interviews (cf. Section 3.1) to include further independent perceptions and increase validity. The participants are from the domain of data analysis, software development, citizen participation, and urban informatics. Therefore, they have a more technical background than the interviewed experts (cf. Table 1). The authors recorded the conduction of the focus group, and the transcript was analyzed as described in Section

3 according to Mayring (2014) by coding relevant statements, which was done in MAXQDA and transferred into a code-relation matrix.

No.	Expertise	Gender	FG Planned	FG Duration
P1.	Software Developer	Male	45 min.	47 min.
P2.	Human-Computer Interaction Expert	Female		
P3.	Urban Sinology Expert	Female		
P4.	Urban Informatics Developer	Male		
P5.	Software Developer	Female		
P6.	Business Model Management and Development	Male		
P7.	Project Manager and Participation Expert	Male		

Table 2. Participants Overview of the Focus Group

15.4 Findings and Implications

In this Section, we elaborate on the findings of the focus group following the four derived design principles and our coding of them as described in Section 3. The focus confirmed many requirements and design principles but also highlighted further needs and adjustments.



Figure 5. Code-Relationship Matrix of the Focus Group by MAXQDA

The automated content analysis was implemented using AI and its subclass ML and was approved by many participants. There is no commitment to specific technologies, so DP1 can also encompass rule-based solutions, provided they reliably provide the tasks according to the design principles. However, participants P4 to P7 also emphasized the importance of traceability and the necessity for the user to believe in the results and the ML models; otherwise, they might be skeptical about their usage. This is founded and of particular significance in large-scale urban planning participation, where subsequent construction projects or similar are often associated with political decisions and high costs. AI-based analyses must be well-founded and could help provide exemplary statements to show how the systems work. Although a comparison of the efficiency of manual and AI-based analysis was not conducted, the participants described the increase as significant. This is also reflected in the applied code from the qualitative analysis according to Mayring (2014) in Figure 4 in row potential, DP1, and DP3. In Figure 4, a significant correlation of the codes on the vertical and horizontal is highlighted with a larger square. If there is no match, this is omitted.

The traceability of the analyzing process relates to DP2. The developed prototype provides three analysis functions, whereby the classification and sentiment analysis are always carried out in combination. The participants confirmed that this is comprehensible and that the transparency of this process is valid. At the same time, many questions were asked about the development and training of the AI model, and only some people agreed with the results of the ML classifier. As stated, "The table is good, and I can see the classes for each contribution, but I don't understand how the model came up with it and how reliable this is." (P7). Therefore, an IT artifact should provide further information about the ML model, its training, and possible visualizations in the form of decision trees and static or interactive visualizations. The visualizations in terms of functionality address the aspects of understanding and explainability of the automated data processing and led us to derive a fifth design principle:

DP5: Implementers should provide information and measurements about the applied ML models to support their comprehensibility and explainability to e-participation experts.

The focus group participants validated DP3 and highlighted the demand for the included functions. However, the instantiation of DP3 only partially considered the participants' expectations, and further functions are required. The statement, "At the broad level, the sentiment analysis helps me see trends and controversies. However, if I have inputs from participants which address more than one topic, it gets mixed up" by P2. The further elaborations of P4, P6, and P7 describe that the current sentiment analysis enables the identification of overall trends across participants but also simplifies the analysis to an extensive degree. Longer contributions from citizens often address multiple topics or classes, depending on the analyzing process of the project and expertise. The blanket determination of sentiment thus turns two positively described topics and one negatively described topic into a positive statement. While this is "helpful for a rough direction, as I can see a general trend" (P6), it is insufficient. It requires an automated breakdown of contributions to the topics and their meaning, the sentiment of which can be determined separately. Therefore, to fully implement DP3, the classification should be enabled with sentiment analysis on (1) contribution level, but also on (2) topic level, which represents parts of citizens' contribution, and (3) without the classification. The latter would enable experts to search for changing and very specific topics and define the sentiment, e.g., the position of the participants, which could strengthen the analysis in considering local aspects. Therefore, we adjust DP3 to:

DP3: Implementers should provide distinct and combinable functions to summarize, classify, and determine the sentiment of citizens' inputs to support e-participation experts in the goal-oriented analysis.

The elaboration of the search function, as shown in Figure 4, validated the demand but also highlighted the possibility of using this in combination with the other function, which the adjustment of DP3 covers. As illustrated in Figure 5, DP3 is perceived to hold significant potential but also presents a considerable challenge. Further discussions regarding the use of AI or ML pertained to data preprocessing before further processing and categorizing content without classes. In preprocessing, steps that follow the upload were particularly mentioned, such as identifying duplicates and concise contributions from citizens, which are typically excluded manually. This leads to the formulation of a sixth design principle:

DP6: Implementers should enable the identification of duplicates and meaningless citizen inputs to enhance the data analysis of e-participation experts.

Additionally, P6 and P7 discussed the categorization of content without classes. This could be beneficial for approaching the evaluation without expectations and exploring the contributions of citizens in an exploratory manner. However, there needed to be more consensus in the discussion, and this approach also contradicts that of Stelzle et al. (2017), who outlined the participation processes and emphasized the objectives of projects that are crucial for participation and evaluation, thereby following knowledge generation in specific areas (Romberg and Escher, 2023).

The visualization of results included in DP4 is highly relevant, as the overlap of the codes in Figure 5 shows. The potential for further visualization is high and correlates with the functions that have already been described. It should enable the summarization and visualization of results in figures or highlight specifics via different colors. In addition, numerous filters should be added, which might also be stored for experts or projects, as this could support the creation of reports and standards. This also affects the self-explainability of our instantiated IT artifact. For example, in Figure 3 (right), it was not apparent that orange highlights the added and blue the already analyzed entries, e.g., citizens' inputs. Overall, DP4 was approved, and the elaboration during the focus group considering DP4 has quickly moved to an operational discussion with a less scientific view, as the design of figures and tables is relatively straightforward.

15.5 Discussion

In answering the RQ, "How to design IT artifacts to support the AI-based analysis of citizens' inputs from e-participation?" (cf. Section 1), we identified eleven issues through the expert interviews, formulated nine meta-requirements, and derived four design principles. In addition, we used these to develop an AI-based web prototype, which we evaluated to validate the design principles, adjust them, and derive two additional ones. The findings highlight the great potential of applying AI and ML to analyze citizens' inputs from e-participation, which was also reflected in the vast

interest of the experts in this work (cf. Table 1 and Table 2) and specify the design appropriate IT artifacts.

The evaluation revealed some adjustments that primarily address the instantiation of DP3. The expert interviews revealed that many companies assign several classes or divide inputs into semantic segments (Quintero-Angulo et al., 2020). Therefore, longer inputs that address multiple topics are weighted more heavily in the evaluation than shorter ones. This can increase the weight of very active citizens, which is challenging considering democratic principles (Arana-Catania et al., 2021). To solve this, a preprocessing or ML model that structures contributions similarly to n-gram, preparing them for meta- and micro-level classification, is needed to enable more detailed analyses (Müller, 2021; Romberg and Escher, 2023). Another challenge is that classification depends on predefined classes, and the experts state that these can change from project to project to consider local characteristics (Mityagin et al., 2021). This enhances the training of proper ML models, as a sufficient amount of data is needed to train reliable models (Pisner and Schnyer, 2020; Romberg et al., 2022). Even if classification is promising, adjustments are expensive without standards or publicly available models. In addition, the finding that all interviewed experts analyze citizens' inputs by assigning them to predefined categories created based on the project and participation objective, as stated by Stelzle et al. (2017), contrasts the potential of clustering algorithms (Li et al., 2019). From a technical perspective, clustering could be used as a flexible approach to identify topics inductively and, therefore, quite flexible from citizens' inputs (Bachiller et al., 2021). However, even if our findings do not highlight this, considering the existing knowledge base, we are confident that clustering can be used in this area (Bachiller et al., 2021).

Besides the typical ML approaches, the categorization needs to be scrutinized further. Even if this corresponds to the current use and successfully supports experts, it should also be determined whether an AI-based approach can support data interpretation. To this end, large language models need to be investigated to summarize and interpret results and, if possible, to support classifications (Fu et al., 2023), as generative AI is highly capable and could be an alternative or additional approach for urban and participation experts, companies, and governments as described by Wang et al. (2023). This would significantly increase flexibility, even if the explainability and transparency of the analysis would decrease as large language models are black boxes. In addressing further research, our six derived design principles are currently of limited validity, which should be faced in the next DSR cycle, including a quantitative elicitation of requirements following an experiment to gather further data and examine the increase of efficiency in comparison to the manual analyses and different instantiation of the design principles. This mainly affects the evaluation of DP3, DP5, and DP6 but should also shift this work's focus from pure design to the usage of the developed prototype and the behavior of experts according to the action

design research paradigm (Gregor et al., 2020). Regarding the DSR paradigm and the movements of DSR project architectures described by vom Brocke et al. (2020), this corresponds to an amplification and contextualization that strives for the use of the IT artifact in real-world scenarios and also supports the development of a new design theory.

Alongside the further development of the IT artifact, a closer examination of current and possible analyzing processes to create standards and extend the minimum viable process of Stelzle et al. (2017) and Münster et al. (2017) is promising. In combination with AI- and ML-based tools, this could have a considerable impact, as many companies and governments are active in citizen participation and depend on proper guidelines, frameworks, and (design) theories (Mariani et al., 2023; Romberg and Escher, 2023). Furthermore, there is a huge lack of publicly available labeled and non-labeled data and trained ML models in this domain. This gap should be reduced and primarily addresses computer science and urban informatics research (Koumetio Tekouabou et al., 2021). In addition to that, as stated in Section 4 in the presentation of the results of DP2 and DP3, the transparency of the application of AI and ML is of enormous interest. This addresses aspects of explainability, visualization of AI, and ML (Ghai et al., 2021) as well as human-AI interaction and knowledge creation (Becker et al., 2022) and demands further elaboration from the discipline of information systems, which also tackles privacy concerns and organizational aspects.

Together, the six derived design principles support stakeholders in the field of e-participation and urban planning as well as developers in this area and thus contribute to the more efficient and comprehensible analysis of citizens' inputs. The consideration of existing literature supports our findings, which expands the existing knowledge base. The call for further research is to be understood as a research agenda that we, and hopefully further researchers and practitioners, will consider.

15.6 Conclusion

In this paper, we present the results of the first cycle of an ongoing DSR project focused on designing AI-based IT artifacts to support the analysis of citizen inputs from e-participation in urban planning. The demand for automatized solutions is high as the quantity of e-participation and the number of participants has increased in the past few years, making the manual analysis of qualitative data challenging in terms of costs, time, and consistency (Romberg and Escher, 2023).

Following the DSR paradigm by Vaishnavi and Kuechler (2004), we conducted ten expert interviews, which were analyzed according to Mayring (2014) and led to the identification of eleven issues, the formulation of nine meta-requirements, and the derivation of four design principles. We instantiated them by developing an AI-based web prototype for which we trained a new ML model. In addition, we used two

existing models to enable a sentiment analysis and keyword search. The web prototype was evaluated with a semi-structured focus group with seven participants from related domains. The findings confirm our design principles regarding the analysis of citizens' inputs by AI and the documentation of changes to support transparency, traceability, and accountability. The elaboration on the provided functions also highlights the possibility of combining and extending them as the explainability and trust in AI, e.g., ML, is required, which led to the deviation of a fifth design principle. In addition, we also formulated a sixth design principle, as the preprocessing of data in terms of cleaning should be conducted automatically, which requires further research and the development of an additional and more accurate classification system, interactive, and user-oriented visualizations (Cai, 2021).

Conclusively, our findings extend the existing knowledge base regarding design principles and an initial design theory for developing AI-based IT artifacts to support the analysis of citizens' inputs from e-participation. In addition, we describe the demand for further research, considering the lack of available data and trained ML models, their explainability (Ghai et al., 2021), and human-AI interaction in e-participation addressing different disciplines (Fu et al., 2023).

15.7 References

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16 Publication C7: Hear Me Out: Supporting Citizens to Create Comprehensible Contributions on Urban Participation Platforms

Conference on Computer-Supported Cooperative Work and Social Computing (CSCW)

Track: Social and Crowd Computing
Completed Research
Ranking: B

Research Question

How to support citizens in creating comprehensible contributions on urban participation platforms?

Contribution to the Dissertation

This publication contributes to the overall RG, especially RQ1, by describing three prototypes that were compared and evaluated, and by examining different approaches to including citizens on urban participation platforms. In doing so, interactive features and AI-based feedback are explored, including an automatic submission analysis that provides real-time feedback contributing to RQ2. According to the design science research paradigm, ten issues, eight meta-requirements, and three design principles were described, which were then extended to five design principles after evaluation.

Citation

Borchers, Marten; Soroko, Daria; Tavanapour, Navid; & Bittner, Eva (2024). Hear Me Out: Supporting Citizens to Create Comprehensible Contributions on Urban Participation Platforms. In: *Proceedings of the ACM on Human-Computer Interaction, Volume 8, Issue CSCW2, Article No.: 432, Pages 1 – 26*. https://doi.org/10.1145/3686971. Completed Research.

Abstract: *Urbanization has increased societal tensions and led to the growth of citizen participation in urban planning, which is often conducted in computer-supported environments and progressively online to include a high number of citizens. Past projects have shown that digital participation creates new challenges and that collaborative online discussions do not achieve the quality of on-site scenarios, as the interactions, in-depth exchange of opinions, and quality of contributions vary. Within a design science research project, we examine how to support citizens in creating comprehensible contributions on urban participation platforms. We identify issues, formulate meta-requirements, and derive design principles to implement feasible prototypes that we evaluated in focus groups. Our findings extend the existing research about urban participation platforms in civic tech, urban informatics, and planning, with validated design principles that specify AI-based feedback and further features to increase interactions and support citizens in producing more specific contributions.*

Keywords: Urban Planning Platforms, Citizen Participation, Civic Tech, Machine Learning, Design Science Research

16.1 Introduction

Urbanization has exacerbated tensions between citizens, governments, and investors [63], and recent studies forecast that this trend will continue until 2050 [103]. Therefore, the demand for new methods and tools to develop citizen-centered and livable cities to support social harmony is highly important [112] and has led to the increasing development of civic technologies (civic tech). Governments, public institutions, and companies use these to integrate citizens to elicit local requirements and demands, which are considered in the development and decision-making of urban projects [97].

In the context of growing cities and their increasing complexity, the use of electronic participation (e-participation) approaches and tools has steadily increased, replacing their less efficient analog counterparts [70, 79], which led to the development and use of urban participation platforms like CONSUL [83], DECIDIM [85], DIPAS [54] to mention only a few. E-participation approaches and urban participation platforms remove spatiotemporal limitations, enable organizers to reach a larger swath of the population, and automate data collection [62]. This can lead to more appropriate urban solutions (e.g., construction- or social projects), a higher project acceptance, and can increase trust in civic tech, public services , and governments, especially if citizens feel appreciated and valued [29, 80, 87].

Past projects have shown that different challenges occur when using urban participation platforms and that it is difficult to achieve the described benefits and objectives [97]. This is attributed to a lack of corresponding infrastructure beyond informing and collecting data via surveys and polls [98] and features that support interactions and in-depth exchange in a fully digital environment [62, 72]. In addition, as the communication and interactions in fully digital environments are usually text-

based and anonymous [24], citizens rarely receive any follow-up and proper feedback for their contributions, which can result in a lack of motivation [92, 94], interest, and conviction that their participation and contributions will create value and will be considered. Moreover, communication occurs asynchronously, as citizens can participate over several weeks, resulting in limited possibilities to enable low-threshold exchange and in-depth discussions, as dialogues rarely resume later [24]. These shortcomings toward contributing and creating public value become particularly apparent compared to on-site discussions, in which citizens can immediately react to each others' input [7, 28, 82]. Providing moderators for the whole duration of e-participations would be a solution, but as they are quite expensive, they are usually absent in fully digital environments [93, 99]. Therefore, innovative features to support and include citizens on urban participation platforms are required to motivate and elicit more useful and helpful contributions from citizens, fostering the development and design of urban projects [43 ,62, 82]. This situation gives rise to possibilities for computer-supported cooperative work and human-computer interactions in the domain of urban informatics as described by Foth et al. [32] and addresses innovative solutions in which artificial intelligence (AI) can be of great value as already examined in other areas [46, 76].

Following this, we examine the research question (RQ) of *how to support citizens in creating comprehensible contributions on urban participation platforms?*

To address the RQ, a design science research project, as described by Kuechler and Vaishnavi [50], is conducted. Existing literature about urban participation platforms was analyzed to identify issues, formulate meta-requirements, and derive design principles according to the specifications of Gregor and Jones [35]. Based on the design principles, we developed three web-based prototypes to instantiate supportive features for participants. We qualitatively evaluated them in a series of focus groups and used the SWOT method to analyze the results [86]. Our findings show that the developed and later, through focus groups , reviewed and added design principles that serve as guidelines to develop intelligent and interactive urban participation platforms.

The paper continues with the Section related work (cf. Section 2) , followed by the description of the method and design (cf. Section 3). Section 4 documents the prototype's design and development, followed by their qualitative evaluation (cf. Section 5). In Section 6, the findings are described and discussed in Section 7. Finally, Section 8 summarizes this work and highlights our contribution.

16.2 Related Work

Urban planning has historically been an expert-centered process. However, as urban areas grow in size and complexity, so do the need and importance for citizen

participation [13, 26, 41, 64]. The participation approach, scope, and execution of citizen participation, as well as the projects' alignment and vision, depend on the responsible parties, e.g., governments, institutional investors, or private individuals [63, 97]. They do not necessarily originate from social responsibility or grassroots democratic ethos [12] and can follow economic interests, as any resistance from the public and politicians [63] can delay or prevent the implementation of urban projects negatively affecting the return on investment [20, 106]. Besides that, citizen participation can also increase the value of urban projects by meeting citizens' demands, which reduces risks [81]. Civic tech and the field of digital civics investigate the mechanisms and technologies by which the desired level of citizen engagement can be achieved.

16.2.1 Civic Tech

According to Hamm et al., the term civic tech describes the technologies "put at the service of citizens and communities" [38, p. 2], while McCord and Becker [59] argue for a more holistic definition in which civic tech "captures not only sets of technologies but practices that use and design technological artifacts to create speculative relationships between civilians and states" [59, p. 9]. Therefore, civic tech can be described as a cross-disciplinary field that examines how to enable and empower citizens to exercise their right to participate in the decision-making processes concerning their immediate surroundings as well as in shaping their relationships [108]. In doing so, civic tech provides computer-supported and additional technical approaches, e.g., for citizens and authorities to engage in discussions concerning common issues and form mutually beneficial partnerships [108]. However, this can be archived differently and in the context of different levels of citizens' influence and processes, which were conceptualized and evaluated by researchers and practitioners and which we use as a baseline.

16.2.2 Levels of Citizen Participation

One of the most well-known pioneer in citizen participation and collaboration is Sherry Arnstein, who worked and contributed to various urban projects. In 1969, Sherry Arnstein published "A Ladder of Citizen Participation" [91], in which she divided participatory approaches into eight levels consisting of manipulation, therapy, informing, consultation, placation, partnerships, delegated power, and citizen control with the ascending influence of citizens. The ladder was used to classify urban participation projects, manage expectations, and support participation [33, 91].

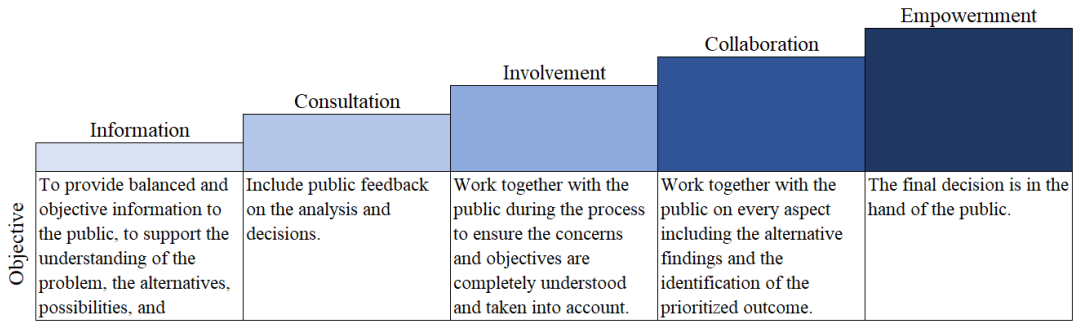


Figure 1. Levels of Citizen Participation [111] (illustration based on Stelzle [99])

Wouters et al. [111] criticized the existing model and argued that citizens' demands and ideas should be considered and always taken seriously in participatory approaches, as otherwise, the methods should not be framed as participatory [63, 113]. Instead, the authors proposed a revised model of the levels of citizen participation, as shown and described in Figure 1, which excludes non- and pseudo-participation.

16.2.3 Participatory Urban Planning Process

Alongside the models presented above, Stezle et al. proposed a process model for incorporating citizens and other stakeholders in urban projects, which has also been tested and applied in practice [68, 96]. The authors developed, described, and evaluated what they call a "minimal viable process" (MVP) for citizen participation in urban planning [97], summarized in Figure 2.

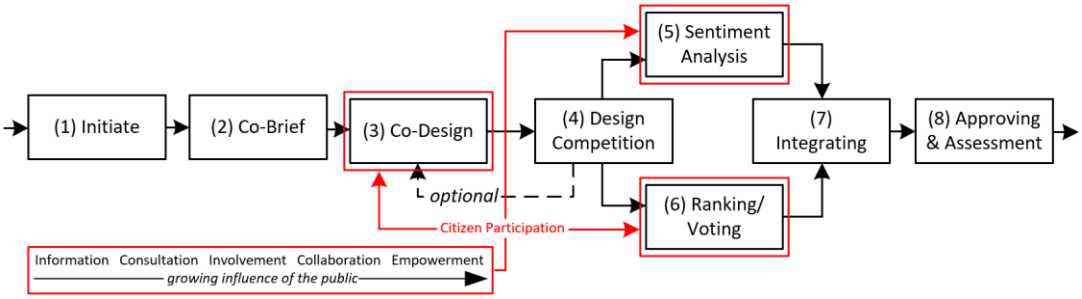


Figure 2. Minimum Viable Process for Urban Citizen Participation

The MVP begins with (1) initiating the urban project and assembling or hiring a project team. In step (2) (co-brief), the project lead's requirements and objectives are documented and prioritized with further stakeholders, e.g., designers and planning authorities, considering the scope and impact of the project and the spectrum of the planned citizen participation (cf. Section 2.2). This lays the foundation for (3) co-design, where citizen participation is conducted analogously, digitally, or both. Depending on the citizens' demographics, location, and group size, their needs and opinions can be collected through information booths, workshops, (online) surveys, contests, social media, and participation platforms, sometimes with the use of integrated 3D models and VR [4 , 68, 97]. It is highly recommended that citizens are

provided with feedback to reconsider their contributions and to facilitate the exchange of opinions with other stakeholders [64]. At the end of the co-design, the results are evaluated and synthesized to determine the strategic alignment of the urban project for architects and designers. If the results are unsatisfying, incomprehensible, or contradictory, it is possible to repeat the co-design phase and minimize or extend the participatory approach by increasing or reducing citizen involvement. In step (4), different project visions developed based on previous results by architects and urban planners are published to elicit further feedback on the now more specific vision from citizens via voting and comments using digital participation platforms. Later, in step (5), the comments and in step (6), the results of the voting are analyzed and integrated (7) into a comprehensive urban project design. This has to be approved (8) by the project lead (e.g., investor) and planning authorities (9) to verify that all regulations are respected and that the necessary permits can be granted [97].

Urban participation platforms can be used to accommodate steps (3), (5), and (6), considering different levels of inclusion and impacts, as described in Section 2.2, being the primary communication and information platform. While the ladder of citizen participation determines citizens' influence, the MVP describes the more concrete implementation and decision-making process of including them in civic projects. Both models are suitable for on-site, digital, and hybrid participation [97, 111]. The models should be considered in urban planning projects, including computer-supported collaborative work systems for participants, as intended, with urban participation platforms to support and unlock the benefits of e-participation [54, 94]

16.2.4 Urban Participation Platforms and AI

The growing scale of participation platforms and increasing usage make it challenging to moderate online discussions and analyze contributions in real time [55, 85]. As a result, we observe an increase in automated, intelligent, e.g., AI- and ML-based approaches for content analysis and moderation to identify hate speech and conduct fact-checking, comparable to the efforts in social media [17, 44]. Lieven et al. [55] applied ML and natural language processing (NLP) methods to citizens' contributions from the urban participation platform DIPAS to automatically link and merge similar content to summarize [17] and create further information for architects and urban planners to support (3) co-design and (5) sentiment analysis (cf. Figure 2) [67]. Bachiller [10] focused on visualization and used clustering methods to identify citizens' interests connected to specific districts to highlight local differences. In Spain, a similar approach was implemented to identify which urban projects citizens were most interested in and involved in on the urban participation platform DECIDIM in Madrid to recommend similar projects to increase participation [19].

Considering related disciplines, AI-based chatbots could also be of interest in increasing user interaction and supporting online discussions [17].

Overall, AI-based methods to automatically analyze citizens' contributions have the potential to support citizens and reduce some of the challenges of urban participation platforms, as discussed earlier [18]. However, to our knowledge, no projects exist that use AI or ML to support citizens while contributing and documenting. This is important due to the often selective participation. Therefore, information should be elicited as comprehensibly as possible in a limited amount of time, as later inquiries are often impossible due to anonymous participation.

16.3 Method and Analysis

In investigating our RQ, we followed the design science research paradigm, which was conceptualized to support the structured and empirical development of (local) design theories by defining and evaluating design principles as described and applied by Kuechler, Vaishnavi, Gregor, and Hevner in numerous publications [25 , 36, 105]. After Kuchler and Vaishnavi [105] design science research proposes the five phases: *awareness of the problem*, *suggestion*, *development*, *evaluation*, and *conclusion*, as shown in Figure 3 (left), which are applied iteratively.

In *awareness of the problem*, the issues regarding the RQ are identified and described. In *suggestion*, meta-requirements are formulated, and design principles are derived. The consideration of the design principles in the development of IT artifacts should lead to the incorporation of the meta-requirements and, therefore, should reduce or solve the identified issues [102]. To verify this, developed IT artifacts are evaluated, for which Gregor and Henver [36] describe different evaluation approaches like focus groups, experiments, and simulations and differentiate in the fitness for the problem space, e.g., the issues and fitness for the solution space, e.g., the meta-requirements [104]. This iterative approach enables the examination and evaluation of the design principles through IT artifacts to create, redefine, and extend them with increasing validity [51]. However, each *design science research* phase needs to be specified, as different methods and implementations throughout the cycles are possible. The details of the applied cycles for this paper are shown in Figure 3 (right).

The first cycle began with a literature review after Kitchenham [48] to identify issues in citizen participation on urban participation platforms. Building upon these, we formulated meta-requirements and derived design principles. To do so, we followed the specification by Gregor and Jones [35], who state that design principles should include instructions for developers, a description of the context, the design principles goal, required operating mechanisms, testable propositions, usable features, and a short rationale for how it will be achieved by the features [35]. The derivation is based on the meta-requirements, the application context, and the objective [35, 107]. We

then used the design principles to develop *prototype 1* and *prototype 2*. *Prototype 1* serves as a baseline and corresponds to citizens' participation on urban participation platforms without any feedback. *Prototype 2* includes a new AI-based feedback system that aims to increase user interaction and should support submitting better contributions.

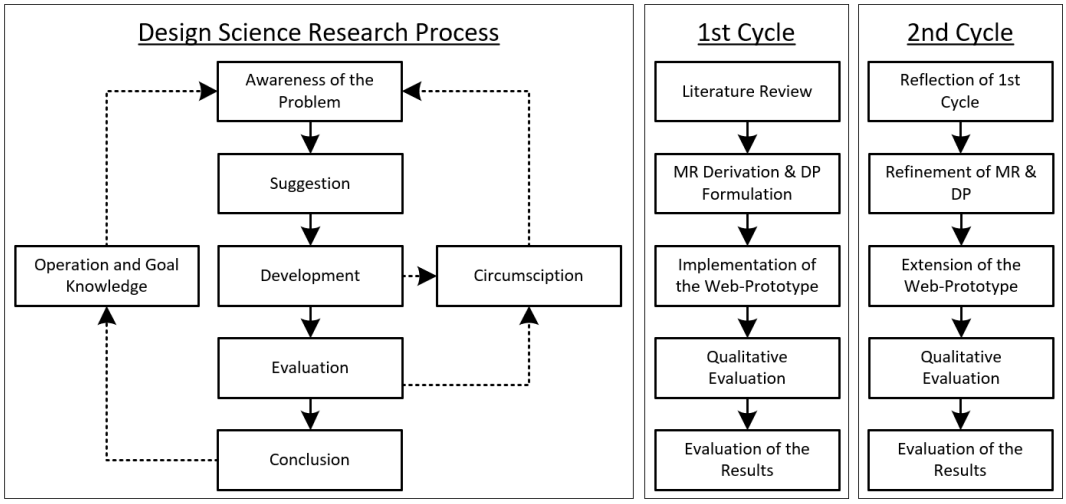


Figure 3. Applied Design Science Research (DSR) Approach according to Kuechler and Vaishnavi [105]

To determine to which degree the prototypes support citizens, as stated in the RQ, we followed a qualitative approach to elaborate in-depth on them and possible alternatives and variations with semi-structured focus groups, including a SWOT analysis [40]. The latter links the evaluation of the prototypes with the strengths and potentials regarding the solutions space and with the weaknesses and threats regarding the problem space [107]. In the second cycle, we reflected on the results and extended the design principles, which led to the development of *prototype 3*. We evaluated it following the procedure of the first cycle. Finally, we analyzed the results of all evaluations and derived complementary design principles for further discussion. The issues of the first design science research cycle were identified by conducting a literature review following Kitchenham's 5-step method [48]: identification of research, study selection, study quality assessment, data extraction, and data synthesis. When searching for relevant publications, we focused on the works published in the ACM Digital Library, ScienceDirect, IEEE Xplore, and Emerald Insight due to their technical, governmental, or societal character, which fits the RQ. To refine our search results, we used the following search string, which considers the variants and designations of urban participation platforms:

[["e-participation"] OR ["digital participation"]] AND [["urban planning"] OR ["urban design"] OR [["urban"] AND [platform]] OR [["digital"] AND [platform]]]

Our initial identification of research, according to Kitchenham [48], included 533 publications. After excluding non-accessible papers and duplicates, we analyzed the

abstracts of the remaining 282. The analysis of the abstracts showed that many publications consider e-participation in urban planning and design aspects from a strategic and conceptual perspective for governments and experts for smart cities. The remaining 60 publications were fully read and reduced by 27 further publications due to a lack of subject reference or quality (e.g., untraceable or nontransparent methods). The remaining 33 publications were systematically analyzed using MAXQDA following the qualitative content analysis method proposed by Mayring [58], applying a deductive-inductive approach. The literature review revealed that citizen participation facilitated with urban platforms provides many benefits, disadvantages, and issues.

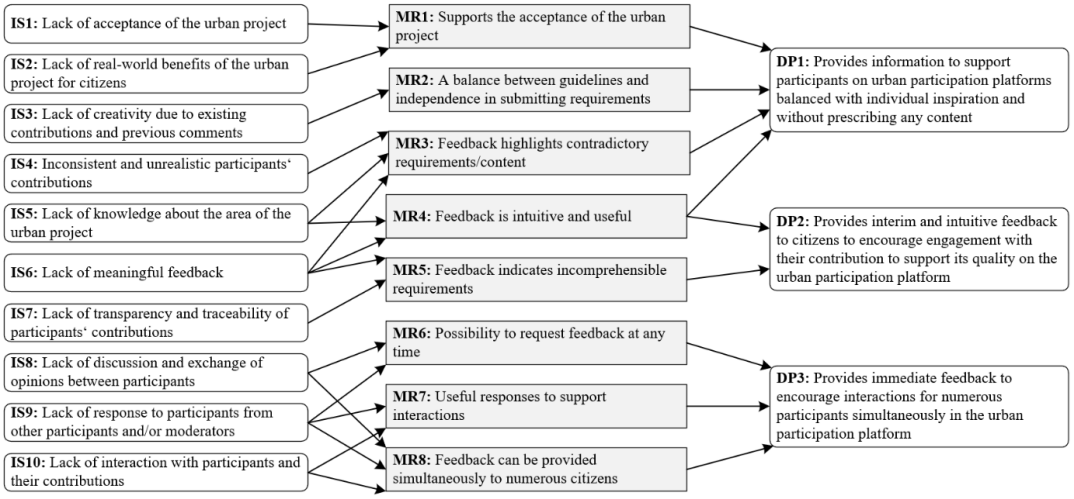


Figure 4. Overview of the identified Issues (IS), formulated Meta-Requirements (MR) and derived Design Principles (DP)

After identifying the issues, we discussed them to formulate eight meta-requirements and derive three design principles [35] describing how to support citizens in creating comprehensible contributions on urban participation platforms. Figure 4 shows the overview of all issues, meta-requirements, and design principles, including their relationships, described in detail in the following Sections.

16.3.1 Awareness of the Problem - Issues

Depending on the kind and stage of urban projects and considering the scope of the participation (cf. Figure 1) and process (cf. Figure 2), a common issue (IS) is the lack of acceptance among citizens for urban projects, which often varies (IS1) [82], especially, if the impression of superficial or non-participation and informing (cf. Section 2) occurs. If this is the case, citizens have the impression that they have no influence on the outcome and feel ignored and, in the worst case, cheated [82]. This is not in line with the idea and aspiration of citizen participation and co-creative approaches [49, 65], where citizens act as (co-)designers and (co-)authors of the project and, therefore, have a strong influence on the project [80]. This applies to analog and digital participation [6] and needs to be pretended regarding the RQ. In

addition, time is precious, and interests vary depending on the participants's life situation [6]. For example, care services for children or the availability of pharmacies and doctors are viewed differently by different groups [21], and the person's interest in participating varies fundamentally depending on the project's objective and simplicity to contribute [28]. This also correlates with time and on-site participation constraints [6], where it becomes challenging for the citizens to stay informed in their limited time. As a result, information campaigns often do not reach them [8].

Urban participation platforms and similar computer-supported channels are nowadays applied quite often, as many past projects lacked a real-world benefit and public value (IS2) [14] for citizens and society and were hindered or delayed during the construction by local resistance and legal complaints [88]. Figure 2 shows that citizen participation is conducted early in the project to elicit requirements and ideas [97]. This enables an open discussion, which can be constrained by the objectives of the responsible parties, the functionalities of the platform, and the submitted requirements of other citizens [85]. The latter can unconsciously influence participants and lead to a lack of creativity (IS3) as already existing requirements and ideas are often reproduced [61]. In addition, citizen requirements can be unrealistic (IS4) and ignore planning or building regulations and laws (e.g., accessibility of health care) [45, 99]. This may result in the exclusion of citizens' contributions, which decreases their influence on the project and, depending on the transparency of the participation process, can reduce the acceptance of the project, as IS1 describes earlier. This is also not in line with the grassroots democratic approach of citizen participation wisdom of the crowd [49, 99], which postulates to encourage citizens' participation as non-experts, even if they are not aware of building regulations and laws due to the lack of knowledge (I5) [23, 83].

The common absence of professional moderators on urban participation platforms, as used in on-site debates and workshops, creates a lack of meaningful feedback during the collaboration (IS6) regarding the project's objectives and possibilities [75]. In this case, missing, inconsistent, or to-be-considered content is not pointed out [22]. Higher expenses for moderators can explain this, as digital participation can reach more citizens over a larger time frame [30]. Furthermore, this also results in a lack of transparency and traceability (IS7), as citizens sometimes only describe their requirements as a solution or vision and not as demands and needs, which could be respected differently [15]. These variations in citizen expression, e.g., contributions, stem from the overarching goal of enabling the inclusive participation of interested citizens from diverse demographic backgrounds and educational levels [49]. Consequently, these variations manifest in linguistic preferences, word choices, verbosity, and depth of engagement [15]. Such diversity is not only acceptable but also imperative, as it aligns with the fundamental principle that citizens should engage authentically without being deterred from unpleasant and annoying requirements [49,

69, 99]. Therefore, mitigating any deterrents that might lead to citizen disengagement is crucial, as these can prevent and terminate participation [24]. In addition, such abrupt cessation may yield displeasure and frustration among citizens and should be preemptively circumvented as this could increase IS1 and IS3. The lack of online moderators to encourage proper phrasing and formulations [21] can further hinder discussions and exchange of opinions (IS8) when compared to on-site scenarios [89, 95].

Sometimes, the contributions contain duplicate ideas or requirements, as past submissions and comments are not always available [56]. The lack of response from other participants or moderators can prevent in-depth discussions (IS9) [75] and the comprehensibility of contributions and demands [64]. The limited number of participants and asynchronous communication further aggravate digital collaboration, discussions, and debates and exacerbate the lack of interaction (IS10) [49, 64].

IS1 and IS2 refer to two key goals of urban citizen participation that are often not achieved despite great efforts. Besides that, IS3, IS4, and IS7 are crucial for developing the vision and as a significant prerequisite for civic engineering, as described in Section 2, as they enable citizens, urban experts, and public officials to identify common denominators to create a shared vision [69].

Therefore, the limitations of existing participation on urban planning platforms have to be overcome, which directly affect the comprehensibility of citizens' contributions and become more apparent in the published dataset by Romberg et al. [84], which incorporates citizen contributions from mobility planning. Short contributions such as "railway crossing/traffic light intersection" [84, ID 11891] are difficult to interpret, whereas comments like "make the intersection safer" [84, ID 11955] can be contextualized within the project location. Detailed contributions, such as "The corners of Simarplatz street, right next to St. Peter's Church and the Italian restaurant, are often so obstructed by parked cars that people with walkers, strollers, or wheelchairs must (!) veer onto the road, as the pedestrian path is entirely blocked" [84 , ID 13078] are in the minority but very informative. In addition, unfeasible or nontransparent citizen contributions can result in exclusion [41, 71], reducing the output of the computer-supported collaborative work and its impact. IS5, IS6, IS8, IS9, and IS10 address challenges that arise through digital interaction in urban participation platforms, as they are not comparable with face-to-face discussions, as expressed in the RQ.

16.3.2 Suggestions - Meta Requirements and Design Principles

IS1 and IS2 relate to the citizens' acceptance and results in the meta-requirements (MR) that IT artifacts and features on urban participation platforms should support the acceptance of the urban project (MR1). Considering the existing literature, this

affects the participation process (cf. Section 2.3), and regarding our RQ, it also affects the attractiveness and usability of participation platforms. MR2 requires a balance between guidelines and independence in eliciting requirements from citizens. This entails that the project's lead/investors' requirements, guiding information, and existing contributions and comments by other participants, as stated by IS3 (cf. Figure 4), are considered citizens without restricting them and keeping them from participating. In addition, IS3, IS4, and IS5 highlight the difficulties of inconsistent and incomplete contributions based on uninformed or uncertain knowledge or improvable documentation [84]. This is particularly problematic when proposing project ideas and designs compared to personal requirements, which can be considered differently (cf. Section 3.1). This leads to MR3, which states that citizens should be supported to submit comprehensible contributions, that do not only claim but also argue why they desire specific things [15].

Considering the literature review results as elaborated in Section 3.1 and further existing findings from citizen participation, computer-supported collaborative work, and human-computer interaction, this can be achieved by external stimuli [31]. A stimulus is any response that aims to influence users, which, in this case, aims to reflect on and expand the contribution and is, therefore, comparable to moderators in on-site scenarios [73]. This can be made possible in digital scenarios, such as chatbots with questions [77] and digital maps with wind, weather, or movement patterns simulations [90]. The decisive factor here is that the feedback is helpful and encourages users to take further action [53], such as reflecting on, revising, and adding to their contribution [16]. Supplementing this, MR4 highlights the intuitive and useful feedback derived from IS5 and IS6, as participants should not be discouraged or induced to quit participation by complicated and time-consuming reading, documentation, and slow interactions. From MR1, MR2, MR3, and MR4 - DP1 is derived (cf. Figure 4). DP1 states that the IT artifact provides information to support participants on urban participation platforms balanced with individual inspiration and without mandating any content (cf. Figure 4) to support citizens to act as co-designers by submitting their individual requirements, needs, and visions freely.

MR4 tackles the need for intuitive and easy-to-understand feedback, is traced back to IS5 and IS6, and highlights the simplicity and self-explanation of feedback. IS7 and IS8 are condensed into MR5. MR5 addresses the scope of IS6 and complements this with the transparency and traceability of IS7, leading to DP2, providing intuitive feedback considering participants' submissions to support engagement and their reflection on the urban participation platform to create better contributions (cf. Figure 4). We hypothesize that rethinking and engaging with their own contribution with computer-supported feedback will lead citizens to produce better, e.g., more

comprehensible and transparent contributions as required by the RQ. However, how such feedback should be realized and designed needs to be investigated.

IS8, IS9, and IS10 define the lack of scalable feedback in discussions on urban participation platforms depending on the number of participants and time frame, which can reduce the exchange of opinions, arguments, and demands [15]. This leads to MR6 (requests feedback at any time), MR7 (useful responses to support interactions), and MR8 (feedback can be provided simultaneously to numerous citizens). This does not have to be achieved through professional moderators as this would be too time-consuming and costly, depending on the size of the project and the expected number of participants [55]. Past projects have shown that projects on urban participation platforms with more than 20,000 citizens, like DECIDIM in Madrid, are possible [85], even if they are rare, and some projects also only include a few hundred participants, especially in smaller communities [56, 93]. Therefore, MR6, MR7, and MR8 describe how the unavailable interactions and exchanges between participants and with human moderators can be (partially) compensated with a human-machine interaction, which leads to DP3 - provides immediate feedback to encourage interactions for numerous participants simultaneously in the urban participation platform (cf. Figure 4).

16.4 Prototypes Design and Development

Based on the formulated meta-requirements and design principles, we developed three prototypes using XHTML, Java, Maven, Jakarta Server Faces, Deeplearning4Java, and further packages. We used XHTML for the front-end and page navigation and Jakarta Server Faces to link XHTML and Java to load and store data (e.g., citizens' contributions), reducing complex session handling. For the evaluations, we hosted all prototypes on a Payara web server [9].

We modeled our web prototypes by focusing on the creation and submission of citizens' contributions and using existing urban participation platforms as a baseline [55]. Therefore, all prototypes contain a description of the urban project, including information about the participation, data collection, processing, and subsequent steps in text form. In the prototypes, citizens can submit and end their contributions anytime. All citizens' contributions can be submitted using the prototypes' text box, and all data is stored in a CSV file, including session ID and timestamp for later analysis.

16.4.1 Prototype 1 - Urban Participation Platform

Prototype 1 is shown in Figure 5 and was designed to be similar to existing urban participation platforms. *Prototype 1* includes a description of the urban project, an argumentation for the project, and information about the objectives, data collection,

and subsequent processes as defined by DP1 (cf. Section 3.2). Citizens can submit their contributions at any time using the input text field.

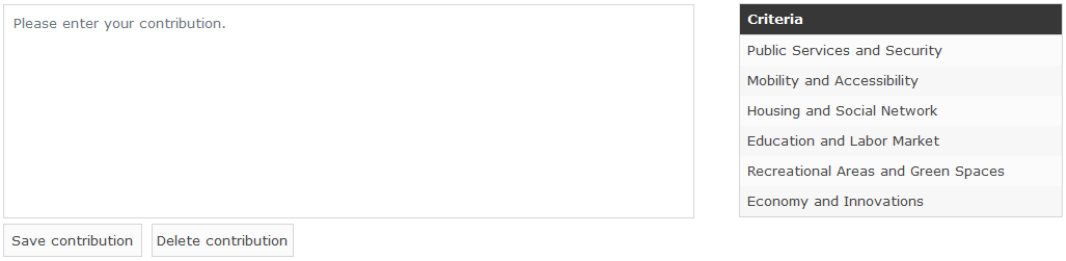


Figure 5. Prototype 1 - Baseline Urban Participation Platform

From DP1, it follows that urban participation platforms need to inspire participants when writing their ideas and opinions, pointing them to different aspects, e.g., the project's criteria, without being prescriptive. The list of categories to the right of the input field aims to fulfill this purpose, as shown in all prototypes (cf. Figures 5, 6, and 7). We chose to include the criteria of public services and safety, mobility and public accessibility, housing and social network, education and labor market, recreational areas and green spaces, and economy and innovations based on the work of Vasudavan and Balakrishnan [106] as they represent the smart city dimension and are of general relevance for urban planning and informatics. It is possible to modify, reduce, or expand the number of categories and adapt them to other project-specific criteria. This may be necessary, for example, if an urban project focuses on mobility and requires criteria like car-free inner city, public transportation, and pedestrian zones. Regarding the RQ, the chosen criteria are not decisive, as the focus is on how to support citizens in creating comprehensible contributions on urban participation platforms, addressing the design of computer-supported functions to influence and change participants' behavior without mandating content, as elaborated in section 3.1.

16.4.2 Prototype 2 - Interactive Urban Participation Platform

Prototype 2 allows participants to analyze their contribution according to the predefined criteria, with results shown immediately after the corresponding button "analyze contribution" is pressed (cf. Figure 6 and 7). The results indicate the extent to which the participants' contribution covers each criterion. This is based on the analysis function addressed by DP2, which emphasizes intuitive feedback to encourage participant engagement with their contribution [16]. The feature we designed aims to accomplish that by providing an intermediate stimulus, e.g., feedback [31], considering the projects' criteria as described in Section 4.1. In doing so, we followed the findings of Szymanski et al., who examine differences in visual, text, and hybrid responses and recommend lastly [100]. Therefore, citizens' contributions are comprehensible if all provided criteria are included, which is communicated to the participant via the scale and colors. Although optional, this interaction should encourage extensions and further content revisions before their

final submission by repeatedly engaging with their written content until their demands are clear.



Figure 6. Prototype 2 - Interactive Urban Participation Platform

DP3 states that immediate feedback needs to yield the most benefit for participants, which can be achieved via human moderators or an automated approach. We chose the latter method as it reduces the costs of hiring trained staff for content analysis and moderation. Considering prior research, we used machine learning and especially word vectors [74] to analyze the content of the citizens' contributions in real time by comparing citizens' submissions to a list of words representing the project criteria. This is similar to the approach by Khan et al. [47] and Lieven et al. [55]. The authors have examined requirements to differentiate the content through categories (criteria) to analyze citizens' contributions to support architects and planners in developing the project's vision. However, we assume that this approach can be used to support citizens in interacting and reflecting on their contributions. The assessment of each criterion itself is estimated within a five-point color-coded uni-polar scale comparable to the well-known Likert scale [34, 39]. For the prototypes, the scale included the levels *not considered*, *incomplete*, *expandable*, *considered*, and *fully considered* to motivate expansion and revision of the contribution by the participants [3] to elaborate and think them through more comprehensively.

To determine the criteria-based feedback, the participant's contributions were first converted to lowercase letters. Then, all filler words (words without content) and punctuation marks were removed, as conducted in other natural language projects [37]. Afterward, all words in the submitted sentences were converted into vectors using Global Vectors for Word Representation, better known as GloVe [74], which defines the semantic relationships of words with the vectors' position so that dense words or sentences are semantically similar [60 , 66] and widely divergent once dissimilar or opposite. Then, the sentence vectors are calculated to compare each sentence to predefined reference words stored in the prototypes representing the

criterion, including the criteria term and synonyms. The sentence comparison was executed by calculating the cosine distance between the vectors, which determined a value between 0 and 1. 0 means that the sentences are completely different, and 1 means that the sentences are semantically equal [2, 5]. All values of all sentence comparisons were then summed up to determine to what degree the contribution addresses the different criteria, determining the scale from *not considered* (sum of 0 to 1) to *fully considered* (sum above 5). Therefore, a comprehensively considered criterion in a participant's contributions has to include at least five sentences that address the criteria. However, as comparisons of semantically dissimilar sentences can also increase the sum, it is possible to reach fully considered with fewer sentences as long as the overall contributions include five or more sentences. The results are presented to the user through the prototype's interface.

We are aware that this approach is explorative and that the specification of comprehensibility can differ from project to project, and no standard for this domain exists. However, this is not decisive, as first, it is possible to change the expectation by increasing or reducing the scale that represents *not considered* (sum of 0 to 1) to *fully considered* (sum above 5) to increase motivation and interaction. Second, participants can elaborate and explain their submission, ignoring or contradicting the feedback, and third. This work focuses on designing urban participation platforms to support citizens in writing comprehensible contributions by following a new approach that requires early evaluations to increase user-friendliness.

16.4.3 Prototype 3 – Advanced Urban Participation Platforms

Prototype 3 is similar to *prototype 2* but differs in decisive functions. It was developed in the second design science research cycle and builds on the insights of the evaluations of p*rototype 1* and *prototype 2*. Figure 7 shows *prototype 3*, in which two further features have been supplemented with the AI-based feedback function. On the right side of the criteria, the possibility to add priorities was implemented so that participants could prioritize the criteria, providing additional information to subsequent processes. In addition, *prototype 3* also considers DP1 by including an interactive map. Participants can use that to explore the urban project's surroundings, as Figure 7 shows in the example of a train station in a large city.



Figure 7. Prototype (3) - Advanced Interactive Urban Participation Platforms

16.5 Evaluation

The objective of the evaluations is to verify the implementation of DP1, DP2, and DP3 to clarify if the developed features are relevant and supportive, considering the RQ. All focus groups followed the same procedure as shown in Figure 8 and were conducted at the university's media laboratory. The target group is citizens from urban areas. Thereby, it is not decisive if the participants have joined citizen participation in urban projects before, as the feedback should suit experienced and non-experienced participants. In addition, a special focus lies on younger citizens, as Pantić et al. and Lieven et al. describe them as the main target group for fully digital approaches [54, 73]. The evaluation was planned with four on-site focus groups, one each for *prototype 1* and *prototype 2*, and two for *prototype 3*. All the participants were advertised and acquired using the university network and online advertisement and were only allowed to participate in one focus group.

At the beginning of all focus groups, consent for the audio records was obtained from all participants, and the evaluation procedure, as shown in Figure 8, was communicated. All participants confirmed that they could operate the provided

devices (Microsoft Surface) with a keyboard and using a browser (Mozilla Firefox) by completing a short questionnaire, which also gathered demographic data and additional information about the participants. This was done to avoid errors and biases in the results due to the different capabilities and experiences of the participants.

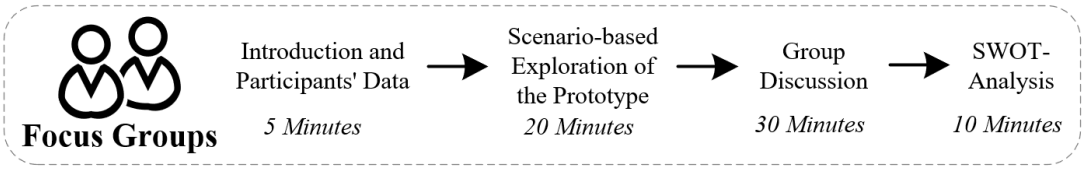


Figure 8. Evaluation of the Prototypes

To explore and use the prototypes, all participants were asked to assume that they lived within a radius of 2 kilometers from the provided and textually described scenario, e.g., an urban project. The scenario describes the reconstruction of a railroad station in a major city, which will result in an ample open space above the ground between two parks. The city conducts participation to elicit citizens' perspectives, requirements, and visions. In developing this scenario, we used existing participation from the past as orientation and decided to use a train station, as most participants are familiar with or affected by that [64, 99]. Therefore, the scenario is plausible, even if it is not an actual urban project.

FG	P	Number of Participants	Experience with Participation	Male	Female	Other	Age	Avg. Age	Duration in min.
1.	1	8	3	7	1	-	18-22	19.3	58
2.	2	8	2	6	1	1	18-20	19.6	77
3.	3	7	1	4	3	-	20-26	23.9	66
4.	4	8	3	2	6	-	25-31	27.8	63
Total		31	9 (24%)	19	12	1	18-31	22.58	264

Table 1. Overview of the Focus Groups (FG), Prototypes (P), and Participants Demographics

The participants had 20 minutes to explore and use the prototype without discussing it with the other participants to create and review their contribution using the AI-based feedback function. The time did not have to be exhausted, and it was not mandatory to use the feedback or other features. The user experiences and impressions were later discussed in all focus groups, and questions about the features, the design of the prototypes, and alternative presentations were asked. Lastly, the results were documented by each participant using the SWOT analysis to highlight the *strengths* and *weaknesses* of the prototypes' designs, as well as the *opportunities* and *threats* of their application [11]. For this, each participant received a printed SWOT matrix, which was briefly explained so that all participants could document their thoughts. All documents were collected and analyzed for each focus group,

aggregated, and compared with the recordings of the discussions to determine the frequencies of the four dimensions to evaluate the *design principles*.

The evaluation of *prototype 1* serves as a baseline, as it is similar to existing urban participation platforms. The evaluation of *prototype 2* was used to examine the feedback system, which was developed based on the design principles DP1, DP2, and DP3 to determine if the feedback is understandable, helpful, and supports citizens. The evaluation of *prototype 3* served to evaluate the AI-based feedback system and its extensions (cf. Figure 7) and was examined two times to increase validity with a broader age structure, as shown in Table 1.

16.6 Findings

The systematic evaluation of the transcripts of the focus groups, as described in Section 3, and the documentation of the SWOT analyses show that the designed and developed features supported the participants and influenced their behavior. However, the participants noticed and perceived the influencing factors differently. Figure 9 shows the combined identified strengths (S), weaknesses (W), opportunities (O), and threats (T). In addition, a more detailed exposition is located in the appendix, wherein the outcomes of the SWOT analysis for each focus group are presented (cf. Appendix A).

The insights from the group discussion and SWOT analyses were discussed by the authors regarding the RQ - *how to support citizens in creating comprehensible contributions on urban participation platforms?* The evaluation confirms that the three initial design principles, derived from the literature, support citizens and highlight necessary adjustments and constrictions.

DP1 describes that the urban participation platform provides information to support participants on urban participation platforms balanced with individual inspiration and without mandating any content (cf. Figure 4). The SWOT analysis, especially S4 and S5, confirms that the designed prototypes meet DP1 and provide informative support, which was especially highlighted in the discussion about *prototype 3*, considering the interactive map. In the group discussions, the participants described its exploratory character, highlighting its emphasis on and support for the locals but also for the citizens who do not live in or close to the area of the urban project. This corresponds to the existing approaches as described by Müller [62], Pristl and Billert [78] and contributes to the levels of citizen participation as provided information in combination with citizen submissions supports the levels of involvement and higher (cf. Figure 1). Therefore, interactive maps or comparable features should be further pursued. In doing so, it should be noted that the technical requirements for participants should not increase, as this may otherwise contribute to T2 and T7 and exclude potential participants due to a lack of media competence [57].



Figure 9. Results of the SWOT Analysis

The focus group discussion considering DP2 (provide intuitive feedback to the participant contribution to encourage the engagement with their contribution to support its quality on the urban participation platform) was divisive. The idea to support citizens with AI-based feedback was welcomed by 19 participants (S3). The immediate and interim feedback motivated them to create longer and more comprehensive contributions considering the provided criteria (S3) and encourage new ideas (S4). However, the criteria and the color-coded scale can influence participants negatively, as stated by T1 and T7. This can affect the participation results and prevent citizens from independently considering and reflecting on their living situation and environment when submitting, contradicting the concept of citizen participation and civic engineering as described in section 2. This became particularly apparent during the group discussion, as some participants attached great importance to receiving the highest AI-based feedback and perceived the feedback not only as an inspiration but also as an assessment. In addition, this was reinforced by the red and orange color codes due to their negative connotations [42], supporting the impression that short contributions are inadequate and the criteria must be considered (W7). In other words, the implemented feature supports participants in revising their contributions intensively by extending and supplementing them.

However, it can also cause frustration if the desired response is not satisfying. Therefore, DP2 needs to be implemented in a neutral manner (W7) in which the crucial term ”encourage” is adequately considered.

We implemented DP3 as described in section 4 with six criteria determining if and to what extent the participants' contributions consider these. The approach of compensating for the interactions between participants and moderators by automated feedback was well received and supported by many strengths (e.g., S4, S7, and S10). However, the participants criticized the feedback estimation as not being transparent (W2) and that the criteria were defined too broadly (W1). Therefore, we propose an additional DP4, which states that urban participation platforms should provide a comprehensible and transparent description of how AI-based feedback is generated to inform and empower citizens. The transparency of the criteria can be supported via a text describing the procedure and illustrating examples [100]. In addition, to visualize the connection between the contribution and the criteria, sentence segments could be highlighted in colors in the input text field (cf. Figure 6 and 7) to support the transparency of the AI-based analysis and criteria toward the participant's contributions, which would support the transparency and trust in the overall participation process (cf. Section 2.3).

The evaluation of the prototype showed that IS4 and MR3 (highlighting unrealistic and contradictory requirements) are not sufficiently implemented, as indicated by weakness W5. As citizens want to create useful and feasible contributions, as the discussions during the evaluations showed, further feedback and hints are required. Therefore, we derive DP5, which states that urban participation platforms should provide substantive information to the participants to support the submission of realistic, compatible, and feasible contributions that consider the urban projects' vision. This could be achieved with further information about local restrictions or an expansion of the interactive map by marking/overlaying restricted areas or where only specific buildings can be constructed, e.g., safety distances from playgrounds to roads. An alternative or additional approach could be evaluating citizens' contributions to identify unrealistic ones that disregard regulations. However, this requires considerable urban expert knowledge. This is challenging to consider in automated AI-based approaches, as it has to be structurally documented to enable a supplementing AI agent to identify this, pointing it out to citizens. Alternatively, this can be executed manually, meaning that the response is no longer immediate and scalable for hundreds or thousands of citizens, contradicting DP3 and strength S3.

16.7 Discussion

Civic engineering is a challenging and multifaceted endeavor closely related to civic tech [38] and citizen participation, which are crucial in incorporating local knowledge

and citizens' requirements into the development of modern cities (cf. Section 2.3). To support this and subsequent decision-making processes (cf. Figure 1), we examined the RQ *of how to support citizens in creating comprehensible contributions on urban participation platforms*.

The systematic examination of existing literature reveals that many issues in the realm of participation exist, which also impact subsequent processes before and after the co-design phase (cf. Section 2.3). The tension of efficiently and intuitively involving citizens with limited time, motivation, acceptance, and knowledge while simultaneously generating extensive, comprehensible, and understandable contributions is significant [24], as these requirements often contradict each other. This challenge is further compounded by the participation scaling to nearly any number of citizens, including asynchronous communication [85]. The systematization and conceptualization of this tension are presented in Figure 4 and highlight the complexity and challenges of fully digital participation with urban participation platforms. Urban planners, architects, and participation experts should consider them if they change their approach and want to use alternative formats like social media platforms or digital surveys [98], as the same or similar issues may occur if interaction and response due to missing counterparts are missing [93].

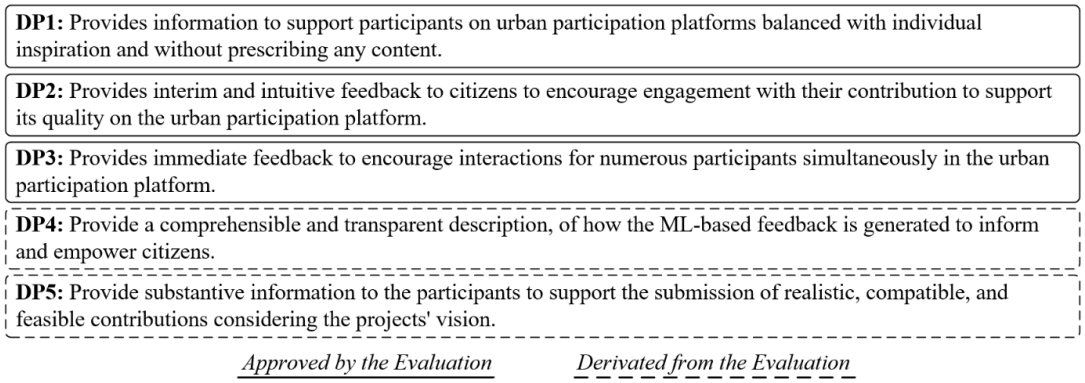


Figure 10. Overview of the derived Design Principles

The five derived design principles (cf. Figure 10) specify how to support citizens on urban participation platforms and specify the implemented design of the prototypes, as described in section 4. The focus groups highlighted the potential of the novel AI-based feedback system, which convinced the participants to respond immediately by offering a scale-based system that is easy to understand [34]. In addition, during the whole participation, citizens can see their contribution and revise it if they want. That also distinguishes our approach from other interactive systems like chatbots, which miss the permanent overview of the inputs [101].

The conceptualization of the design principles and the implemented IT artifact represents an essential step toward developing a novel design theory to support civic engineering [51]. Together, our contributions specify a cause-effect relation supported and influenced by the design and provided functions, as Kuechler and

Vaishnavi describe [50]. This lays the foundation for further theoretical work for citizen participation on urban planning platforms. As elaborated by vom Brocke et al. (2020), further designs science research cycles can now continue to abstract from our findings to other theories, to generalize them by expanding the focus, amplify them with further details, or contextualize our solution by developing the IT artifact towards a product [109]. While the first three possibilities build on and enhance the theoretical contribution, the last would strengthen practical implications. However, our design principles and prototypes can already be used as an orientation and guideline by practitioners like urban experts, planners, moderators, and developers to develop better platforms and participation [97]. This also applies to variations and the use of AI and should be continued with a contextualization which could lead to an open-source framework, including source code, directly impacting and contributing to citizen participation and civic engineering [59].

Nevertheless, our contribution is of limited validity, and its applications in practice should be conducted carefully, as further research is required to examine enhancements and increase validity. The limited number and homogeneity of participants (cf. Table 1), which was chosen to lay a foundation by elaborating on how to support citizens on urban participation platforms, enabled the approvement of the design principles but has to be considered critically as the validity of them is limited, even if the comparison of the SWOT analysis is consisted and does not include any outliers (cf. Appendix A). Further focus groups with additional demographics and supplementing quantitative studies can increase the validity of the third design science research cycle [51]. They should also quantify and compare the submitted contributions in detail to prove or refute that the AI-based supports a significant change in the participant's behavior. To do so, a proper definition of the quality of citizens' contributions, e.g., as described in argumentation theory [110], would be helpful and could support the development of ML models and comparative studies [15, 77].

The evaluations also showed that further research is required to examine alternative and additional features, as not all design principles and meta-requirements were met. This especially applies to MR3, MR5, DP4 and DP5. A combination of the AI-based feedback guiding questions, comparable to existing chatbot approaches, could guide participants toward the criteria by pointing out unconsidered topics [27]. This could be archived by applying the findings of Küstermann and Bittner [52] but would also increase the complexity of the interface, which should be examined considering the usability and cognitive load [1] to not overstrain and discourage participants [28]. Another aspect that should be examined is if and how the developed AI-based feedback system changes discussions with other participants. In this paper, we used AI-based feedback to support participants in creating and documenting more comprehensible contributions. However, if we want to apply this in discussions with

fellow citizens, it could lead to longer contributions, which increases reading time, which might prevent and reduce the motivation of others to respond. This could hinder or reduce discussions so that participants would submit their contributions independently without responding to others. Lastly, it should also be examined whether some of the weaknesses like W2 and W5 can be compensated by using alternative interface features, like 3D models, to increase the effectiveness and improve the overall experience [88]. This also affects the number of provided criteria, as six is suitable, but depending on the desired level of detail and impact on citizens' contributions, more or less could be appropriate.

However, despite these restrictions and further research, the derived design principles are a legitimate contribution to civic tech and e-participation in urban planning and contribute to the development of AI-based feedback systems for computer-supported environments and a novel design theory.

16.8 Conclusion

In this paper, we investigated *how to support citizens in creating comprehensible contributions on urban participation platforms* (RQ). We approached the RQ by applying the design science research paradigm according to Kuechler and Vaishnavi [51], beginning with a literature review. The urban planning and informatics review revealed ten issues and highlighted the demand for computer-supported collaborative features. These were used to formulate eight meta-requirements and three initial design principles (DP), which were supplemented by two further as a result of the qualitative evaluation with focus groups. DP1 highlights the balance between guidelines and the independence of citizens creating their contributions, while DP2 states the need for intuitive feedback to facilitate interaction. DP3 emphasizes the importance of immediate, interim feedback during the submission phase to encourage content revision by the citizens to revise, reflect, and submit comprehensible contributions to lay an extensive foundation supporting subsequent decision-making processes. DP4 concerns the transparency of the ML model, which was used to provide immediate AI-based feedback, and DP5 addresses responses to support the submission of realistic and feasible citizen contributions. Together, design principles can guide developers, experts, and scientists from the domain of computer-supported collaborative work and urban informatics in developing supportive urban participation platforms. The developed and presented new AI-based, interim, and immediate feedback and prototypes serve as a baseline for further examinations and studies.

Further validation of the design principles through, e.g., quantitative approaches and the examination of alternative AI-based feedback systems is required, which also affects a proper definition and measure of the quality of citizens' contribution. This

would support the development of specific ML models considering and enabling comparative studies to examine and quantify the impacts of different features.

The results should be seen and applied considering the domain and validity. However, we are confident that the elaborated design principles can be used in practice and lay the foundation for further research and the development of AI-based computer-supported collaborative work on urban participation platforms to support the development of sustainable and resilient cities.

16.9 Acknowledgments

We want to express our sincere gratitude to the Federal Ministry of Education and Research (Bundesministerium für Bildung und Forschung) for supporting the project RESCUE-MATE, which examines innovative approaches to support civic engagement in crisis scenarios. The funding of RESCUE-MATE, with the grant numbers 13N16835 to 13N16845, enabled us to carry out this research and enable this paper

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16.11 A Appendix - SWOT Analysis of Focus Groups 1, 2, 3, and 4

The "-" in Tables 2, 3, 4, and 5 indicates that this strength, weakness, opportunity, or threat cannot be applied to the focus group, because the evaluated prototype does not contain the required functions. The column "total" is calculated by the focus group (FG) 1, 2, and 3 as these focused on interim and immediate responses.

No.	Total	FG 1.	FG 2.	FG 3.	FG 4.	Strength
S1	20 (26)	6	6	6	8	Enables efficient, location- and time-independent participation due to the web-based approach
S2	19 (22)	3	5	7	7	Citizens can contribute their ideas independently from the feedback
S3	19	-	5	7	7	The platform motivates through feedback to consider the criteria
S4	18	-	6	6	6	Provides an orientation through the criteria and encourages new ideas
S5	15	-	-	7	8	The map supports exploring the area of the projects to obtain further information
S6	14 (14)	1	4	5	5	Motivates to write longer contributions through the feedback
S7	12	-	6	3	3	Citizens can verify, whether they have considered the criteria whenever they want
S8	9	-	3	2	4	Feedback is highlighted in different colors
S9	6 (9)	3	2	3	1	Enables intuitive participation
S10	3 (4)	1	2	0	1	Supports a feeling of involvement in the urban project
S11	1 (2)	1	1	0	0	Large text box to submit the contributions

Table 2. SWOT-Analysis - Overview of Strength over the Focus Groups (FG)

No.	Total	FG 1.	FG 2.	FG 3.	FG 4.	Strength
W1	12	-	4	3	5	Analysis of the contributions is not transparent
W2	10 (14)	4	5	2	3	Criteria are defined very broadly
W3	10 (11)	1	5	2	3	Criteria indicate the proposals' direction
W4	8	-	-	4	4	Priorities are not affecting the determination of the criteria's feedback
W5	6 (8)	2	4	2	2	The feasibility of the contributions and ideas is not evaluated and can lead to unrealistic requirements
W6	6	-	3	2	1	Scale levels and colors are not appropriate and should always encourage citizens without judging
W7	3 (4)	1	1	0	2	High participation aggravates the manual evaluation of e.g. ideas and visions

W8	3 (7)	4	3	0	0	Relative time-consuming as the documentation of the requirements is accomplished by a longer text
W9	3	-	0	2	1	The zoom of the maps is limited

Table 3. SWOT-Analysis - Overview of Weaknesses over the Focus Groups (FG)

No.	Total	FG 1.	FG 2.	FG 3.	FG 4.	Strength
O1	16 (18)	2	5	4	7	Can increase real-world use of urban projects
O2	12 (15)	3	5	3	4	Enables scalable citizen participation at any time
O3	10 (13)	3	2	4	4	Enables the elicitation of multifaced ideas to create knowledge about citizens' needs in a (specific) area
O4	2 (3)	1	0	0	2	Can increase the participation and interest of citizens sustainably
O5	2	0	0	2	0	The platform can be used to advertise future projects and participation
O6	1	-	1	0	0	Enables automated clustering to customize individual feedback
O7	1 (2)	1	0	1	0	Can reduce the distance between politicians and citizens due to a deeper exchange

Table 4. SWOT-Analysis - Overview of Opportunities over the Focus Groups (FG)

No.	Total	FG 1.	FG 2.	FG 3.	FG 4.	Strength
T1	16 (23)	1	7	5	4	Participants only follow the criteria and want to cover them completely, even though this was not their original intention
T2	8 (10)	2	2	2	4	Citizens without necessary media competence are excluded from participation
T3	6 (8)	1	2	2	2	Participants can participate more often to influence the results due to the anonymity
T4	4 (5)	1	2	1	1	Bias in the algorithm falsifies the evaluation and thus leads to misleading results
T5	3	0	2	0	1	Participants cannot change their requirements due to the anonymity
T6	3 (5)	2	2	0	1	Citizens can get the impression that their requirements aren't considered if their

						impact is not transparent which can reduce trust in urban participation approaches
T7	2	0	0	1	1	Can lead to imbalances if predominantly young citizens are participating
T8	2 (3)	1	1	1	0	Possibility of manipulation of participants through targeted feedback

Table 5. SWOT-Analysis - Overview of Threats over the Focus Groups (FG)

17 Publication C10: Emergency Management: Designing mobile Applications to support Citizens during Storm Floods

International Conference on Design Science Research in Information Systems and Technology (DESRIST)

Track: Sustainable Development and Environmental Solutions
Completed Research
Ranking: B

Research Question

How should mobile emergency apps be designed to support citizens during storm floods?

Contribution to the Dissertation

This publication contributes to the overall RG, especially RQ1, by describing the interactive mechanism in time-critical environments, comparable to citizen participation, in which participants often lack time. Furthermore, aspects of interactive maps are considered in more detail, as are checklists. The publication describes twelve issues, twelve meta-requirements, and four initial design principles, which were later extended to seven based on insights from the evaluation with citizens.

Citation

Borchers, Marten; Milutzki, Enrico; Bode, Alexander; Magdych, Valeria; Semmann, Martin; & Bittner, Eva (2025). Emergency Management: Designing Mobile Applications to Support Citizens During Storm Floods. In: *Chatterjee, S., vom Brocke, J., Anderson, R. (eds) Local Solutions for Global Challenges.* DESRIST 2025. Lecture Notes in Computer Science, vol 15704. Springer, Cham. https://doi.org/10.1007/978-3-031-93979-2_17. Completed Research.

Abstract: *The risk of storm floods is increasing and is enhanced by climate change, as the water level is rising and the temperature shift is warming up oceans and the atmosphere, increasing storms and heavy rain. Therefore, governments, cities, and urban areas, often settled close to water due to economic benefits, should react and prepare for this by further developing emergency management. In doing so, we examine how mobile applications should be designed to support citizens during storm floods to support and self-secure them. Therefore, we initiated a design science research project, conducted interviews with citizens and emergency-relevant stakeholders, identified twelve issues, formulated twelve meta-requirements, and derived four initial design principles. We instantiated these with a prototype that we evaluated with ten more citizens and emergency-relevant stakeholders to approve and further develop these. The derived design principles were approved, and three new ones were derived, highlighting the possibilities of local-based evacuation routes, bidirectional communication, and data collection by citizens. Overall, this study contributes to the emergency management domain, focusing on floods with meta-requirements, design principles, and an IT artifact to support practitioners with guidance and lay a theoretical foundation for further research in developing extensive mobile applications for evacuating citizens in large cities before and during floods.*

Keywords: Storm Floods, Emergency Management, Mobile Application

17.1 Introduction

Climate change is ongoing, and global temperature is increasing, even due to many actions being implemented to reduce it [1]. This also affects the oceans, even if they warm up slowly, and increases the amount of evaporation, which, together with higher temperatures, supports clouds to store more water [2]. At the same time, the sea level is rising, and as of today, more than 100 million people live in places below sea level, and this number will increase to more than 450 million by 2050 [3]. Combined but independently, these developments threaten citizens' lives, infrastructure, and nature and are also considered in the UN sustainable development goals 11, sustainable cities and communities, and 13, climate action [4].

The recent floods in the USA and Western Europe in 2024 in the Czech Republic, Poland, Germany, and Spain, with more than 466 deaths and damages of more than 4.2 billion euros, highlight this [5–8]. As a response, many governments are evaluating their emergency management plan, capabilities, and infrastructure [9]. As the objective of emergency management is to save lives and reduce damage to infrastructure and nature, citizens are an essential part of this. Often, alarm signals via cell broadcast and mobile applications like MetService, Emergency+, Katwarn, FEMA, and NINA [10–12] are used. However, most of these warning systems concentrate on providing essential information and warnings [13], which can be explained as the information flow should be fast and straightforward, even if the emergency is complex and sometimes chaotic [14]. Interactions are rare, bidirectional communications are not possible, and functions to increase awareness for, e.g., floods

and communication to emergency actors are not included. The dissemination of this mobile warning app is often relatively low. For example, in Germany, only 16% of the population has ever used an emergency app [10]. However, new and more extensive solutions are required with today's possibilities and advancements in weather and flooding simulation and the need to prepare citizens for floods and other events. To examine this, we state the following research question (RQ).

RQ: How should mobile emergency apps be designed to support citizens during storm floods?

The following paper continues with the related work section, in which we describe the foundation of emergency management and specify stakeholders and their actions. Afterward, we describe the method according to the design science research paradigm, followed by the section on awareness of the problem & suggestion, in which we formulate meta-requirements and derive design principles. In design & development, we used these to develop a prototype, and in evaluation & findings, we describe the evaluation results. Finally, in the discussion & conclusion, we elaborate on our findings in the context of the existing knowledge base, including and highlighting practical and theoretical implications, limitations, and future work.

17.2 Related Work

17.2.1 Emergency Management Phases

Emergency management focuses on safeguarding human life and minimizing damage to property and the environment, which requires various capabilities and competencies specified in the three cyclical emergency management phases (cf. Fig. 1).

The first phase, risk mitigation, involves implementing effective techniques and management principles to address hazards such as floods, incorporating prevention and preparedness activities by organizations and individuals [15]. Prevention includes structural measures that reduce risks, like regulations and standards, while preparedness ensures effective responses by equipping relevant parties (Yousefi Mohammadi et al., 2024). The response phase activates emergency plans, including issuing alerts, providing accurate information, delivering relief and assistance for the injured, evacuating people, and ensuring access to essential services [16, 17]. Finally, recovery involves restoring systems and facilities to customary conditions, performing damage assessments, and maintaining the continuity and quality of essential services until complete restoration is achieved [15].

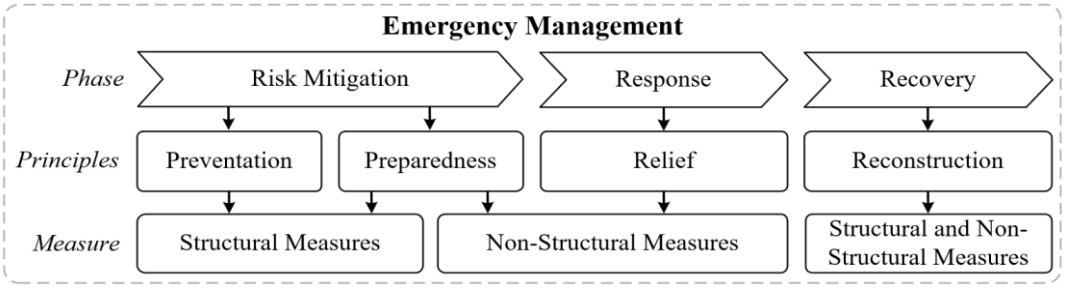


Figure 1. Overview of the Emergency Management Phases, Principles, and Measures [15]

Strom flood risk mitigation and emergency response are governmental responsibilities regulated by laws in most countries and can be implemented differently. At the state level, responsibility is usually placed on the Ministry of the Interior and public services specialized for emergencies, fire departments, and police, and quite often, the army will act in case of emergencies [18]. This includes informing citizens to increase awareness proactively and, in cases of an emergency, warn, evacuate, and respond by building and securing damns, infrastructure, and citizens [10]. In emergencies like floods, these organizations must work together, which requires approved processes and communication, which is challenging in stressful, dangerous, and (chaotic) floods with hundreds or thousands of stakeholders [7, 19].

17.2.2 Existing Mobile Emergency Applications

Many emergency applications for mobile devices exist and more have been developed. However, they often do not fit the requirements and are only disseminated to a small degree. For example, the *Katwarn* app, released by the Fraunhofer Institute in 2013, and *NINA*, released by the Federal Office for Civil Protection and Disaster Assistance in 2015, have been extensively researched and analyzed [10]. Both applications are designed to address various emergencies and are not explicitly tailored to floods and selected locations. Moreover, both applications offer limited interaction with users. While general recommendations for action are provided, these are not specifically adapted to the user's situation. There is no mechanism for users to communicate their circumstances, thereby failing to contribute to a comprehensive situational awareness from within the affected areas [20]. Utilizing users as information sources is implemented in a mobile application developed by the Federal Emergency Management Agency in the USA [10]. This government warning tool application allows users to call for help directly through the app or access support via hotlines [21]. However, intensive real-life interactions in which citizens and emergency actors directly communicate and provide data are not possible. In emergencies, this is also challenging, as citizens' data provision can create an information overload [22].

17.2.3 Guidelines for Designing Mobile Emergency Applications

Some design guidelines exist and should be considered in emergency management. A particular emphasis is placed on minimizing users’ cognitive load, allowing the

applica-tion to be used quickly and effectively, even under stress [23]. Therefore, apps should be designed as structured as possible. Furthermore, the application should require minimal user input for interaction, or such inputs should be straightforward, facilitating ease of operation and efficiency [24]. Adapting the application to the user's situation is described by the guideline of situational awareness [25]. This guideline emphasizes customizing the design to meet the user's context, ensuring that all necessary information and func-tionality are readily available. It aims to support users without overwhelming them with too many options [25]. Another essential guideline is to highlight critical information so that it is perceived under all circumstances. Prioritizing information and displaying it sorted by priority can be an effective method. Additionally, using different colors or fonts can enhance the emphasis on vital information [24].

17.3 Method

To answer the **RQ**, we follow the design science research (DSR) paradigm, which is well-known in information systems and has been described by numerous authors. DSR is a problem-solving paradigm that generates new knowledge by creating an innovative artifact. The outcomes of DSR consist of the artifact itself and the resulting design knowledge [26]. In this work, we apply DSR according to Kuechler and Vaishnavi [27], which involves the five phases illustrated in Fig. 2).

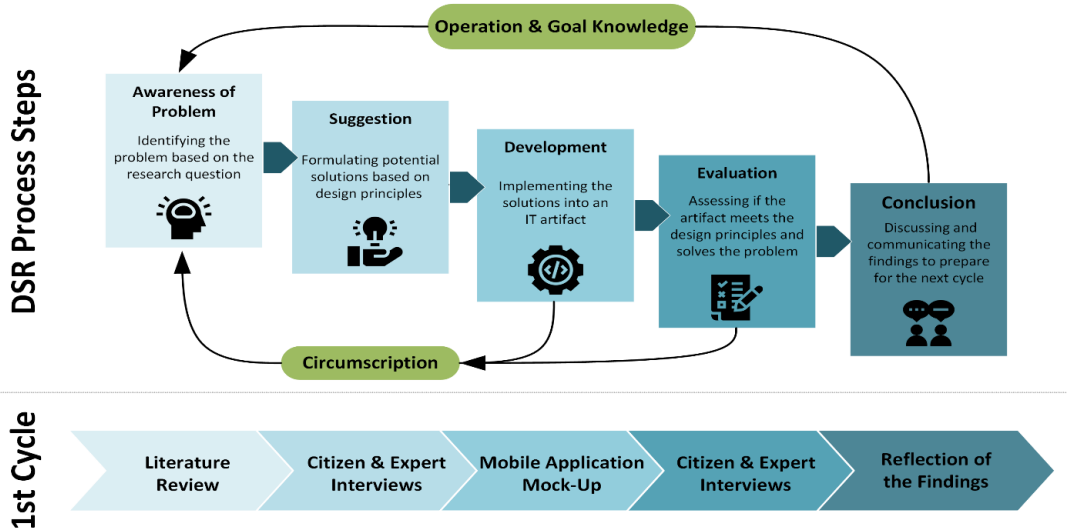


Figure 2. Overview of Design Science Research and the conducted Cycle [27]

The first phase, *problem awareness*, requires the specification of the problem as implied by the RQ. In the phase of *suggestions,* we formulate potential solutions, and in *development*, these solutions in terms of design principles are instantiated into an IT artifact. The subsequent evaluation phase assesses the newly developed IT artifact regarding the design principles derived in the suggestion phase and resolves the initial problem. Finally, the findings are discussed and communicated (conclusion). One

DSR cycle is conducted for this paper. In the first phase, we specify the problem, described as issues in detail based on existing literature [28]. Afterward, we interviewed citizens who are users of a mobile application for the domain of floods. Additionally, we interviewed emergency experts from different departments to gain further insight into evacuations and typical challenges in urban areas. The prototype was developed in Figma and evaluated with other citizens. All interviews were documented, if allowed, and analyzed according to Maying's paraphrasing approach [29]. Finally, we elaborate and conclude on our findings in the context of the existing literature and knowledge base.

17.4 Awareness of the Problem and Suggestions

Following the process as outlined in Sect. 3, we reviewed existing literature and documents by authorities and conducted six interviews with citizens and emergency stakeholders (cf. Table 1) to identify issues (ISS), formulate meta-requirements (MR), and derive design principles (DP). The citizens were interviewed to elicit the perception and experience of the main target of a mobile application, which is also why we ensured that some of them have already used emergency apps but also have a broader background to reduce possible biases. The emergency stakeholders were interviewed to elicit comprehensible expert knowledge about floods, storm surges, and internal, e.g., management structures that might have to adapt to mobile solutions.

No.	**Citizens Background**	**Age**	**Emergency App Experience**
C1	Student (Physic)	25	No
C2	Student (Informatics)	28	No
C3	Law	22	Yes
C4	Industrial Engineering	57	Yes
C5	Human Resources	58	Yes
C6	Architecture	21	Yes
No.	**Experts Background**	**Responsibility**	
E1	Disaster Response Unit	Emergency Management, Information Provider & Action	
E2	Ministry of Interior	Emergency Management & Political Responsibility	
E3	Police Department	Implementation of Evacuations	
E4	Fire Department	Dike Protection & Rescue	

Table 1. Overview of the conducted Interviews with Citizens (C) and Experts (E)

We conducted this approach to extend the theoretical knowledge base from literature with practical insight from different emergency actors while incorporating user insight. After analysis, we concluded that the results can be divided into three clusters. The first cluster concerns providing citizens with valuable information related to flood situations. The second cluster concerns evacuating citizens, and the last cluster addresses data. In the interviews, citizens indicated that they often feel

lost in emergencies due to their inability to understand the events. Following an initial warning, little to no further information is typically provided. To address these issues, MR1, MR2, and MR3 were developed. These are collectively covered in DP1. By utilizing functionalities such as a frequently updated news feed and an interactive map visualization, the system aims to enhance preparedness and support evacuation actions, as researchers have already shown in a similar map view [30]. During the discussions, three additional issues were identified. The lack of preparedness among the general population is a recurring theme in the literature and was also evident in the interviews with citizens. Users demonstrated a general lack of emergency-related knowledge, which is also confirmed in a European survey. According to the survey, 65% of citizens feel unprepared [31]. Furthermore, clear guidelines or recommendations for action during crises were absent. Experts highlighted the existence of relevant documents; however, these do not resonate sufficiently with the public. Consequently, the discussions emphasized the need to provide information on preparedness (MR4). In addition, a checklist with relevant recommendations can help users prepare and guide them during a crisis. DP2 incorporates these two MRs and includes a support functionality that enables users to access essential information quickly during a flood event.

During the evacuation phase in an emergency, issues related to a lack of preparedness also became apparent in the interviews [13]. Experts indicated that citizens often do not know the locations of safe shelters or how to access location-based instructions. Additionally, detailed instructions for evacuation are often lacking. Experts further noted that, during an emergency, citizens tend to experience panic and stress, which impairs their ability to concentrate and act effectively under pressure. This is also reported in the literature [32]. MR6 and MR7 aim to address these issues by advocating support that builds user confidence and provides simple, user-centered instructions. Moreover, an IT artifact of this kind must provide information about shelters and evacuation points while enabling navigation to these locations (MR8, MR9, MR10). These meta-requirements are consolidated into DP3. Another aspect that presents new opportunities for crisis apps is the inclusion of bidirectional communication capabilities. Such functionalities are currently less common and could be significantly improved (ISS12). Experts also highlighted the challenge of obtaining sufficient on-site information to assess the situation better. The problem is already recognized in research and is being tackled in various areas [33]. Creating an accurate situational map from the available inputs is often difficult. MR11 and MR12 define system requirements for users to collect and communicate on-site information. These requirements are encapsulated in DP4, which was derived through further analysis of the expert interviews. During an evacuation, when users encounter obstacles, the system should allow user input to capture and integrate this information [34].

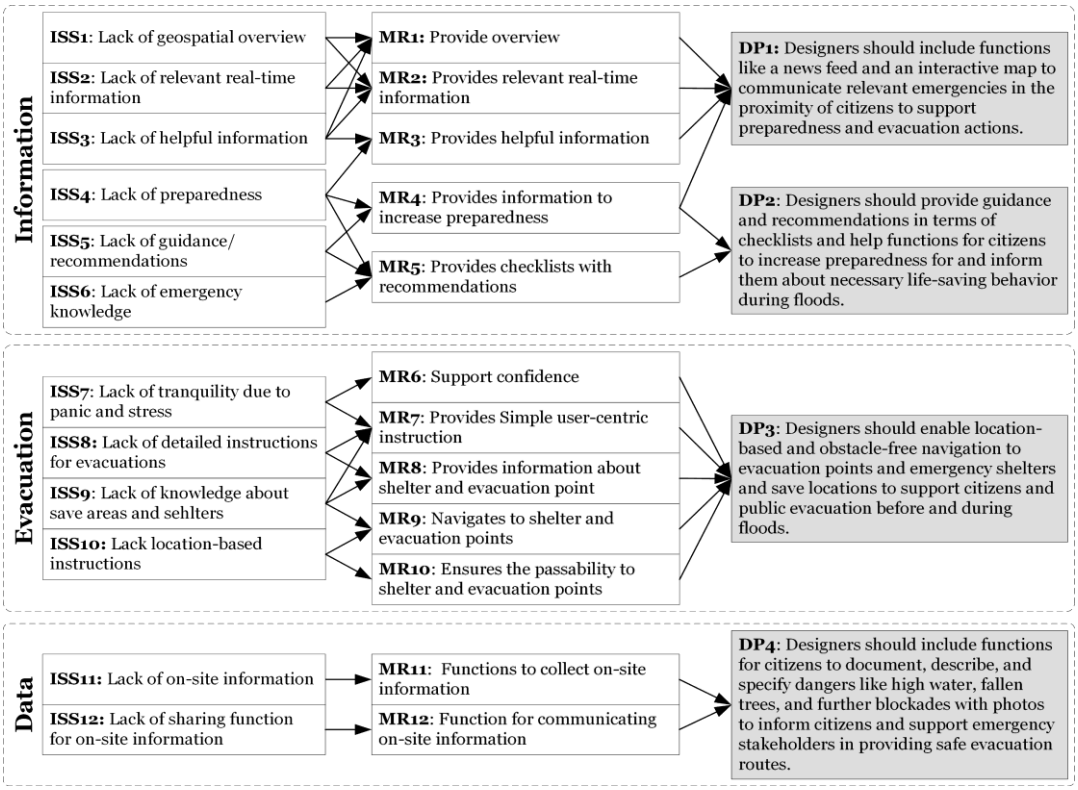


Figure 3. Overview of the identified issues (ISS), the formulated meta-requirements (MR) and the derived design principles (DP)

17.5 Design and Development

The instantiation of the design principles is achieved by developing a Figma mock-up, which serves as a demonstrator. Figma enables the creation of a (mobile) web app that participants can explore interactively and, therefore, receive an authentic impression of the solution [35]. The prototype is compactly divided into three main menu screens, allowing intuitive navigation via the bottom navigation bar. Each menu item corresponds to distinct design principles, focusing on simple visual representations and input methods that are easy and quick to execute.

The “News” screen addresses DP1 by presenting all relevant news items in a list, providing an overview of past events. The three most recent news items are also displayed on the home screen to give users a quick overview at first glance. A map view addresses the other part of DP1 and is in the map screen, shown in Fig. 3 (right). The map, sourced from openstreetmap.org, is zoomable and displays typical elements of navigation maps. Additionally, simple and clickable icons represent danger zones, evacuation centers, evacuation stops, and the current location [30].



Figure 4. Overview of the Prototype showing the Checklist (left), the Navigation-to-Screen (middle), and the Map Screen (right)

This main screen also provides access to the implementations for DP2. A two-part checklist has been developed, displayed as a to-do list, and depicted in Fig. 3 (left). These checklists allow users to view and mark off critical to-dos related to emergency equipment and recommended actions [33]. DP2 is further integrated into the artifact through a question-and-answer sequence navigated via YES and NO responses. The simplicity of these interaction methods ensures usability even in chaotic situations. The questions are thematically linked, with each question building on the previous one, starting from the topic selected by the user, such as “Help.” The question sequences result in actionable guidelines on what to do or, in life-threatening situations, establish a connection to emergency responders.

The evacuation navigation (DP3) can be initiated through these map icons or via a compact list of potential navigation destinations. The navigation-to-screen is showcased in Fig. 4 (middle). The navigation interface is designed with a structure similar to Fig. 4 (right), modeled after existing systems [30], and includes dynamically orienting the map toward the user’s movement [34]. Additionally, the system displays the remaining distance to the destination in terms of time and length. The next turn or intersection is prominently displayed in advance to support user preparedness further.

A distinctive feature of the navigation system is integrating obstacles reported by users and authorities. These obstacles are incorporated into the system, enabling it to account for them when calculating the optimal route to the destination for which, citizens locations are send to a sever aware of obstacles and verified save streets,

provided by emergency actors. As an added feature addressing DP4, users can report obstacles to emergency actors with a single button press. These reported obstacles will then be displayed on the map. Users can specify the type of obstacle, such as flooded areas, blocked paths, or restricted zones. Once an obstacle is reported, the system recalculates the route accordingly.

17.6 Evaluations and Findings

The evaluation of the prototype to approve, disprove, change the derived, and create new design principles was conducted following two different approaches. First, we conducted ten interviews with citizens (C7 to C17) following a nested-two-stepped approach. In all interviews, the citizens received the prototype link and a task they should complete. The task was open to a certain degree and included the evacuation of the citizens from a location in an endangered building to a safe location. The objective of this approach was for all citizens to explore the mock-up in a guided and similar way to ensure that they could try out all functions and that the interviews were comparable to a certain degree. All citizens had ten minutes to explore the mock-up, which was sufficient. Secondly, their experience and perception were discussed and guided by core questions, which implicitly and explicitly focused on the design principles [26].

In addition to the evaluation with citizens, we conducted a focus group with already interviewed emergency relevant stakeholders (cf. Table 1). The focus was especially on DP4, as this addresses collecting data to gain on-site knowledge about, e.g., barriers and flooded areas that can be documented via text and pictures. This information is of high value [14], as it can support emergency stakeholders in their action but also can be communicated by them to citizens to only evacuate on safe routes (DP3) and provide further information as stated by DP1 and DP2. All collected data was analyzed, and related statements were aggregated [29].

The evaluation emphasizes different aspects of the issues, meta-requirements, and design principles. The simple, intuitive, and unpretentious design was emphasized positively several times (C8, C9, C15, and C16), knowing that the possibilities described in Sect. 2.3 have not yet been exhausted, as we focused on the functionalities.

Nearly all citizens confirmed DP1 as the desire for warning and further helpful information is high, and functions like news feeds and interactive maps are known from other applications like Google Maps. [30] However, we want to highlight that, by default, only necessary information nearby should be shown to avoid panic and information overload (cf. Sect. 2.3). What “near” means in detail remains unclear and should also be defined by emergency stakeholders, as some actions might be conducted quite close to citizens but not relevant, while others are farther away but

can have huge impacts. For example, when a dike breaches, a whole district can be affected [15]. At the same time, C7, C8, and C13 demanded more information to plan their actions, especially about the predicted progression of the coming storm flood [36].

Regarding DP2, the "checklist helps to quickly consider and pack the most important things" (C9, C11, C12, C14, and C15) and was appreciated and seen as a preparation step toward the evacuation, especially if no time remained [25]. The discussion was two-fold. The "awareness" factor is important, and the more citizens know before an emergency, the more appropriately they should react [21]. The discussion regarding life-saving behavior opened the question of how this information can be provided during an emergency, e.g., a flood while citizens are evacuating. The stress level then is higher than before a flood, and citizens are likely to panic in case of injuries. In the evaluation, the citizens elaborated on the panic button to call for help in case of accidents or hurt people (C7, C10, C12, C13, C15, and C17). Therefore, we derive DP5, which needs to be investigated further, as the implementation is unclear.

DP5: Designers should provide an emergency button and first aid guidelines for injured citizens to enable fast and supportive self-help, help by relatives, and further assistance until emergency stakeholders arrive.

The discussion leading to DP5 highlighted a panic button that calls for help and sends the current location and further account information as mandatory. However, until help arrives, question-response approaches via buttons (without text), a chatbot, checklists, or starting a direct call to the next rescue forces could make sense, knowing that lastly might not be possible in huge floods, as all emergency stakeholders are in action and communication channels overloaded.

The evacuation function starts at the current position of the citizen, e.g., the smartphone holder, navigates to a safe location. In the mock-up, this was simulated using a static navigation example. However, in practice, the location is based on GPS and will automatically calculate the way to the next evacuation point [34]. The navigation will vary as citizens can choose if they use a car, take a bus, walk, or else. Even if it sounds strange, many mobility possibilities are usually available in the early flood stages, as public transport providers initiate evacuation points to which citizens can walk and will be evacuated by extra buses. However, this is only possible if the flood is known, but with today's weather prediction, quite often, this is possible with a time lead of up to two days [37]. During floods, evacuation is getting more challenging, and a mobile application can recommend staying there, looking for high ground, or walking to an official shelter with the capacity for more citizens (C7 and C8). These are often public buildings high above the water level, like public offices or schools.

All participants appreciated the evacuation approach. However, they also highlighted the necessity of ensuring that only safe routes are recommended so that citizens

always know they will be safe if they follow the app instructions and no dangers exist. In addition to the evacuation, the news function should inform about blocked roads, reduce the possibility of information overload, show information depending on the location, and include filters (C8, C11, C12, C13, and C14). However, the comments about the news feed were inconsistent, as some citizens preferred only to have information about blockades on the map, reducing the interactions and possibility of mental overload (C8, C10, and C11), leading to DP6 [25]. Besides that, two citizens also asked for the option to share their positions, organize carpools, and help each other (C9 and C11). Still, some also argued that this would complicate evacuations and delay them.

DP6: Designers should enable the specification of citizens' mobility capability to individualize evacuation routes by considering restraints (e.g., health issues) as well as the availability of different vehicles to optimize evacuation routes and reduce overload.

The evaluation with the emergency experts considered all design principles but focused on DP4, which is critical for them. Regarding DP1 and DP2, emergency experts see that it is a challenge for citizens to stay informed, as quite often, no single point of information exists, as these are published on multiple websites and paper flyers. However, the approach is one-directional, and citizens still have to look it up, as no established direct and bidirectional communication channel exists [20]. Therefore, it is currently also impossible to filter information based on location (cf. Sect. 2.3). Moreover, a mobile application is also suitable for DP3, and the emergency stakeholder specified a vast potential in providing location-based recommendations [38]. This was argued, as this approach also enables the collection the position data of all citizens with emergency apps during storm floods as indicated by DP4, and this would enable the visualization of the number of cities in the endangered area, safe area, and the moving patter, which should, in the best way indicated, that all citizen are leaving the endangered areas in time. Moreover, by documenting on-site barriers and dangers like already flooded areas or fallen trees, citizens can contribute further data, which they should only do if they are safe. This highlighted the approval of DP4, but in cases of immediate dangers, citizens, of course, should always focus on their safety.

DP7: Designers should include functions for citizens to share their GPS position and enable emergency stakeholders to actively contact them to provide and collect information and acquire support.

In addition, the emergency stakeholder also described the potential to contact citizens if they realize, based on their GPS position, that they are not moving or are already evacuated and are acquiring helpers, leading to DP7. Acquiring helpers is quite relevant in ongoing emergencies, and having enough capabilities to prepare and

supply food, fill sandbags for dikes, support logistics, or recover after an emergency is also important, as described in Sect. 2.1.

17.7 Discussion and Conclusion

In this paper, we examined the RQ, "How should mobile emergency apps be designed to support citizens during storm floods?" To address the RQ, we initiated a DSR project following Kuechler and Vaishnavi [27] and completed the first cycle, as illustrated in Fig. 1. We interviewed six citizens and four crisis-relevant stakeholders, identified twelve issues, formulated twelve meta-requirements, and derived four design principles. The prototype developed subsequently served as a demonstrator and was evaluated by ten additional citizens and the already interviewed emergency-relevant stakeholders [26].

The initial derived and evaluated design principles were confirmed (cf. Sect. 4). However, DP2 prompted extensive discussion, as citizens exhibited varying expectations regarding how information to treat injuries should be communicated. The assumption that emergency services can be permanently accessible during severe storm surges is untenable, as emergency-relevant stakeholders pointed out a significant lack of personnel and resources to meet this demand [7, 13]. Furthermore, disaster protection is a societal responsibility that is, at best, needed infrequently and sporadically. This led to DP5, which aims to maximize the potential of a mobile application in supporting medical emergencies and enhancing both self-care and care provided by others [14].

Regarding evacuations, there is considerable potential in utilizing location-related data. Citizens appreciated being reliably and safely guided to a secure location or evacuation point, depending on their circumstances and mobility options. The customization of routes and route optimization is addressed in the derived DP6, which suggests that users should ideally enter relevant data during the application setup. The potential for citizens to gather data, combined with direct communication through automated messages sent to all users or specific location-based groups (as discussed in DP4 and DP7), was perceived as highly valuable by crisis-relevant actors. Nonetheless, it became clear that analyzing all data within a highly scalable bidirectional communication framework presents challenges. Thus, standardized approaches and reliance on automated evaluation options are essential [33].

Our findings, particularly the design principles, serve as a guide for emergency management practitioners and underscore that advancing existing approaches from one-way information dissemination to bidirectional communication channels can enhance emergency management efforts [28]. This can be accomplished through data collection and targeted individual and location-specific mass communication. The

prototype suggests viable implementation prospects, even though some functionalities remain unfulfilled.

In addition, this paper contributes to the scientific knowledge outlined in Sect. 2. Climate change necessitates adaptation to new realities characterized by increasing flood risks and storm surges [9]. This is also reflected in the UN sustainable development goals 11 ("Sustainable Cities and Communities") and 13 ("Climate Action"), which advocate for secure and resilient cities alongside measures to address climate change [4]. Moreover, the solution described herein extends significantly beyond existing approaches. Many emergency management systems documented in the literature rely on stationary warnings issued via loudspeakers or radio network messaging [14]. This reliance may stem from not all citizens having access to mobile devices, and radio networks may be insufficiently stable, potentially collapsing under high demand. However, our findings did not support the idea that networks in industrialized urban areas are fragile. Instead, they appear robust and can be strengthened during crises by installing additional antennas. Moreover, it is possible to exclude specific devices from networks to alleviate strain.

While our findings are compelling and valid, it is important to note that the three newly derived design principles have yet to be instantiated and evaluated thoroughly. Additionally, the first cycle involved only the development of a prototype rather than a fully operational application. It remains to be determined how route optimization for evacuations during a crisis, or information provision regarding injury care, can be effectively automated [39]. The potential application of AI, which is still relatively sparse in the literature on this topic, warrants further investigation. This concern also extends to the data collection methods employed with citizens [40]. While this approach is promising and can mitigate information shortages, it could lead to information overload if not systematized and processed, potentially utilizing AI to integrate into situational assessments and inform decision-making [41]. This aspect deserves further exploration, particularly from the perspective of the crisis-relevant actors, whom we intentionally excluded from our analysis but who should be viewed as counterparts to our work. In the subsequent cycle, we aim to implement additional functionalities and plan to test these in a laboratory environment. This will enhance the validity of the design principles. However, it remains challenging to ethically test a mobile emergency application under conditions like those experienced during storm surges, particularly concerning citizen behavior under high stress and anxiety.

In conclusion, this paper addresses the RQ, "How should mobile emergency apps be designed to support citizens during storm floods?" through the developed design principles. These offer practitioners' significant insights into designing communication and interaction with citizens and expanding the existing knowledge base. However, the limitations described should be acknowledged, and further

research should focus on these and consider the facilitation and evaluation of mobile emergency applications in realistic environments.

17.8 Acknowledgement

We want to express our sincere gratitude to the Federal Ministry of Education and Research (Bundesministerium für Bildung und Forschung) for supporting the project RESCUE-MATE. The project examines innovative approaches to support civic engagement in crisis scenarios. The funding of RESCUE-MATE, with the grant numbers 13N16835 to 13N16845, enabled us to carry out this research and enable this paper.

17.9 Disclosure of Interests

The authors have no competing interests to declare that are relevant to the content of this article.

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18 Publication C13: Developing Machine Learning Models for the Analysis of Citizens' Contributions from E-Participation

EGOV-CeDEM-ePart (EGOV)

Track: CEUR-ONGOING RESEARCH
Research in Progress
Ranking: -

Research Question

How should textual citizens' contributions from e-participation be classified with machine learning techniques?

Contribution to the Dissertation

This publication contributes to the overall RG, especially RQ2, by analyzing real-world citizen contributions from surveys and urban participation, describing them, and elaborating on textual data. Furthermore, this publication contributes to RQ3, as the data were cleaned and manually labeled according to the created labels, e.g., categories based on topics and findings from the labeling process. Afterward, the data were preprocessed and used to train machine learning models for category (class) prediction. The findings are described in terms of accuracy and training variations and formulated into seven insights.

Citation

Borchers, Marten; Habash, Delzar; & Bittner, Eva (2025). Developing Machine Learning Models for the Analysis of Citizens' Contributions from E-Participation. In: *Proceedings EGOV-CeDEM-ePart conference*, August 31 - September 4, 2025, University for Continuing Education, Krems, Austria. https://ceur-ws.org/Vol-4127/. Completed Research.

Abstract: *Citizen participation is increasingly relevant in acquiring local knowledge for urban projects. However, the increasing number of participants has created a problem of data overload, as manual analysis is hardly feasible due to its expense, time intensity, and slowness. AI and ML can help reduce or solve this issue. However, due to the lack of proper ML-based approaches, we investigate how textual contributions from citizens can be analyzed using machine learning techniques. To achieve this, we followed the knowledge discovery in the database framework, collected data, and trained several machine learning models, which we analyzed and compared. Our findings demonstrate that urban development contributions often cover multiple topics, making classification challenging, which also corresponds to the length of citizens' contributions. Transformer models, however, show remarkable precision when compared to SVM models. With our findings, we contribute to the analysis of citizen contributions to support democratic processes and scalable citizen participation.*

Keywords: Citizen Participation, Machine Learning, Urban Planning, Data Analysis, Knowledge Discovery in Databases

18.1 Introduction

Today, most of the global human population lives in urbanized areas, and this trend is expected to continue until 2050 [1]. However, this growth has led to difficulties for urban developers and planners, who aim to plan projects in the most efficient way possible, thus saving resources, improving the quality of life [2], and increasing sustainability [3]. Planning such projects comes with its own set of problems [4]. Ideally, the main stakeholders should be the local citizens since they live in the area concerned. However, citizens' wishes may conflict with the priorities and objectives of other stakeholders like local businesses and industries, development or construction companies, environmental and conservation agencies or groups, local government policies, and more [5]. As a reaction, governments involve citizens in urban planning to increase transparency, trust, acceptance, and the real-world benefit of projects [6].

However, electronic participation (e-participation) with websites and comprehensive participation platforms, such as Decide Madrid [7] and DIPAS [8], among others, lacks automatic analysis systems that can handle thousands of citizen contributions to support urban experts in subsequent processes. For example, in 2019, a Scottish portal generated around 16,000 responses [9]. The absence of automatic analysis approaches and the fact that the gathered citizen contributions are mainly in free-text [10] increase costs and errors during the analysis process, e.g., inconsistencies. Therefore, new solutions are required to automatically analyze citizens' contributions [11].

The scientific literature describes demands and requirements, e.g., summarized and focused on sentiment analysis, keyword search, and clustering [12], and presents initial solutions for machine learning models (ML). Natural language processing

(NLP) is crucial in handling textual data. Despite the significant strides in the field of NLP, the processing of participation data with NLP, particularly classification, remains understudied, which can be attributed to a lack of publicly available data. Therefore, we build upon the existing knowledge of artificial intelligence (AI), ML, and NLP in citizen participation to examine the following research question (RQ).

RQ: How should textual citizens' contributions from e-participation be classified with machine learning techniques?

To answer the RQ, we pursue a practical and data-oriented approach as described by the Knowledge Discovery in Databases Framework (KDD), which defines a structured process for gaining new knowledge from data and ML models [13]. Therefore, we collected a dataset from e-participation and manually labeled it. We then trained several ML models, which were compared to each other and further analyzed to increase their accuracy, as described and elaborated on in the following sections.

18.2 Theoretical Foundation

Citizen participation can be defined as an involvement characterized by interactive and iterative deliberation processes among citizens and government officials [14]. Another definition, provided by Boudjelida et al., is "a form of democracy in which citizens are part of the decision-making process about the development of their society" [15]. Both show that solutions or views imposed on the public top-down by leaders and experts are no longer considered optimal and that governing institutions need to build networks to link them with the public to keep up with modern complexities to which many agree [16].

18.2.1 Minimum Viable Process for Citizen Participation

Stelzle et al. [17] proposed a process model for incorporating citizens and other stakeholders in urban projects, which has also been tested and applied in practice, called the minimal viable process (MVP), summarized in Figure 1.

The MVP begins with (1) initiating the urban project and assembling a project team. In step (2) (co-brief), the project lead's objectives are documented and prioritized with stakeholders, including designers and planning authorities, focusing on project scope and citizen participation. This sets the stage for (3) co-design, where citizen participation occurs through various methods like information booths, workshops, (online) surveys, contests, social media, and participation platforms and therefore contributes huge amounts of textual data [16].

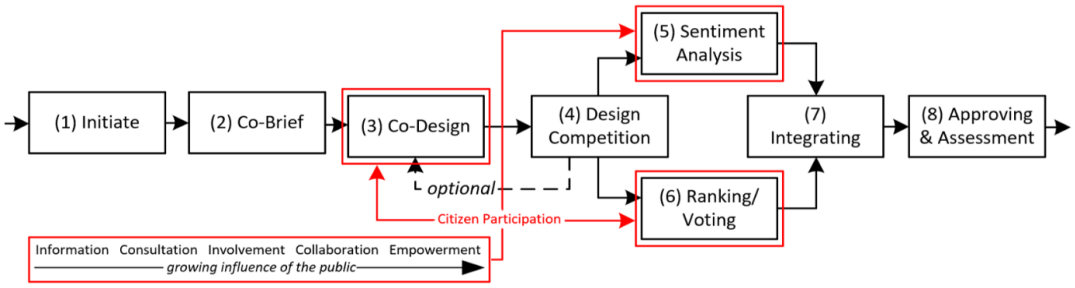


Figure 1. Minimum Viable Process (MVP) for Citizen Participation

At the end of the co-design process, results are evaluated to determine the project's strategic alignment. In step (4), project visions developed by architects and urban planners are published to gather further feedback from citizens through voting and comments on digital platforms. Steps (5) and (6) involve analyzing comments and voting results, which are then integrated (7) into a comprehensive urban project design. Finally, this design must be approved (8) by the project lead and planning authorities (9) to ensure compliance with regulations and facilitate permit acquisition [17].

18.2.2 Challenges in the Analysis of Citizens' Contributions

Citizens' inputs generated during participation must be analyzed and evaluated by experts (cf. Figure 1) [12]. Experts face challenges in this context, as the number of participants in e-participation and on participation platforms has increased significantly [9]. This creates an overload of information for subsequent processes, including analysis, sense-making, and the development of shared ideas and visions [18].

A larger number of participants is beneficial for e-participation because it generates broader, more diverse, and more comprehensive knowledge [19]. However, massive participation events, such as the U.S. Federal Communications Commission's net neutrality implementation, which gathered over 450,000 comments [20], showcase how the volume of contributions can increase. Experts often lack the resources and skills to exploit this knowledge pool [21]. The extensive data volumes pose significant challenges for processing, and the resulting information overload becomes a real issue. Real-time analysis could significantly reduce the time between analysis and decision-making [22]. Another challenge in analyzing citizens' contributions is the individual and qualitative processing [12]. Evaluators can build on reusable and standardized methods and categories, saving time and financial resources [16].

18.2.3 AI and ML for analyzing E-Participation

AI encompasses various technical approaches that facilitate the automatic execution of tasks that mimic human capabilities [23]. Within this domain, ML refers to algorithms that enable models to learn from to make predictions, classifications, or

clustering [24]. NLP is a subfield of AI and ML that focuses specifically on analyzing and understanding human language, making it a valuable tool for interpreting citizen contributions in free-text formats. Despite the increasing interest in leveraging ML and NLP for e-participation initiatives, practical applications remain limited [10].

Recent studies highlight the potential of ML and NLP in addressing the challenge of information overload on e-participation platforms. Arana-Catania et al. [21] proposed utilizing these technologies to analyze citizens' interests, fostering increased participation and enhancing user experience on urban platforms. Similarly, Lieven et al. [8] emphasized the efficiency of using ML to evaluate complex and unstructured citizen inputs by generating automatic summaries. Moreover, researchers have examined clustering models to analyze sentiments from social media contributions, aiding moderators in real time [25]. However, the ambiguity inherent in short or keyword-based contributions poses challenges for accurate interpretation. Romberg et al. [22] provide an analogous approach, illustrating the training of a classification model with citizen inputs from a mobility project to establish a preliminary analysis framework. These studies collectively underscore the promise of ML and NLP in enhancing the analysis of citizen contributions.

18.3 Research Methodology

As stated by the RQ, ML models have not yet produced suffiecient results for analyzing citizens' contributions from e-participation. Given the importance of data, e.g., citizen contributions, we follow the Knowledge Discovery in Databases Framework (KDD) [13].

18.3.1 Knowledge Discovery in Databases

The framework delineates a systematic methodology for iteratively deriving insights or knowledge from data [26]. This framework operates on the premise that IT systems can document data related to usage, user behaviors, and outcomes, which, when analyzed, facilitate the making of inferential statements and a deeper understanding. Furthermore, a robust dataset enables the training of new ML models. Knowledge generated through the framework is expected to be generalizable, non-trivial, novel, useful, and comprehensible [26].

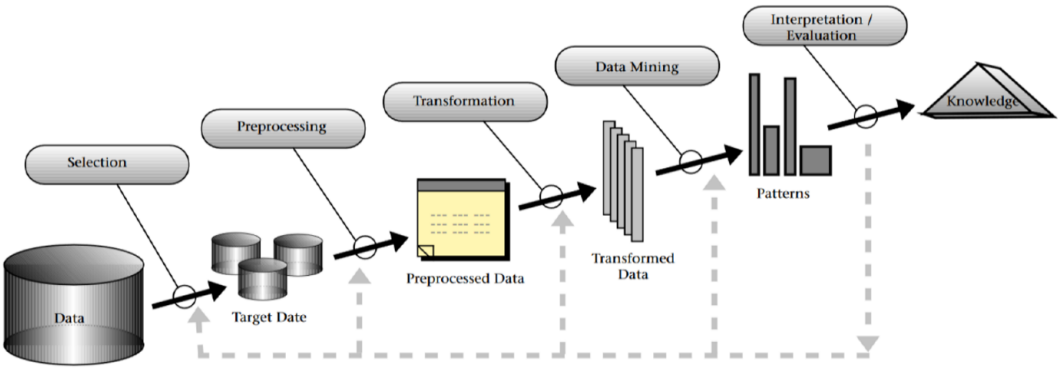


Figure 2. Knowledge Discovery in Databases Framework [26]

The KDD is distinguished by its structured process, as illustrated in Figure 3.1, and is critically relevant in today's data-driven world [27]. Unlike more pragmatic and flexible methodologies focused on resolving specific business challenges, the KDD emphasizes a rigorous protocol that includes data cleansing and standardization, thereby facilitating the replication and verification of results by other researchers. In the initial phase, the goal and domain knowledge are defined. Subsequently, the KDD procedure is traversed in five phases (cf. Figure3.1). In the selection phase, the data suitable for the goal are chosen. In the preprocessing phase, data quality is evaluated and cleaned. The data is converted into a format that ML algorithms can process in the transformation phase. In the data mining or ML phase, algorithms are selected to search for patterns or insights in the data [26]. The KDD process focuses on the data, which is why ML or NLP can be employed. In the interpretation and evaluation phase, the results of the ML algorithm are finally analyzed and visualized [13].

18.3.2 Application of the Framework

In applying the framework, we elicited a dataset of citizen contributions to urban planning in Germany. We archived that by combining available data from two past participations. One was implemented in eastern Germany, and the other in middle Germany. Both focused on the reconstruction of buildings: the first was a university campus in a larger city, and the second was a school in a smaller city. Together, the dataset comprises nearly 18,000 contributions from citizens.

In the selection step, we conducted a detailed examination of the data set to understand its nature and properties. This preliminary analysis is critical, laying the groundwork for all subsequent stages of the framework process. In the preprocessing step, we cleaned the data, addressed irregularities, and handled missing values by manually correcting or removing them to create a uniform dataset of 17,031 entries as shown in Table 1.

The transformation step was extensive. To train a classification model, we had to label all entries. This was achieved with the help of two hired and trained students who labeled all data manually according to the ten categories as shown in Table 1.

Both students labeled the data according to a description of the categories in the literature [12, 22]. The last category was used to count unclear and not understandable contributions. The prepared data was formatted appropriately for text categorization, involving organizing the texts and their corresponding labels into a structured dataset.

No.	Class	Entries	Proportion
1.	Mobility	6,059	35.85 %
2.	Environment	2,409	14.14 %
3.	Living	1,813	10.65 %
4.	Social Network	1,313	7.78 %
5.	Education	1,222	7.718 %
6.	Economy	1,145	6.72 %
7.	Culture	536	3.15 %
8.	Sport	370	2.17 %
9.	Public Service	206	1.21 %
10.	Undefined	1,946	11.43 %
Sum		**17,031**	**100.00 %**

Table 1. Overview of the Dataset

In the data mining step, we conduct various experiments to study the data characteristics and identify potential challenges that impede effective text categorization. These experiments also helped in understanding the baseline performance of NLP techniques on the data [24]. In the evaluation and interpretation step, we focused on the performance of the developed ML models and interpreted their effectiveness in classifying contributions within citizen participation. ML Prototypes were tested, and an ensemble approach was favored due to the unbalanced and multi-topic nature of our dataset [28].

18.4 Evaluation and Findings

The dataset under investigation was partitioned into a training set (80%) and a testing set (20%) and was subjected to classification using five different classifiers, as shown in Table 2. The dataset underwent several sequential transformations to investigate the effects of the preprocessing techniques on the performance of successive transformations. Each subsequent transformation builds upon the output of the previous one.

The initial condition involved no preprocessing. Therefore, it contained only the pure text, vectorized using the wiki corpus dataset [29]. The next step involved normalizing capitalization so that the holder text is in lowercase to increase semantic similarity, and the last step was to stem the tokens, ensuring that words are converted into their base form. The performance of the classifiers was evaluated using the F1 score, a harmonic mean of precision and recall calculated via the confusion matrix

(true-positive, false-positive, true-negative, and false-negative), which is particularly useful in situations where a balance between these metrics is desired [30]. This measure is crucial when dealing with datasets that may have an imbalance in class distribution or when the costs of false positives and false negatives are significant.

No.	Model with F1-Score(s)	Pure Text	Without Stop Words	With Capitals	Stemmed
1.	Naive Bayes	0.44	0.48	0.48	0.49
2.	Logistic Regression	0.67	0.66	0.66	0.67
3.	Support Vector Machine	0.69	0.68	0.68	0.69
4.	Decision Tree Classifier	0.50	0.56	0.56	0.58
5.	Gradient Boosting	0.62	0.61	0.61	0.63

Table 2. Comparison of Trained ML Models

In the training and analysis conducted, support vector machine (SVM) and logistic regression exhibited superior performance. This robust performance was observed across various stages of text preprocessing. Naive Bayes showed notable improvement when stop words were removed, consistent with their probabilistic foundations, which can be sensitive to irrelevant features. Decision trees, which are generally weaker classifiers for text data but robust against outliers, showed poor performance across all text variants, whereas ensemble methods, such as gradient boosting, demonstrated enhanced outcomes.

Further analysis was conducted using the same classifiers as before. Similar preprocessing steps were applied except for removing special characters, which had already been conducted during data cleaning. SVM again performed the best among the classifiers, though the F1 scores indicated that the classifiers struggled more with citizens' contributions than with the initial dataset. Attempts to optimize the SVM's hyperparameters did not yield significant improvements, with the F1 score plateauing around 0.7. A fascinating insight was gained by excluding entries labeled as "undefined," which typically represent contributions that are too vague or ambiguous to be classified meaningfully. This exclusion led to a noticeable improvement in the SVM's performance, from an F1 score of 0.69 to 0.75. This improvement underscores the importance of dataset quality and the impact of ambiguous data on classifier performance.

The trained SVM models concentrated on the length of citizens' contributions to identify possible patterns that ML models could abstract. The existing literature suggests that longer texts generally enhance classifier performance. However, this assumption requires validation within the domain of citizen participation [28], where texts are typically quite short, nuances differ significantly, and empirical data are limited. This validation involved conducting three different approaches to assess how

text length affects classification in this context. The data processing was conducted as before, and training and test data were the same size as before. Notably, while previous studies measured text length by character count or word count, this analysis used word count [31].

Max. Word Count	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
n-Entries	937	1,931	3,075	4,144	5,175	6,155	6,999	7,805	8,490
F1-Score	0.708	0.750	0.771	0.761	0.760	0.760	0.750	0.748	0.748

Table 3. Overview of F1-Score for Citizen's Maximum Length of Contribution for the trained Support Vector Machine Model

Table 3 shows that the length of citizens' contributions influences the performance of the trained SVM models. In columns 4 to 7, an increase in performance was observed with longer text lengths, surpassing baseline levels and corroborating previous research [12]. However, benefits from increasing text length plateaued after reaching eight words, with slight declines in performance thereafter. While these findings are not definitive due to the variable dataset sizes, the trend becomes more apparent when considering the results together, further suggesting that longer texts are leading to diminished performance.

Min. Word Count	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
n-Entries	14,859	13,151	12,007	10,938	9,907	9,827	8,083	7,277
F1-Score	0.733	0.730	0.724	0.714	0.708	0.703	0.697	0.696

Table 4. Overview of F1-Score for Citizen's Minimum Length of Contribution for the trained Support Vector Machine Model

Our findings indicated an unexpected trend: as text length increased, the F1 score generally decreased, suggesting that longer texts might not necessarily yield better models. This was contrary to prior assumptions [22] and raises questions about the optimal text length for training classifiers in citizen participation. However, longer texts can also lead to poorer performance when the narrative deviates from the central theme, complicates label assignment, or tends to be ambiguous. This pattern led to the conception of the third training of SVM models, where a sliding text length window was applied to the dataset to fine-tune the optimal word count range. The results, presented in Table 4, begin with an evaluation of model performance in identifying a specific range where text length maximizes classification accuracy.

Our analysis indicated that datasets with shorter texts, as displayed in the first column of Table 5, exhibited the highest performance. Performance consistently declined as the text length window expanded to include longer texts. This pattern was not attributable to dataset size, as datasets with shorter texts performed significantly

better than those with longer texts of comparable size, identifying text length as the critical variable affecting model performance.

Word Windows	1-5	2-6	3-7	4-8	5-9	6-10	7-11	8-12
n-Entries	3,075	4,137	4,952	5,218	5,068	4,730	4,346	3,905
F1-Score	0.772	0.764	0.759	0.747	0.733	0.701	0.695	0.672

Table 5. Overview of F1-Scores for different Word Windows in Number of Words for the trained Support Vector Machine Model

These three approaches collectively suggest that the established research findings might not directly apply to the domain of citizen participation data, e.g., citizens' contributions. Although evidence was found that shorter contributions are easier to categorize, variations could arise with different datasets and methodologies. This insight is valuable for facilitators, who may encourage participants to make brief contributions for more efficient processing.

Entries per Class	400	500	600	700	800	900	1,000	1,100	1,145
n-Entries	2,400	3,000	3,600	4,200	4,800	5,400	6,000	6,600	6,870
F1-Score	0.704	0.723	0.741	0.758	0.772	0.784	0.792	0.802	0.806
Improvement	-	1.9 %	1.8 %	1.7 %	1.4 %	1.2 %	0.8 %	1.0 %	0.4 %

Table 6. Overview of F1-Scores for trained Models with the same Number of Entries per Class for the trained Support Vector Machine Model

To examine the impact of dataset size and the number of entries per class, we trained several additional ML models. The F1 score of SVM models that contained at least 1,145 entries is shown in Table 6. The classes included are Mobility, Environment, Living, Social Network, Education, and Economy (cf. Table 1). The performance increased significantly when the dataset size increased over the trained models up to 1,145 entries per class. Although results kept improving with each increment, diminishing returns were noticeable, as denoted by the last row of Table 6. This suggests a performance plateau at a certain dataset size, but the dimensions of the plateau could not be captured with the limited amount of the citizens' contributions.

Dataset	Entries	Classes	Duplicates	Duplicate Proportion	F1-Score
1.	1,145	6	False	0 %	0.79
2.	1,200	6	True	3 %	0.86
3.	1,500	6	True	4 %	0.91
4.	2,000	6	True	5 %	0.92

Table 7. Overview of F1-Scores for the upscaled Transformer Model

Next, we focused on transformer technology. We trained a transformer model (DistilBERT) using default parameters from the Simple Transformers library (Python), with a batch size of 8 and over 8 epochs, achieving an F1 score of 0.759% on an evaluation dataset of 600 instances. Further trained models, including an up-sampling of the training data with duplicates, were allowed, and datasets were assessed at 1,200, 1,500, and 2,000 instances per class (cf. Table 1). Despite maintaining less than 5% duplicates in test sets to minimize bias, performance increased impressively, highlighting that transformer models benefit from larger training datasets. Incremental epochs 12 and 16 showed no significant improvement, reinforcing the model's responsiveness to dataset size over extended training durations. However, an accurate classification with an F1 score of 0.92, as shown in Table 6, is promising, even if it was only achieved with the six classes of Mobility, Environment, Living, Social Network, Education, and Economy (cf. Table 1) due to a lack of further data.

18.5 Discussion

In this paper, we examined the RQ "How should textual citizens' contributions from e-participation be classified with machine learning techniques?" by applying the KDD Framework, which provided a structural approach for analyzing data and deriving knowledge. To answer the RQ, we collected and created a labeled dataset of 17,031 preprocessed entries representing real citizens' contributions from past participation projects, which we used to train and analyze multiple ML models.

For practitioners and scientists, the dataset created can serve as a baseline for future development and currently represents the largest dataset so far, which we hope will soon be extended. This desire is also reflected in our findings. The trained ML models demonstrate that training is possible with an acceptable F1 score, e.g., validity, especially for the classes in which our dataset contains many entries. However, as urban experts and decision-makers should develop a proper vision and decide if these sometimes very costly (construction) projects are implemented, a high validity of the analysis of data is required, leading to the following insights.

Insight 1: Only validated ML models with high validity should be used to analyze citizens' contributions from e-participation, which requires more data.

Insight 2: Preprocessing is mandatory, especially regarding the meaning of contributions and their decomposition into sense-making pieces.

Insight 3: ML model classifiers must represent the desired classes by experts in the training data equally to increase the accuracy of the prediction.

Insight 4: The length of the text contributions is decisive for the classification and must be preprocessed as required and divided into semantic paragraphs.

Considering insight 1, we cannot say which validity of an F1 score is required. However, the trained transformer models showed the highest scores and a value above 0.9 may be enough to support experts, while a fully automatic analysis might require an even higher validity. Insight 2 is derived from the findings of Table 2, Table 4, Table 5, and Table 6. In creating the dataset, all contributions were divided into sense-making pieces, allowing for abstraction and highlighting existing findings [32]. This is represented in the results and should be considered. Alternatively, it is possible to predict multiple classes at once. However, the abstraction in terms of semantics usually becomes more advanced, and the number of classes is fixed, which reduces the flexibility of the current approach. Insight 3 highlights the demand for an equal proportion of class entries, as shown in Table 7. Furthermore, our current results indicate that shorter texts generally yield better classification results, although this finding may be context-specific. Nevertheless, this, along with the increasing F1 score in Table 7, highlights the need for further data that we specify with Insight 5.

Insight 5: ML model classifiers should at least contain 1,145 (preferably more) entries per class for the training to lay a profound base for the classification.

Insight 6: Transformer models are more capable of classification than SVM in terms of limited datasets but are black box models and not transparent.

Insight 7: Practitioners should deviate between transparency and efficiency of the trained model (in SVM or decision trees) and higher accuracy (e.g., black box models like transformer models).

The training of the SVM and transformer models demonstrated that while SVM models are efficient and require shorter training times, transformer models, though slow and resource-intensive, provided superior classification. This highlights a trade-off between efficiency and performance, influenced by the specific needs and resources of participation facilitators. For practitioners involved in e-participation initiatives, the implementation and development of ML models provide a significant opportunity to enhance the analysis of citizen contributions. These models can automate the processing of large volumes of data, enabling a more efficient and systematic approach to understanding citizens' requirements and sentiments [10]. By employing ML techniques, practitioners can offer insights that drive urban planning and policy-making processes. However, there is a pressing need to tackle all gained insight to effectively design, implement, and interpret ML models [21]. This will lay the technical foundation for the usage of ML and empower urban experts and practitioners to harness the full potential of ML in analyzing the qualitative complexity of citizen contributions, as described in section 2.3.

For governments and urban planners, understanding how ML can be developed and utilized in the context of citizen participation is essential [22]. The integration of ML can facilitate a more democratic and participatory governance framework where real-

time data analysis aids decision-making [33]. Our insight and the developed ML models contribute to that and establish an initial baseline for how ML is deployed in analyzing citizen contributions. However, a critical consideration in deploying ML models is acknowledging existing constraints, particularly concerning the availability of training data and a standardized classification framework (cf. Insight 4). With sufficient quality data and established classes, the performance of ML algorithms is likely to be maintained. To navigate these challenges, governments and practitioners must prioritize collecting and curating diverse datasets that accurately reflect the spectrum of citizens' contributions [22]. Additionally, developing standards for data classification will help streamline analysis procedures and enhance the effectiveness of ML applications in this domain [34].

The findings from this research contribute to the scientific literature by confirming existing patterns and revealing new insights into the nature and complexity of citizen contributions across urban planning contexts. By systematically applying the KDD framework to analyze e-participation data, the study yields new insights into the domain of citizen participation and e-participation, enriching the understanding of how ML techniques can effectively categorize qualitative information [28]. This exploration extends the current knowledge base and emphasizes the importance of integrating ML technology into participatory processes [24].

Moving forward, insights 4 to 6 should be interpreted as a research agenda and call for further action from other researchers to develop ML standards, train extended and capable ML models, and also publish their data and source code. This should include defining best practices for data handling, processing techniques, and model evaluation, as well as the selection of models. Building trust in them is also challenging. For instance, transformer models, such as neural networks, are not transparent, while decision trees can be fully visualized and explained [12].

One of the principal limitations of this study is the lack of ample training data, which constrains the performance of the developed ML models. Without a sufficiently large and representative dataset, the models may struggle to generalize findings effectively, potentially leading to biases in classification outcomes. Moreover, the study indicates the need to explore additional ML approaches beyond the transformer models used. Techniques from generative AI may also hold promise for improving the capabilities of citizen contributions analysis, warranting further research into their applicability and effectiveness [35]. The trust of experts and practitioners in these ML models remains a critical issue that requires further examination. Stakeholders must be assured of the reliability, accuracy, and utility of ML systems when applied to citizen data. Therefore, ongoing dialogues and workshops should be conducted to disseminate findings and cultivate confidence in these technologies. Finally, to ensure user engagement and satisfaction, the design of interfaces built around these ML models should be rigorously tested and evaluated [34]. Feedback from urban experts,

moderators, and decision-makers will be essential in constructing intuitive and effective analytical tools that foster effective communication between citizens and policymakers [10].

Looking ahead, we aim to enhance and retrain our current datasets to improve the predictive capabilities of our machine learning (ML) models. Ongoing efforts to collect fresh data and refine existing datasets are essential to ensure that our models remain relevant and effective in responding to the ever-changing dynamics of urban environments. Future research should also prioritize the exploration of additional ML models and the implementation of advanced visualization techniques. These enhancements can increase the interpretability of model outputs, building trust and acceptance among stakeholders while effectively conveying insights gathered from citizen contributions. Ultimately, investigating the efficiency potential that ML offers to governments and companies in e-participation can provide significant benefits. By automating data analysis and accelerating decision-making processes, ML models can promote a more collaborative and practical approach to urban planning, ultimately benefiting both the public and governmental entities.

18.6 Conclusion

In this paper, we examined the RQ "How should textual contributions from citizens be analyzed using machine learning techniques to classify e-participation data?" The efforts undertaken in this paper aimed to find the appropriate methods and techniques for combining the technical aspects of modern ML paradigms with established research on citizen participation.

After thoroughly examining the relevant research on e-participation, its current implementations, advantages, and weaknesses, it became clear that scholarly deficiencies exist. Participation facilitators, decision-makers, and official bodies often lacked the necessary tools to process, aggregate, and draw unbiased conclusions from participation data. The lack of will and resources to conduct meaningful participation, among other factors, leads to apathy and distrust among the public. The theoretical field of classical participatory democracy is well-studied, and the barriers to participation are known. However, the scientific knowledge base to overcome technical barriers that hinder the advancement of participatory democracy is yet far from sufficient. Efforts to facilitate mass participation by creating adequate IT artifacts are lacking.

The suggested models can extract the topic, e.g., the class of any contribution from a set of defined classes, to an impressive degree of accuracy. The presented SVM ensemble can also extract all present topics in a contribution, thus performing multi-class classification. This gives participants the freedom to express as many wishes as desired in their contributions, and it allows decision-makers to understand where the

public interest lies, enabling them to create better plans that are satisfactory for most citizens. However, in addition to the trained ML models and findings about the characteristics of citizens' contributions, further research is needed to enhance accuracy and expand existing and publicly available datasets. Overall, while the results are promising, they underscore the need for further research to explore the nuances in citizens' contributions to developing accurate ML classifiers.

18.7 Acknowledgments

We want to express our sincere gratitude to the Federal Ministry of Education and Research (Bundesministerium für Bildung und Forschung) for its funding of the RESCUE-MATE project. The project examines innovative approaches to support citizen participation and civic engagement in urban planning and emergency management. The funding of RESCUE-MATE, with the grant numbers 13N16835 to 13N16845, enabled us to carry out this research and this paper.

18.8 Declaration on Generative AI

During the preparation of this work, the author(s) used the GPT-4 mini and GPT 4.1 models from Open AI to translate texts and to support the writing and development process in Python. Additionally, we utilize Grammarly for spelling checks. After using these tool(s)/service(s), the author(s) reviewed and edited the content as needed and take(s) full responsibility for the publication's content.

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19 Publication C14: Emergency Management: Designing Situation Maps to support Rescue Forces during Flood Disasters

International Conference on Information Systems (ICIS)

Track: CEUR-ONGOING RESEARCH
Research in Progress
Ranking: A

Research Question

How should IT artifacts be designed to support informed decision-making of emergency forces during floods in urban areas?

Contribution to the Dissertation

This publication contributes to the overall RG and RQ1 by exploring the possibilities for designing and interacting with urban maps, including providing different types of data layers that support users in gaining a better understanding of districts and other areas of interest. Furthermore, this publication contributes to RQ2 by exploring and designing a map that specifies data attributes and how it can be intuitively provided to users. The publication describes twelve issues, twelve meta-requirements, and five design principles, which were extended to eight design principles due to the evaluation.

Citation

Borchers, Marten; Milutzki, Enrico; Fetzer, Lisa; Magdych, Valeria; Bittner, Eva; & Semmann, Martin (2025). Emergency Management: Designing Situation Maps to support Rescue Forces during Flood Disasters. In: *Proceedings of the 46th International Conference on Information Systems* (ICIS). https://aisel.aisnet.org/icis2025/sustain/sustain/2. Completed Research.

Abstract: *In the face of climate change, flood disasters increasingly challenge the coordination and decision-making of emergency forces. This paper explores how digital tools can be designed to support emergency responses during storm floods in urban areas. We conducted expert interviews with six emergency management organizations. Twelve critical issues in current practices were identified, informing the formulation of meta-requirements and the derivation of five design principles. Based on these, we developed a web-based prototype of a situation map that enables structured, cross-organizational data input, presents information in a uniform and accessible format, and allows role-specific information flow. The prototype was evaluated in expert focus groups, confirming and extending the design principles. Building on these insights, we propose a data-driven response model and design guidance to support faster and informed decisions under emergent conditions, highlighting the crucial role of novel situation maps in modern disaster management.*

Keywords: Situations Maps, Floods, Emergency Management, Response Phase, Design Science Research

19.1 Introduction

Climate change is an ongoing phenomenon that leads to increasing global temperatures. Governments, companies, and citizens are implementing actions to prevent and reduce their consequences (Hajat et al., 2005). However, the sea level is expected to rise by up to 2 meters by 2100 (Bhushan & Sharma, 2022). Even if the timespan seems long, many side effects have already significantly increased the risk of flooding (Bindoff et al., 2007). Higher temperatures and temperature differences favor stronger winds, which increase the risk of storm surges (Pastor et al., 2020). The increasing temperatures also affect the oceans and increase evaporation, which, together with higher temperatures, enables clouds to store more water (Wang et al., 2023). In addition, more than 100 million people already live in places below sea level (Kulp & Strauss, 2019), and more than 2,15 billion people live in coastal regions (Reimann et al., 2023) because oceans and rivers provide economic and agricultural benefits that go back thousands of years. In the past few years, the number of floods has risen continuously. In Europe, in 2024, excessive rainfall flooded large parts of USA, Spain, Poland, the Czech Republic, Austria, and southern Germany, causing at least 247 deaths only in Spain and Germany and estimated damage of at least four billion euros, as thousands of buildings, streets, and bridges were damaged (Chan et al., 2022; Hartmann, 2024; Knittel et al., 2024). These developments threaten citizens' lives, infrastructure, and nature. They are also considered in the UN Sustainable Development Goals (SDG) for Sustainable Cities and Communities (SDG11) and Climate Action (SDG13), calling for innovative solutions (Henriksen et al., 2021). Regarding floods, SDG11 is important and affects the safety and resilience of citizens. At the same time, SDG13 calls for action to prevent and respond to emergencies and therefore addresses responsible authorities, infrastructure, and processes (Kaiser & Deb, 2025). In literature, many challenges are described. They

include old infrastructure, slow processes (Lourenço Neves, 2024), reduced risk awareness of citizens (Park & Kwon, 2024), a lack of information elicitation and sharing to organize and support rescue forces like medical personnel, fire brigade, police, and auxiliary forces (Yousefi Mohammadi et al., 2024). This is also reflected in the lack of modern information technology (IT) tools for natural catastrophes (Mukerji et al., 2024). These need to be networked across organizations and capable of collecting, distributing, and displaying data at scale to support stakeholders in making decisions under high stress and with immense impact. The literature mentions simulation tools for weather, floods, storm surges, and wind, as well as sensor systems to collect data from different areas, visualization approaches ranging from VR to AR, and simple interactive maps (Bakhtiari et al., 2023). However, it remains unclear how the existing approaches can be used synergistically in emergency scenarios without data loss and unnecessary communication, particularly for cooperation across organizational boundaries. Socio-technical and holistic solution approaches are lacking and currently under development (Bräker et al., 2022; Feagan et al., 2025). To contribute to this domain, we investigate the following research question (RQ).

RQ: How should IT artifacts be designed to support informed decision-making of emergency forces during floods in urban areas?

We are focusing on cities and urban regions, which are highly relevant due to their importance in terms of population (SDG11) and economic power (United Nations, 2022). To answer the RQ, we applied the design science research (DSR) paradigm (Vaishnavi et al., 2004) and plan to develop and evaluate an IT artifact that supports emergency forces during floods. We do that to create knowledge in terms of design guidelines to strengthen theory and contribute with an IT artifact in a more practical way. The paper continues with a description of the Theoretical Foundation section, concentrating on emergency management and existing approaches. The Methodological Approach section is specified afterward, and the identified problems are described in the Awareness of the Problem section, followed by the Resulting Suggestions section, which includes the meta-requirements and design principles. Based on these, we developed a web prototype that we evaluated as described in the sections Development and Evaluation. The results are presented in the Findings section and elaborated on in the Discussion section regarding the impact, limitations, and further research needs. Finally, we summarize this paper in the Conclusion section.

19.2 Theoretical Foundation

This section describes the fundamentals of emergency stakeholders, framework, and solutions. In general, there are two types of floods. First, floods that are caused by

overflowing rivers can be mitigated with dike systems and are caused by storm surges and heavy rain (Bräker et al., 2022). Second, heavy rains that result in inland floods, which can appear everywhere, aggravate preparedness as stationary dikes usually do not exist (Van Well et al., 2018).

19.2.1 Emergency Stakeholders

At the state level, emergency management is often placed on the Ministry of the Interior (Federal Ministry of the Interior, 2015), and states should prepare for emergencies, considering their local infrastructure and demography. They achieve this by providing resources to operating organizations, enabling them to build dikes and develop the capacities and capabilities necessary for appropriate responses (Rodrigues et al., 2002). Local districts are responsible for informing and warning citizens and providing shelter, as these have the closest connection to their inhabitants (Bakhtiari et al., 2023). For dikes, fire departments, and harbors, the port authorities are responsible for preparing and strengthening them with sandbags and closing floodgates. For the evacuation of citizens, the police are responsible and allowed to use force if citizens do not cooperate to remove them from their property against their will (Bera, 2023). Additionally, this includes removing vehicles to mitigate environmental threats from oil, petrol, and batteries, which are susceptible to salt water and can cause environmental crises. Besides that, there are cases in which citizens cannot move independently, for example, in hospitals, elderly homes, and individuals who are cared for at home and need permanent assistance and medication. In those cases, medical forces support evacuations and transport patients to other hospitals (Bera, 2023). Therefore, during floods, multiple organizations must work together, which requires effective communication and information sharing, which is challenging in stressful, dangerous, and chaotic situations with thousands of citizens (Lourenço Neves, 2024).

19.2.2 Emergency Management Framework

Emergency management is concerned with safeguarding human life and minimizing damage to property and the environment. This endeavor necessitates continuous planning and training, encompassing three cyclical phases as a baseline for emergency scenarios and management (cf. Figure 1), which are described in the following with a focus on the response phase, as included in the RQ.

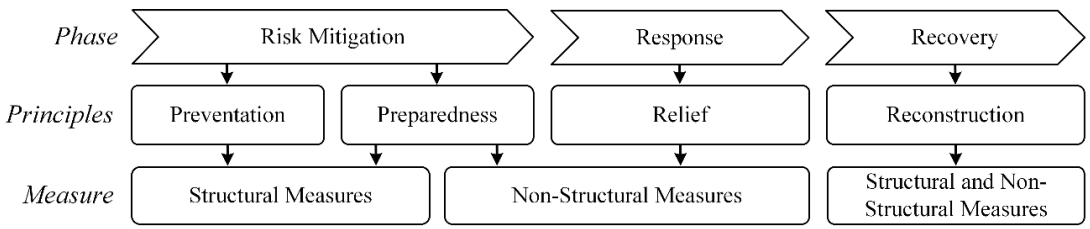


Figure 1. Emergency Management Framework according to Rodrigues et al. (2002)

Risk Mitigation

The first phase, risk mitigation, describes suitable techniques and management principles for addressing risks such as floods, including preventing and preparing activities undertaken by organizations (society) and individuals (Rodrigues et al., 2002). Preventative principles aim to reduce the likelihood of flooding events or minimize their severity. These include structural measures such as constructing flood protection infrastructure, dikes, levees, and drainage systems (Aziz et al., 2024). In addition, land-use planning, flood zoning, and public education programs aim to increase community preparedness and resilience. Preparedness encompasses enhancing response capabilities before flood events occur (Ma et al., 2025). This includes developing early warning systems and disseminating information and resources to communities to ensure they are equipped to act swiftly and effectively in the event of flooding (Yousefi Mohammadi et al., 2024).

Response

The phase response entails the activation and execution of emergency plans and procedures (Boin & Bynander, 2016). This includes issuing alerts and warnings, providing accurate emergency information (Truptil et al., 2010), and delivering relief and emergency assistance, for which rescue-forces and emergency operation centers (EOC), that function as a command hubs, need information (Feagan et al., 2025). The principles of relief in the response phase involve the coordinated efforts of emergency stakeholders, governmental agencies, and community organizations to address immediate needs and minimize impacts during flood events (Rodrigues et al., 2002). Relief defines non-structural measures as immediate actions to ensure safety, provide essential services, and maintain life during flood events. These measures include search and rescue operations, providing food, water, and medical care (e.g., caring for the injured and deceased), facilitating evacuation, and ensuring access to emergency shelters (Rodrigues et al., 2002). Coordinating various emergency services, such as police, firefighters, and medical teams, is crucial for an efficient reaction (Bräker et al., 2022). The ability to deploy resources rapidly and provide aid to those affected is a testament to the effectiveness of the Relief phase in risk response, for which EOCs are responsible. Besides effective and efficient processes and capabilities, this also includes information systems and situation maps, which, as described in the Introduction section, often connect the relevant stakeholders and data from a socio-technical perspective (Ferman Carral et al., 2025). Urban areas face unique challenges during flood events due to dense populations, complicated infrastructure networks, and limited natural drainage capabilities (Aziz et al., 2024). Effective responses in these settings require a robust framework capable of addressing the environment's complexity and the urgency of human needs. In urban

settings like Dhaka or Oldenburg, activating emergency processes is critical during flood events (Mohuya et al., 2025; Wiedemann et al., 2024).

Recovery

The third phase, recovery, involves restoring systems and facilities to their normal operating conditions. It affects conducting damage assessments and ensuring the continuity and quality of essential services until restoration is achieved (Rodrigues et al., 2002). This involves short-term activities, such as debris removal and the restoration of essential services like electricity, water, and transportation systems, as well as long-term efforts to rebuild infrastructure and communities to withstand future hazards better (Thieken et al., 2007). Besides infrastructural topics, the recovery phase aims not only to restore conditions to what they were before the flood but also to strengthen the capacity of communities to respond to and recover from future flood events, thereby fostering a more resilient and sustainable environment (Salvo et al., 2025), which is also measured with structural measures and non-structural measures (Rodrigues et al., 2002).

19.2.3 Emergency Situation Maps

Emergency situation maps and interactive overviews of disasters can be found across various domains and facilitate data, analyzing functions and communication (Zhu et al., 2025) by displaying information in thematic layers that can be toggled on or off, encompassing geo-specific data, such as road networks and topographical features. However, numerous factors must be considered within emergency management, including the tailored presentation of diverse information and the seamless integration of existing emergency plans (Federal Ministry of the Interior, 2015). Li et al. (2024) examine an emergency in a case study in New Zealand during Cyclone Gabrielle. They highlight a gap in understanding the micro-level processes and introduce a digital resilience coordination process model. They specify that solutions should facilitate seamless communication and coordination among various actors to synchronize their efforts, ensuring that all actors are aligned and informed about ongoing developments during a disaster (Li et al., 2024). For example, in the city of Oldenburg, during the winter floods of 2023/2024, the emergency management platform was activated, incorporating EOCs and local emergency actors to manage the flood response efficiently (Wiedemann et al., 2024). This system enabled the local government to coordinate evacuation plans, establish mobile water barriers, and allocate resources to high-risk areas promptly, despite relying heavily on manual communication via mail and phone. Similarly, Dhaka's flood response incorporates structural measures and non-structural measures. The Dhaka integrated flood control embankment project emphasizes using embankments to manage floodwaters, while collaborative efforts among government agencies and community groups ensure rapid response and relief for affected populations (Mohuya et al., 2025).

19.3 Methodological Approach

To examine the RQ, "How should IT artifacts be designed to support informed decision-making of emergency forces during floods in urban areas?"

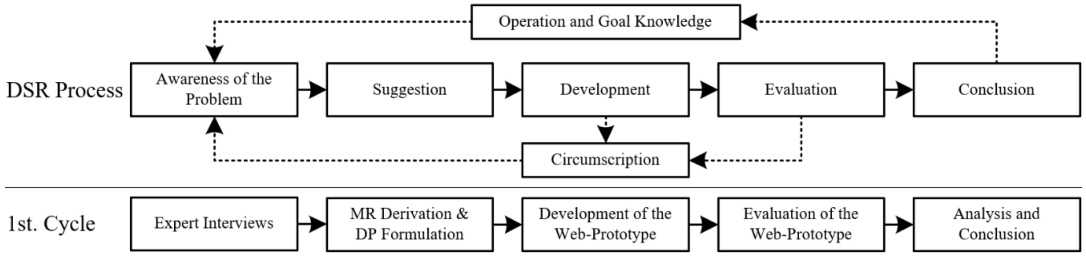


Figure 2. Applied Design Science Research Process according to Vaishnavi et al. (2004)

We utilize DSR, which is an established information system paradigm. It supports developing design principles and design theories by developing and evaluating IT artifacts, including software solutions, models, and methods (Hevner et al., 2004).

19.3.1 Design Science Research

DSR is a cyclical paradigm that different authors define through a meta-process and generally follows five phases (Vaishnavi et al., 2004). Each step requires further specifications, and the implementation should be argued. Solutions move between the problem and solution space and should be evaluated according to the requirements and objectives. The problem space specifies the challenge or issues regarding stakeholders, domain, time, and criteria for solving it via technology, information, or interaction. The solution space specifies constructs, models, methods, and design principles, together with activities and processes, which correspond to the problem space. Findings should be considered in the context of the design knowledge base, which should be expanded to achieve a scientific contribution (Vom Brocke et al., 2020). In this paper, we implement the DSR process as shown in Figure 2.

19.3.2 Application of the first Cycle

According to Vaishnavi et al. (2004), we identified and elaborated on the issues in the awareness of the problem section by conducting interviews with emergency management experts. According to Mayring's (2014) inductive-deductive qualitative analysis approach, we recorded all interviews, transcribed them, and analyzed them. We formulated meta-requirements and derived design principles based on the identified issues, as Gregor et al. (2020) describe, to specify the IT artifacts regarding the solution space. In the development phase, we used the design principles and instantiated them with a web prototype. In the evaluation phase, we evaluated the web prototype with two focus groups of experts to determine if the requirements were met. In doing so, we included experts from the initial interviews to gain feedback

from stakeholders who specified the issues and are familiar with the overall progress, as well as experts who were not involved initially to get unbiased feedback (Baker et al., 2012). The focus groups were documented in the same way as the expert interviews were systematically analyzed, and their findings were discussed regarding the existing emergency management framework.

19.4 Awareness of the Problem

To shed light on the problem space, we conducted eight expert interviews with a total of 14 experts from six different organizations in emergency management. For the interviews, we contacted various organizations relevant to emergency management. The interest was huge, and in organizations with many volunteers, we tried to include a wide range of opinions by interviewing experts from different departments. The inductive analysis led to the identification of 35 missing functions (Mayring, 2014), leading to a total of twelve issues (cf. Figure 3). The interviews revealed different needs for collecting, processing, and visualizing data. The interviewed stakeholders engaged in a variety of tasks and activities. Specifically, the police, fire department, and port authority are present on-site, preparing and ensuring the security of flood defenses, buildings, and the harbor. This involvement generates immense information from direct exchanges with hundreds of individuals on the ground and observations. The sheer volume of information results in an information overload (ISS1). This is caused and enhanced by the unstructured collection and recording of data, primarily in analog formats, which also leads to a significant loss of information (ISS2).

In addition, much of the information is communicated verbally on-site and transmitted via telephone or email, highlighting a lack of proper information structure and format (ISS3). While team leaders in emergency response operations usually possess devices that support information documentation in formats such as Word or Excel, the situation's urgency often hampers their ability to record data systematically. The existing formats rarely facilitate quick input of information (Aziz et al., 2024), which could be enhanced through alternatives like speech-to-text technology and automatic data provision to others, but also beyond that, local forces are hesitant. In addition, many of the stakeholders interviewed possess their own IT infrastructure. This is partly attributable to legitimate concerns, as not all data can and should be automatically exchanged and disseminated among all emergency forces. In some cases, it is prohibited by data protection regulations. However, due to the lack of standards for digital data and information collection (ISS4), as well as for applications and (mobile) devices (ISS5), data elicitation and sharing are often only possible when the data is manually sent to others. This also aggravates automating data elicitation (ISS6), knowing that police and fire department vehicles are equipped with GPS. This can be cumbersome, as information from various data sources needs to be compiled for decision support (Wiedemann et al., 2024).

No.	Expert	Organization	Role	Experience	Duration
I1	E1	Port Authority	Project Harbor Management	4 years	64 min.
I2	E2		Hydrographer	10 years	60 min.
I3	E3	District Office	Team Lead Crisis Management	9 years	60 min.
	E4		Employee Crisis Management	15 years	
I4	E5	Harbor Office	Nautical Engineer & Inspector	12 years	90 min.
I5	E6	Ministry of Interior	Head of Crisis Management	13 years	64 min.
	E7		Crisis Management	1 year	
	E8		Crisis Management	1 year	
I6	E9	Fire Department	Operations Management	30 years	65 min.
	E10		Fire Brigade Management	11 years	
I7	E11		Staff Work & Guest Lecturer	8 years	78 min.
	E12		Head of Digitalization	22 years	
	E13		Strategic Operational Planning	25 years	
I8	E14	Police	Situational Awareness & Assessment	8 years	54 min.

Table 1. Overview of Likert-Scale Items with Average (AV) and Standard Deviation (SD)

In addition, all interviewed experts emphasized the need to trust all data and information (ISS7), as their decisions and prioritization on both operational and strategic levels depend on this. However, data validation is challenging as verification typically requires unavailable human resources. Automatic processing is required for the representation of data and information. Currently, this is not possible (ISS8). This issue must be addressed, especially during major emergencies when data may be provided by hundreds or even thousands of individuals, as otherwise, confusion and chaos ensue, further exacerbating ISS1. In addition, the lack of data and information sharing (ISS9) correlates with ISS8. For example, the ability to relay targeted information to control centers and rescue teams is crucial to being adequately equipped. Ironically, this leads to local entities collecting substantial amounts of data during their operations. Yet, they cannot guarantee its dissemination and suffer from a lack of information from supplementing sources (ISS10). While this may not directly pertain to data collected in their immediate vicinity, it certainly includes information that may be relevant and indicates, for instance, that areas currently occupied by rescue forces are about to be flooded, necessitating their self-evacuation. ISS9 and ISS10 are also highly concerned with the EOC, where these images or pieces of information should ideally be compiled. However, if operational transmission and data collection are not possible, control centers cannot create

situational assessments, nor can they provide timely warnings to on-site forces, engage in proactive planning, and coordinate evacuations for residents as same as resources planning regarding supply routes for e.g. sandbags, food, and medical supplies (Salvo et al., 2025). In addition, there is a pressing need for adequate representation of this information, as reported by experts, especially districts and the Federal Ministry of the Interior (2015). Visualizations are often created manually (ISS11), and information is usually filtered and curated based on immediate needs. Regarding the potential for automating data collection, verification, and transmission, it is essential to establish filters and selectors to prepare role-based and target-oriented information specified in ISS12 (Zhu et al., 2025).

19.5 Resulting Suggestions

All issues were discussed and clustered, as shown in Figure 3. Regarding the twelve issues, we formulated twelve meta-requirements and derived five design principles to address the RQ.

The first seven issues were clustered in information acquisition & storage as they mainly address data elicitation and saving. The issues regarding information overload, loss, and lack of structure led to the meta requirements that enable intuitive and straightforward submission of information (MR1), which are also structured (MR2) and include consistency checks (MR3) to increase data quality. Together, these led to the derivation of DP1, which was summarized by addressing the designers, e.g., "implementers," and IT artifact goals. Therefore, designers can be software developers and others who are in a position to define the interface of a situation map. ISS4 and ISS5 address the lack of standards, leading to the formulation of MR4, MR5, and MR6. The structured processing of information is necessary, particularly when data is aggregated, and analyses are required to support information platforms and maps that represent both the on-site and overall flood situation. The architecture of an information map remains to be specified. Still, it should be possible to use and submit data from various registered devices and sources (MR7) regarding data and format standards (MR4). This leads to DP2, which highlights the transparent elicitation of information. Considering further regulation, not only elicitation but also data processing needs to be logged so that data streams are explainable and so that in cases of emergencies and false decisions, transparency and accountability are granted, which leads to DP3.

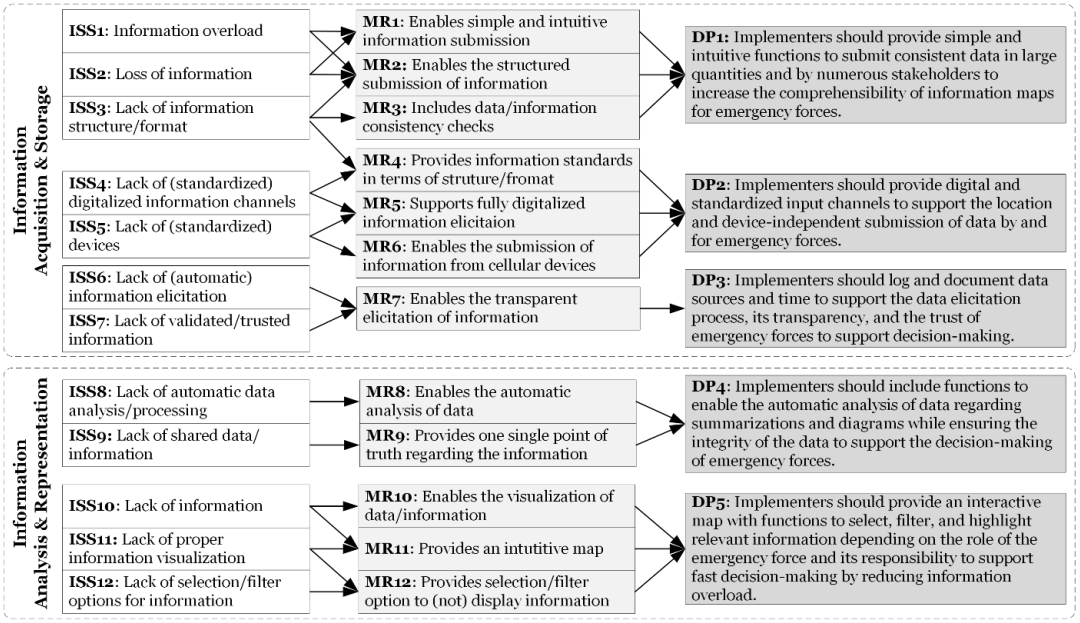


Figure 3. Overview of the identified Issues (ISS), formulated Meta-Requirements (MR), and derived Design Principles (DP)

In the information analysis & representation cluster, ISS8 and ISS9 led to MR8 and MR9, highlighting the automatic data analysis, as all information should be stored and accessible centrally. This enables the sharing of data to all or selected rescue forces, if a legitimate interest exists, independently of their organization, leading to a single point of data and truth (MR9) and to DP4. To not limit technical possibilities, a centrally available information platform can and should include proper architecture with backups and backup systems to ensure high availability, considering existing infrastructures, capabilities, and competencies. Lastly, DP5 provides an overview of a flood area and its surroundings in terms of a map. All experts, except the one from interview I5, favored a 2D map. However, we do not exclude 3D or other visualizations and highlight the demand for filters with MR10, MR11, and MR12, as not all information is always relevant. Organizations and stakeholders can use these to manage and reduce information overload, as described by ISS1. This also applies to the experts from I5, e.g., the Ministry of Interior, which was more in favor of a dashboard and the diagrams mentioned in DP4, as they are active on a strategic level and, therefore, have a lesser interest in local action and more in the number of rescue forces, operations, demand, and overall situation to organize supplies and inform the public.

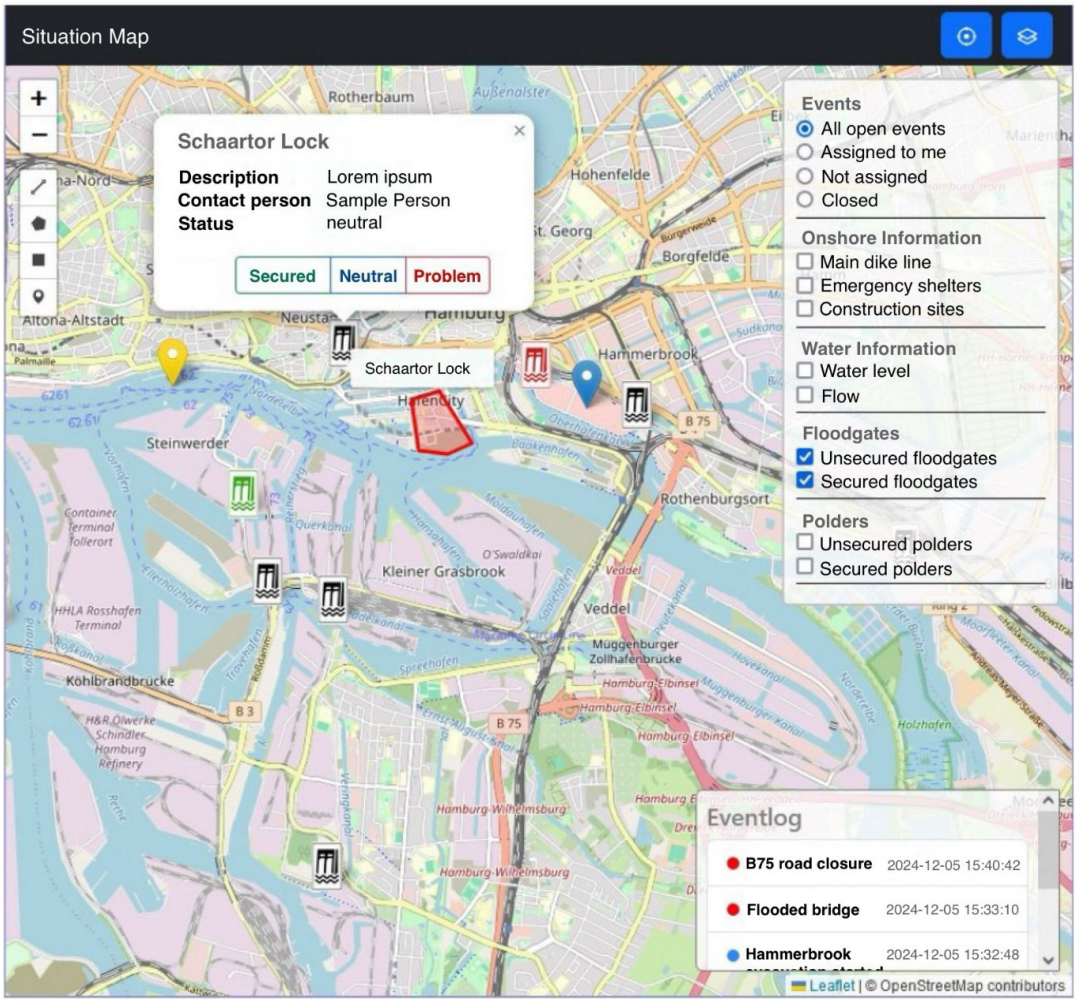


Figure 4. Layers, Event System, and Infrastructure of the Developed Prototype

19.6 Development

We developed a web prototype based on the derived design principles summarized in Figure 4. To organize data entries, we used state-of-the-art technologies, such as TypeScript, HTML, CSS codebase, OpenStreetMap, and GeoJSON. DP1 describes that crisis-relevant actors need to be able to contribute large amounts of data intuitively. To enable that, we built the prototype on GeoJSONs, which is known from other map-based systems, so that data from existing applications can also be imported. To prove this, we imported freely accessible data from GeoPortal Hamburg about the position of dikes, dike kilometers, locks, floodgates, emergency shelters, construction sites, and water levels (Hernández et al., 2020). We used Leaflet to integrate an interactive map (DP3) as Leaflet provides integrated functions to interpret and create GeoJSON data for mapping geographic data structures by including information on the type of data structure (e.g., points, lines, polygons) and the corresponding coordinates and a SQLite database for the backend. As mentioned, we implemented the web application independent of the different operating systems of potential end devices, addressing DP1 and DP2 so that only an internet connection

and a browser are needed, allowing users' physical location to be independent and enabling multiple users to access the application simultaneously (DP1).

Upon accessing the prototype, every user is presented with the same view of the city of Hamburg with existing events that require action. This view is also stored so that users can freely change the map view and return to the starting position with the click of a button (DP5). To the left is a menu with various icons; to the right is a selection of different layers, one of which is initially activated; and at the bottom right is an event log that displays new events in chronological order (DP3). New information is added by users solely in the form of GeoJSON data by selecting a shape from the menu on the left, which is then placed on the map. This digital standard (DP5) ensures the uniform format of information (DP1), which is subsequently referred to as events. Options include lines, polylines, rectangles, and markers, with some examples already on the map, as shown in Figure 4. This selection enables users to create events as precisely and individually as possible. Lines are suitable for sections of roads, rectangles for rough areas, polylines for precise and complex areas, and markers for simple points that can be set with a single click. When a user creates an event, an input form for further information appears in the middle. The title serves as a brief description, displayed when hovering over an event and in the event log, assisting in identification. The description can include all other relevant information about the event, such as the number of people affected or other valuable details (Lalone et al., 2023).

Finally, a priority level should be selected to help decision-makers assess the criticality of an event (DP5). Each new piece of information is thus in a uniform format and can be analyzed and used by any user (DP1, DP3, and DP5). As seen in Figure 4, the events on the map have different colors. These colors correspond to the priority selected when creating a new event and follow an intuitive traffic light system. Adhering to cultural color-coding conventions improves visual information representation and addresses DP3 by suggesting a sorting order for decision-makers that should support and simplify their decision-making process. The initial assessment of a situation is thus performed locally by an on-site person. For further information regarding an event, it's possible to click and open a detailed view. Here, the information provided when creating the event is displayed as additional meta-information, such as the date and time and the person who created the event (DP4). The initial view was chosen for the prototype to display all open events, as seen in the layer overview on the right. This includes all events that are not closed and are, therefore, relevant for the acute decision-making process. If an event is closed and action is no longer necessary, the event's color automatically changes to green and moves to the "Closed" layer (DP2 and DP3). Assigning an event using the "Assign to me" button does not change its color coding or visibility on the "All open events" layer. However, if a user wishes for a filtered, reduced view of open events, the

"Assigned to Me" layer can be selected, showing only open and assigned events (DP2 and DP3). Additionally, through the "Not assigned" layer, a view can be selected that shows all open events currently not being worked on by anyone. This supports communication and improves transparency between different actors, though it is more of a forward-looking feature at this stage (Li et al., 2024). Event layers function exclusively so that only one can be selected at a time to prevent misunderstandings in assignments. All other layers can be additionally shown or hidden as needed (DP2). Thus, users can select only the information necessary for their decision-making without being distracted by additional information (DP3).

Prior concepts have already discussed the importance of supporting existing emergency plans (Li et al., 2024). An example is the closure of lock gates, which needs to be checked based on the water level. Two layers of lock information can be shown simultaneously to see all locks or individually to filter the view (Bräker et al., 2022). Furthermore, the symbol for locks differs from the symbols for events. The same applies to construction sites or emergency shelters, allowing users to identify the type of information (DP3) immediately. This functionality is enabled by a "style" object that can be included within the "properties" attribute of each GeoJSON. Suppose a user has selected the layers needed for their decision-making process and no longer requires the layer menu. In that case, it can collapse via the button at the top right, focusing the user's attention on the map view (DP2) (Zhu et al., 2025).

19.7 Evaluation

We conducted two focus groups to evaluate the prototype and the design principles. This approach was chosen to include different perspectives of stakeholders from the field of emergency management from different organizations. Nevertheless, these organizations work together and usually report to the EOC (cf. section Response), which makes central decisions, handles press relations, and can also call on other emergency services and the military across national borders. In addition, we included two researchers from two other universities who are researching emergency management as well as experts from the requirements elicitation (cf. Table 1), to extend the view (cf. Table 2).

No.	Expert	Organization	Role	Experience
W1 (n=11)	E16	Ministry of Interior	Ministry of Interior	16 years
	E15	Crisis Aid Entity	Innovation & Research	4 years
	E17	Urban University	Crisis Researcher	1 years
	E18	Police	Innovation Manager	18 years
	E19	Software Company	Developer	10 years
	Further participants were E1, E6, E8, E9, E10, and E12 which are described in Table 1.			

W2 (n=9)	E15	Crisis Aid Entity	Innovation & Research	4 years
	E20	University	Data Platform Researcher	6 years
	E21	Innovation Association	Development	1 years
	E22	Ministry of Interior	Crisis Management Employee	16 years
	E23		Crisis Management Employee	1 years
	E24	Technical University	Sensor Researcher	4 years
	Further participants were E1, E4, and E8 which are described in Table 1.			

Table 2. Overview of the conducted Focus Groups with Emergency Management Expert

A total of 18 different experts (n=18) were involved in the focus groups. In the focus groups, all participants received access to the prototype via a URL to explore it. Then, we asked questions about the design and its functionalities that implicitly and explicitly refer to the design principles and analyzed them according to Mayring (2014) in a deductive-inductive manner to approve but also derive new insights.

19.8 Findings

All stakeholder statements were coded and assigned to the respective design principles (Mayring, 2014). Notably, statements could address multiple design principles. DP1, which specifies that developers should enable the input of large datasets, was confirmed and detailed by 16 statements. In addition to traditional imports, the focus was on integrating with urban data platforms to obtain static data on infrastructure, its condition, and other IT systems (Kucharczyk & Hugenholtz, 2021). It became clear that integrations with drones and camera systems are also in demand to provide real-time data from city cameras or drones that fly over areas on demand or automatically, providing data supplemented with geospatial and other attributes (n=7). Consequently, DP1 is being reformulated to accommodate the diversity of IT systems.

DP1: Implementers should provide functions to submit consistent data in large quantities and by numerous stakeholders and IT systems to increase the comprehensibility of situation maps for emergency forces.

DP2: Implementers should provide digital and standardized input channels and prescribe mandatory data attributes to support the location and device-independent submission of data by and for emergency forces.

DP3: Implementers should log and document data sources and time to support the data elicitation process, its transparency, and the trust of emergency forces.

DP2 was confirmed by 22 statements and received minimal criticism. While DP1 specifies the automated collection of data from other systems, DP2 is concerned with the data input by emergency stakeholders. This is significant, as it was repeatedly mentioned that information about the author, date, time, location, event type, responsibility, contact details, and priority must always be provided (Mohuya et al., 2025). This is crucial for tracing incidents and comprehensively assessing their prioritization, potential hazards, and impacts to make informed decisions, leading to an extension of DP2 (n=6). DP3 was elaborated on with 19 statements and received little discussion, as there was a broad consensus that logging all data is crucial for reconstructing incidents, especially those involving injured individuals or infrastructure damage, as it is an essential legal obligation, relevant for insurance, and for reconstructing decisions that may later turn out to have been misjudgments. The event log, as confirmed in Figure 4 (bottom right), is essential, even though, unlike the news display, all data and changes to this data must be documented (n=4). DP4 was mainly discussed and confirmed during the first evaluation with twelve statements (cf. W1 Table 2). DP4 does not fully meet its requirements as currently implemented. The current prototype summarizes content visually without a comprehensive automatic data analysis as, initially described by Landwehr et al. (2024). This capability is essential for supporting meetings in EOCs and other organizations (Ferman Carral et al., 2025). The discussions highlighted that brief written situation reports focusing on selected periods would be beneficial and that artificial intelligence could generate such reports from log files and situation map entries. Additionally, visualizations like charts, which can be consolidated into a dashboard, are valuable as “a dashboard where messages pop up and are higher depending on their relevance, are divided into different categories and are not georeferenced” (E20) states (Borchers et al., 2024; Lalone et al., 2023). These can provide overviews, such as the number of incidents, their criticality, and the resources available versus those required (Li et al., 2024). This also extends to flood protection infrastructures such as dike systems, floodgates, and evacuation zones, specifying where evacuations have been declared or are currently in progress. As such, DP4 remains a relevant point for consideration and should be expanded with additional functionalities and interfaces to enhance its comprehensiveness (n=7).

DP4: Implementers should include functions to enable the automatic analysis of data regarding summarizations and diagrams while ensuring the integrity of the data to support emergency forces' decision-making.

DP5: Implementers should provide an interactive map with functions to select, filter, and highlight relevant information, depending on the emergency force's role and responsibility, to support fast decision-making by reducing information overload.

Both evaluations affirmed DP5 with 15 statements. The challenge of creating intuitive overviews is prevalent in almost all emergency organizations, as data from various systems is often manually compiled for discussion within EOCs, which delays response and decision-making times (Lourenço Neves, 2024). Since many data points are currently not systematically captured, the issue of information overload is not yet fully recognized. If DP1 to DP3 will address this, it becomes crucial to implement filtering by layers (Zhu et al., 2025), priorities, and areas of operation as "if you have the hierarchy, you could always change the areas quickly or simply say that certain areas have been completely eliminated because they are safe or something […] so that we only show all evacuation areas where evacuation is necessary and that we can ignore, so that we do not have such an information overload" (E3) highlight (n=10).

DP6: Implementers should ensure that the application dynamically adapts the information flow to the responsibilities of the emergency forces, providing tailored and relevant information for them to enhance situational awareness and decision-making.

DP7: Implementers should provide possibilities to monitor activities and updates from other emergency forces and enable communication with them to coordinate assistance or share critical information.

Both evaluations were deliberately conducted with experts from various emergency-relevant organizations, recognizing that their requirements may diverge. However, this was only partially the case, as many organizations require the same infrastructural elements and similar information, even though they typically focus solely on the aspects within their specific areas of responsibility (Wiedemann et al., 2024), leading to DP6 (n=9). As outlined in DP1, DP2, DP3, and DP4, all emergency stakeholders collect and utilize data. Unexpectedly, this data sharing currently occurs only to a limited extent across organizational boundaries, as each organization essentially functions as its own data silo, with information being shared manually only upon request. It remains uncertain whether such an application should represent all organizations simultaneously, as this would involve centralizing critical data. Nevertheless, it should be possible to view information from other organizations, even if not immediately in full detail, leading to DP7, which was elaborated with 36 statements. To implement DP7, it is necessary to map organizational structures as a supplementary feature, for which the organizational hierarchy is crucial, as shifts in operational areas occur frequently, and certain areas can become irrelevant over time, as noted by E3. These structures are already maintained in other tools, indicating that an import capability, as mentioned in DP1, should be pursued.

Given that organizations such as the police and fire departments often collaborate and jointly manage operational sections, it is logical to enable mutual visibility of each

organization's deployments and the number of personnel present, as emphasized by E9. Therefore, it should be possible to request and display information from other agencies, with preset configurations in situational awareness tools, allowing for the consistent display of locations and contact information of other organizations (Bräker et al., 2022). Additional information can be requested as needed via these tools. This was referred to as "rule-based behavior [...], such that [we] at least receive a notification [...] and can then make targeted inquiries" (E6) in evaluation W1 (cf. Table 2). This requirement also applies to aerial imagery, which may be centrally coordinated from a drone base and integrated into situational awareness (Oliveira, 2023). An example from E6 illustrates the potential utility: "I would actually need an aerial view of the area to see which unit is nearby. If there is a drone from another unit, whether from the fire department, technical aid organization, rescue swimmer, or port authorities, flying 50 meters south, it would be useful to coordinate with the drone operator, asking them to fly a specific loop, so we do not have each unit sending up its own drone, provided that is even feasible." Such feedback and similar statements have led to the development of DP6 and DP7 (n=8), emphasizing the dynamic adaptability of situational awareness and information flow. Together, they highlight the need for updates, data sharing, support requests to and from other organizations, and establish direct contacts in the field of interoperable situation maps.

DP8: Implementers should ensure that the entire situation application is designed to be intuitive and apply standards such as emergency symbols to enhance users' recognition.

Finally, we received 20 expert statements addressing the design and interaction with the situation map. This leads to DP8 and should be considered in more detail in further development (Dusse et al., 2016), as the focus of the first cycle was on the functionalities (n=6).

19.9 Discussion

The description of the findings in the previous section approved the design principles derived but also highlighted the demand for adjustments and further derivation, which led to DP6 and DP8, which have not yet been included in the prototype. We now want to elaborate on all design principles in the context of the emergency management framework to clarify their connection and answer the RQ. The RQ states with "during" that we are focusing on the response phase of the emergency management phases as described in the emergency management framework section. Depending on the situation, this phase specifies the action and measurement that emergency organizations can and must initiate (Boin & Bynander, 2016). In cases of flood warnings issued with sufficient lead time, this may involve, for example,

preventive evacuations and the construction of mobile dike systems. Regarding the Awareness of the Problem and Resulting Suggestions section, it became evident that much data and information are currently only available to a limited extent, are not accessible at all, and must be manually compiled for the EOCs and other entities (ISS1 to ISS7). Therefore, a technical solution, such as the interactive situation map depicted in Figure 5, is essential, with DP1 to DP3 specifying the data input and extraction processes. It is also necessary and advisable to pre-load data and information from external databases like urban platforms (cf. Figure 5, bottom left), which supports the response, risk mitigation, and recovery phases, as infrastructure data is continuously required (Hernández et al., 2020). Additionally, the third input channel discussed in the focus groups pertained to the contributions that citizens can make. Mohuya et al. (2025) and Mukerji et al. (2024) have examined citizen data in the literature and hold significant potential. However, this data is not always reliable, and it must be ensured that incorrect or faulty data is not integrated, for which there is currently no scalable solution (Borchers et al., 2023). Nonetheless, we incorporate this aspect into our proposed data-driven response model for flood emergency management (cf. Figure 5), as images from evacuation areas, escape routes, and location data can provide vital support to emergency organizations.

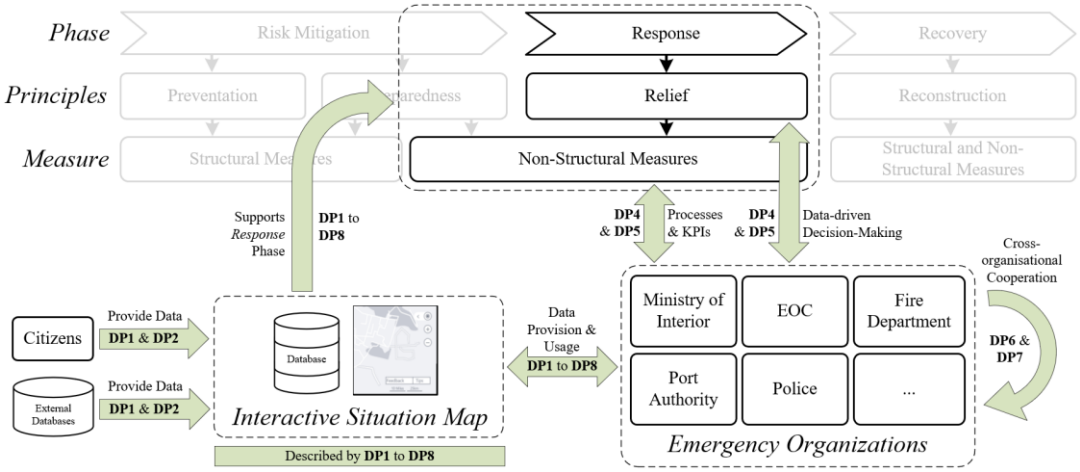


Figure 5. Data-driven Response Model for Flood Emergency Management

Regarding emergency organizations, the interactive situation map centralizes data to (1) expedite decision-making processes, as it reduces the need for labor-intensive data collection, (2) facilitates the query of data from other organizations, thereby (3) supporting decision-making processes through access to a more comprehensive situational overview. These three aspects are supported by DP1 to DP8 and are highlighted in the developed model in Figure 5 under data provision & usage, building on the results of Zhu et al. (2025). DP1 and DP3 establish the standards for data collection, enabling DP4 to DP7 to standardize, automate, and visualize the data effectively. DP8 addresses the aspect of intuitiveness. Furthermore, aspect (2) is specified within the model through cross-organizational cooperation, which many

experts have identified as a lacking and improving area in current operational practices and which supports decision-making due to the higher availability of information (Li et al., 2024; Zhu et al., 2025). Thus, the lower half of the data-driven response model contributes to the practical application and development of future applications by summarizing and connecting emergency stakeholder demands. In addition, this also benefits emergency organizations, noting that the design principles require further specification, for instance, through design features. At the same time, the web prototype serves as a guiding reference.

In the upper part of Figure 5, the aspects described are considered within the context of the emergency management framework. The focus is particularly on the response phase and the relief principles achieved through the decisions made by emergency organizations, which access all data stored in the interactive situation map to plan interventions and take necessary actions. (Rodrigues et al., 2002) The effectiveness of these measures, such as increased safety through constructed (mobile) dikes, rescued individuals, and (preventively) evacuated persons, as well as those provided for in emergency shelters and secure infrastructures like water locks and flood protection gates (Aziz et al., 2024), can also be assessed through non-structural measures. To do so, practitioners need to be aware, as mentioned in the section on Findings by DP4 and DP7, that the prototype should be expanded with diagrams and a dashboard. For theorists, it is important to recognize that the abstraction level of design principles is currently relatively high, necessitating further detail-oriented examination alongside surveys and (laboratory) tests in and between emergency organizations. This study's findings and the proposed data-driven response model should be interpreted considering several limitations. Only one DSR cycle has been implemented, during which the derived design principles DP1 to DP5 have been evaluated, confirmed, and adjusted. However, the evaluation for DP6 to DP8 remains outstanding.

The validity of the results can be considered high, as overall, 24 experts from various emergency organizations were interviewed in the elicitation and evaluation process. It is important to note the limitations of the design associated with DP4 regarding automated evaluations, as the current implementation does not adequately address this aspect. Future research, particularly in the context of AI, should pay close attention to this issue, as highlighted by Salimi et al. (2024) and Tyskbo and Nygren (2024). Furthermore, for DP6, it is unclear how large volumes of data inputs will be verified and approved before being integrated into the situational overview to avoid erroneous or incomplete information (Torpan et al., 2021). This aspect requires further investigation, as the information and sharing solution has high requirements from the perspective of all emergency organizations, as well as data protection and technical interoperability, as confirmed by many experts and the literature (Torpan et al., 2021). The same applies to DP7, which should be considered within the

framework of a multi-organization system and reflect the hierarchies, roles, and response teams of emergency organizations. DP8 also has considerable room for improvement, and existing findings in the literature, particularly in human-computer interaction and information overload, as previously mentioned in DP5, should be integrated into its development (Bawden & Robinson, 2020; Han et al., 2025). Besides the design principles, which mainly describe a technical system, we did not focus on the sustainability of the developed system itself, which, especially in large-scale systems, needs to be considered. This is affecting energy consumption and carbon footprint. This is required for data collection and processing and is related to SDG11 and digitalized cities and communities, but also affects SDG13 and the systems' sustainability, which enables actions against floods, but should not increase their causes, e.g., climate change (Henriksen et al., 2021). Overall, the newly developed data-driven response model is an initial effort that bridges theory and practice within the context of the emergency management framework and the design principles derived from practical applications.

19.10 Conclusion

In this paper, we examined the RQ "How should IT artifacts be designed to support informed decision-making of emergency forces during floods in urban areas?" as described with the conduction of the first DSR cycle (cf. Methodological Approach). We identified twelve key issues through 14 expert interviews across six emergency management organizations, formulated twelve meta-requirements, and derived five initial design principles. We used these to develop a comprehensive web prototype that was assessed via two focus group evaluations with a total of 18 different experts. Our findings underscore the crucial role of novel situation maps in supporting decision-making capabilities amid escalating flood challenges as required by SDG11 and SDG13 (Henriksen et al., 2021). The derived design principles emphasize capabilities such as intuitive data entry, structured information management, and real-time data analytics and led, in combination with the emergency management framework, to the proposal of the data-driven response model for flood emergency management, which specifies the relationships between the response phase, framework, the developed IT artifact, and emergency organizations. In addition, our model advocates for a holistic approach to emergency management, characterized by cross-organizational thinking and collaborative data collection and sharing to enhance decision-making. This distinguishes it from existing focused approaches, which can be viewed as sub-areas within the model. The limitations include the preliminary nature of our DSR cycle, which may restrict deeper exploration into certain design principles. This especially addresses the possibilities of AI analyzing and summarizing data in the same way as the integration of organizational hierarchies, diagrams, and citizens’ data. Looking forward, the interactive situation

map can guide practitioners, and the proposed data-driven response model can support theoretical advancements in developing a holistic emergency management framework (Rodrigues et al., 2002). By addressing the research gaps described and integrating advanced technological solutions, this research contributes to the SDGs by enhancing urban flood resilience and sustainability. Future studies should continue to innovate within the derived design principles and proposed model, promoting proactive preparedness and adaptive responses to further climate-related challenges.

19.11 Acknowledgement

We would like to express our sincere gratitude to the Federal Ministry of Research, Technology, and Space (Bundesministerium für Forschung, Technologie und Raumfahrt) for supporting the RESCUE-MATE project (grant number: 13N16836), enabling us to examine emergency management and this paper.

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20 Publication C15: Facilitating Urban Participation Project with Generative AI to Support Citizen Engagement and Interaction

Hawaii International Conference on System Sciences (HICSS)

Track: e-Democracy, e-Participation and e-Voting
Completed Research
Ranking: B

Research Question

How should AI-based chatbots be designed to support citizens' engagement and interaction on urban participation platforms?

Contribution to the Dissertation

This publication contributes to the overall RG, especially RQ1, by describing the design of a web prototype and the usage of AI systems, e.g., an LLM that analyses citizens' submissions. This is done using a prompt-based approach, with guiding requirements and a description of the urban project's objective. Open questions are generated and asked of the participant to enhance data elicitation and interaction. In doing so, the publication also contributes to RQ2, as the analysis itself and contextual knowledge specify the data and information demands for urban experts in subsequent processes. The publication contains twelve identified issues, formulates eleven meta-requirements, and proposes five initial design principles, which were extended to seven due to the evaluation findings.

Citation

Borchers, Marten; Uba, Chikaodi; Milutzki, Enrico; Ittner, Fynn, Magdych, Valeria; Bittner, Eva; & Semmann, Martin (2026). Facilitating Urban Participation Project with Generative AI to Support Citizen Engagement and Interaction. In: *Proceedings of the 59th Hawaii International Conference on System Sciences* (HICSS). https://hdl.handle.net/10125/111674. Completed Research.

Abstract: *This paper investigates how AI-based chatbots can enhance citizens' engagement and interaction on urban participation platforms. Using a design science research approach, we identified twelve issues, formulated eleven meta-requirements, and derived five design principles. These were instantiated with a web prototype designed in Flutter, utilizing a large language model, including interaction and expressing guidelines. Our evaluation revealed increased engagement, lower participation barriers, and improved citizen contributions compared to non-AI-based participation. However, the evaluation also led to the addition of two new ones, highlighting document access and interactive urban maps. Together, they specify information presentation and interaction with participants. Despite promising findings, challenges persist regarding the perception and explainability of large language models. Our findings provide a practical blueprint for future AI-enabled citizen participation in urban planning, suggesting directions for further research on the retrieval-augmented generation architecture, which can incorporate additional domain knowledge and behavioral guidelines.*

Keywords: Citizen Participation, Artificial Intelligence, Chatbot, Engagement, Design Science Research

20.1 Introduction

Urbanization is an ongoing trend, leading to economic growth but also creating numerous challenges (Butt, 2021), which, nowadays, is truer than ever, as inequalities create conflicts that are enhanced by a lack of resources and limited access to living space (Caragliu & Del Bo, 2022). In response, many governments and city districts are involving citizens in the development of urban areas (Bono Rossello et al., 2023). Citizen participation in urban planning encompasses a broad array of mechanisms and activities designed to incorporate diverse perspectives into the planning process, supporting projects that better reflect the needs of the population (Vagena & Sneiders, 2022). This process enables individuals to share their experiences, opinions, concerns, and suggestions from which decision-makers and urban planners are benefiting (Borchers et al., 2024). A significant challenge associated with citizen participation is the logistics of communication. Electronic participation (e-participation) lowers barriers to participation by using modern technologies (Adnan et al., 2022). However, as moderation is hardly scalable, participant often submit their ideas but do not receive any (immediate) feedback or response, which then corresponds to one-directional communication, even if participant-to-participant communication is possible. This limits interaction and citizens' engagement (Arana-Catania et al., 2021).

Artificial intelligence (AI) offers a potential solution by facilitating information about urban projects, allowing citizens and chatbots to ask and answer questions actively (Von Brackel-Schmidt et al., 2025). However, this would require the AI site to be aware of the current project in which citizens participate. On the other side, the use of AI could also constitute a barrier for some citizens, given a widespread skepticism

and lack of trust (Adnan et al., 2022) These challenges emphasize that in this domain, AI-based chatbots have not yet been properly examined (He & Chen, 2024), which is why we state and answer the following research question (RQ).

RQ: How should AI-based chatbots be designed to support citizens' engagement and interaction on urban participation platforms?

To answer the RQ, we conduct a design science research (DSR) project. In Section 2, the foundations are described. Subsequently, we described the method (cf. section 3), and the identified issues are summarized (cf. section 4). In Section 5, we present the meta-requirements and design principles, which we implement in Section 6 with a prototype. The evaluation is described in Section 7, and the findings (cf. Section 8) are presented and discussed afterward (cf. Section 9). Finally, we summarize our work in Section 10.

20.2 Related Work

Citizen participation refers to the active engagement of individuals in political and societal decision-making processes, empowering citizens to express their opinions and articulate their needs, particularly regarding projects that directly affect them (Cooney, 2021; Milutzki & Borchers, 2025). E-participation defines the use of digital technologies to facilitate more efficient, inclusive, and transparent citizen involvement within decision-making processes (Adnan et al., 2022).

20.2.1 Urban Participation Platforms

In the domain of urban planning, e-participation plays a vital role in creating and shaping cities to create public value (Vagena & Sneiders, 2022). Urban participation platforms simplify information dissemination, provide access to relevant data, and lower participation barriers, thereby often increasing the number of participants per project (Royo et al., 2024). Urban platforms usually include digital forums and discussion areas, which enable citizens to communicate time- and location-independently by submitting their comments and requirements, which are crucial for value creation (Becker et al., 2022). Nevertheless, these platforms face challenges, including a lack of interactions, as most communications are asynchronous, and real-time discussion is scarce. Typically, requirements and information are only sent in but rarely out and are not comparable to on-site, face-to-face discussions (Borchers et al., 2024).

20.2.2 AI in E-Participation

Conversational agents like chatbots are AI-driven applications that can simulate human conversation using advanced technologies (Nicolas et al., 2021). Early implementations relied primarily on predefined rules, while contemporary chatbots

leverage deep learning and are capable of nuanced understanding and adaptive language generation (Cortés-Cediel et al., 2023). Past public and governmental chatbots have often been informal and focused on increasing access to information, websites, and public services via text-based web interfaces with limited personalization (van Noordt & Misuraca, 2022). By contrast, AI-based chatbots promise a distinct change in urban participation, as dialogic flexibility and exchange enable participants to articulate claims, evidence, and counterarguments dynamically, as described by Bono Rossello et al. (2024). Within the context of citizen participation, chatbots could serve as automated moderators between citizens and participatory platforms, thus supporting real-time interaction and reducing barriers. This is also described in the literature, for example, in public ideation processes, where large language models (LLMs) have supported finding ideas of how to increase sustainability, adapt to climate change, and increase mobility (Pinto & Macadar, 2024). Furthermore, it is also highlighted that simple scale-based feedback can lead to richer and more coherent citizens' contributions (Borchers et al., 2024). In addition, Bono Rossello et al. (2025) describe an overall architecture of how to use AI in digital citizen participation, naming the demand for domain knowledge and a cognitive and information balance for participants. Therefore, reliability is important, and chatbots should be aware of the specific urban project and its objective, which they are currently discussing, to provide detailed data and ask relevant questions (Nicolas et al., 2021), and be aware of the target audience (Bono Rossello et al., 2023).

20.3 Research Methodology

To answer the RQ, we apply the DSR paradigm. DSR is a well-known approach in information systems, which can be used to create design theories and gain knowledge by developing and elaborating on IT artifacts (Tuunanen et al., 2024). In doing so, issues, meta-requirements, and design principles are identified and derived. The latter lays the foundation for the theoretical contributions, while the development addresses real-world problems (Kuechler & Vaishnavi, 2012). For this work, we implemented the DSR activities as described by Hevner et al. (2004), as shown in Figure 1. In the first step, we identify issues regarding the RQ with a literature review. In step 2, we formulate meta-requirements based on the issues and derive design principles from these, as well as the existing knowledge base, as described in Section 2. Afterward, we instantiated the design principles and evaluated them with the target group by providing a fictive urban project and hosting both prototypes on web servers. The collected data were analyzed, and the initial design principles were discussed, adjusted, and extended.

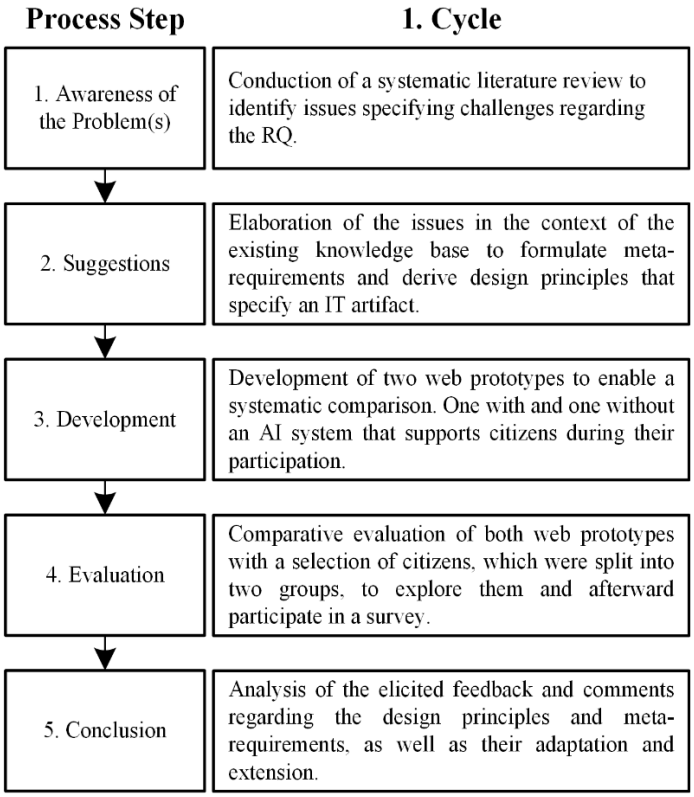


Figure 1. Overview of the applied DSR Approach according to Hevner et al. (2004)

20.4 Awareness of the Problem

The identification of issues was conducted through a literature review utilizing the databases of AIS and ScienceDirect, and the research was limited to findings since 2022, when OpenAI published the first GPT model. For the search, we used the search string “citizen participation” AND ("AI" OR "artificial intelligence" AND "chatbot")." We received 23 hits in the AIS and 72 hits in ScienceDirect, leading to a total of 95 hits. After excluding unavailable publications, reading all abstracts, and reviewing the results, twelve relevant papers remained. As a result of our literature review, we identified twelve issues and eleven meta-requirements for AI-based conversational systems for citizen participation. The identified issues and meta-requirements relate to three overarching dimensions, namely, "Information Presentation," "Citizen Impacts," and "Citizen Interactions."

Information overload is a core issue in solutions for citizen participation (ISS1), as urban citizen participation projects are often part of a complex, multifaceted discourse, and navigating this complexity is a significant challenge (Bono Rosselló et al., 2024; Cortés-Cediel et al., 2023). In addition, a lack of visualization (ISS2) further exacerbates this problem (Cortés-Cediel et al., 2023; Shin et al., 2024). Especially in urban planning initiatives, visualizations benefit citizens by supporting their understanding and imagination to better grasp potential developments and scenarios. Furthermore, a lack of transparency regarding the impact and

consequences of citizens' participation (ISS3) hampers engagement (Bono Rosselló et al., 2024; Borchers et al., 2023).

Citizen participation solutions often suffer from insufficient feedback during the participation process (ISS4). As these solutions frequently serve as support tools for citizens to form their opinions, understand different perspectives, and engage with various arguments related to new urban planning initiatives, timely and relevant feedback on citizens' input and ideas is essential (Bono Rossello et al., 2024; Borchers et al., 2023; Cvetkovic et al., 2023). Maintaining the long-term engagement of participating citizens (ISS5) is particularly difficult, as various factors often hamper ongoing engagement (Bono Rosselló et al., 2024; Moghayedi, 2025; Mohamed & Han, 2022). This opacity can discourage otherwise motivated citizens from actively engaging, as they may feel that their contributions are not recognized or have no impact. Overall, these issues undermine the credibility and effectiveness of citizen participation initiatives, making it crucial to address them to foster more meaningful and sustained citizen involvement.

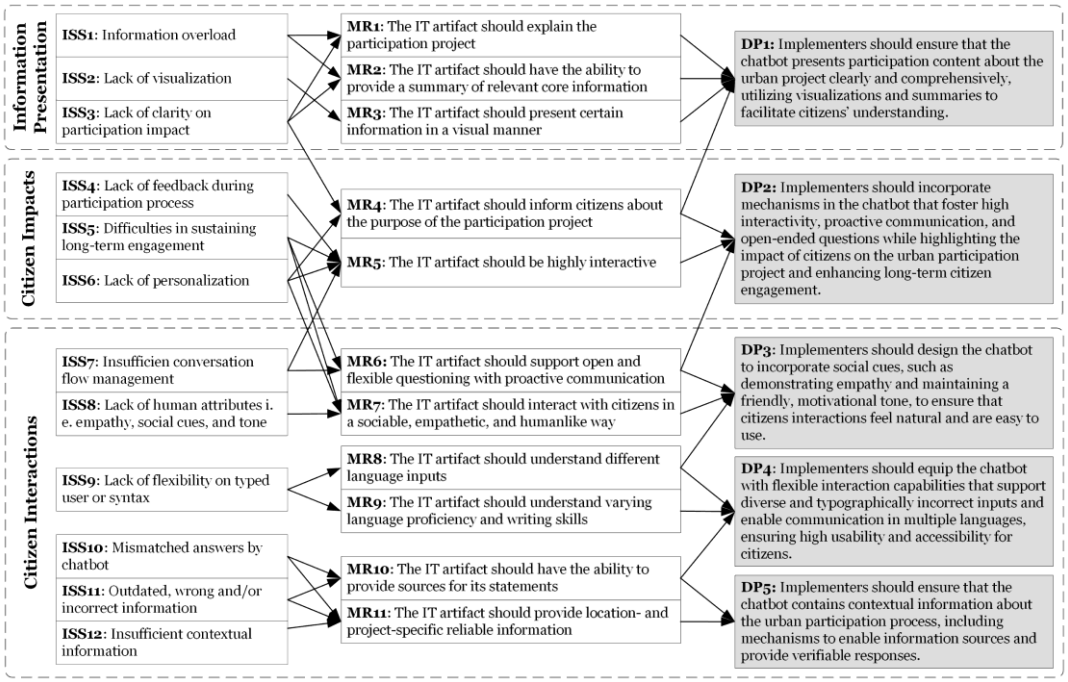


Figure 2. Overview of the identified Issues (ISS), formulated Meta-Requirements (MR) and derived Design Principles (DP)

Additionally, tailoring such feedback to the specific participation context first and to the individual user's context second presents a significant challenge (ISS6) (Bono Rossello et al., 2025; Borchers et al., 2023; Pini et al., 2025). Regarding the conversation and interaction design of AI-based citizen participation systems, many face the issue of insufficient conversation flow management (ISS7) (Azzahro et al., 2025; Borchers et al., 2022; Cortés-Cediel et al., 2023). Such solutions often serve as platforms for citizen ideation, posing closed questions, and a lack of proactive

communication further hampers the usability of the system. Additionally, the absence of social cues, empathy, and non-motivational tone (ISS8) can negatively impact user engagement (Al-Ansi et al., 2024; Cortés-Cediel et al., 2023; Shin et al., 2024). As citizens should also express themself in their natural way to reduce barriers, the system's ability to adapt to diverse communication needs becomes even more critical. Another issue related to users' system interaction is the lack of flexibility in user input (ISS9), which impedes usability (Borchers et al., 2022; Moghayedi, 2025). This is particularly critical in citizen participation contexts, as a diverse range of citizens from various backgrounds, education levels, and language proficiencies interact with these systems.

Lastly, one issue that remains is system defaulting and consequently providing mismatched answers in conversations (ISS10) (Cortés-Cediel et al., 2023; Moghayedi, 2025). This further hinders usability but might have long-term effects on citizens' willingness to use participation systems in the long term. AI-based solutions that provide incorrect, inaccurate, or outdated information represent another central issue (ISS11) (Azzahro et al., 2025; Bono Rossello et al., 2025; David et al., 2025). Such systems may deliver incorrect data due to technical failures, outdated databases, or limited domain expertise. This challenge is closely related to the need to provide contextual information (ISS12) (Abed, 2024; Bono Rossello et al., 2023, 2024, 2025). Particularly in citizen participation solutions that serve as ideation tools, sufficient scenario- and location-specific information is crucial for productive citizen facilitation and meaningful contributions.

20.5 Suggestions

Building upon the identified challenges, we formulate meta-requirements and condense them into design principles, as illustrated in Figure 3. Information overload (ISS1) justifies MR1 and MR2, which describe the IT artifact's ability to provide a description and explanation of the participation project (MR1) and the ability to provide summaries of relevant information (MR2), which can be achieved with an AI-based chatbot (cf. section 2.2). Building on ISS2, MR3 calls for visual elements, and ISS3 concretizes MR2 and MR3 by emphasizing the influence of citizens. This is crucial so that citizens, as described in the literature, perceive themselves as co-authors and are convinced that their contribution provides real, tangible added value, thereby increasing acceptance and engagement. Together, MR1 to MR3 lead to DP1, which, as shown in Figure 3, specifies the type of information and its representation and identifies specific functions and objectives. The lack of feedback (ISS4), the challenge of long-term engagement (ISS5), and the absence of personalization (ISS6) necessitate a highly interactive solution to achieve a pleasant and meaningful interaction flow (MR5). ISS6 also leads to MR4 with ISS3, which specifies that the project purpose must be clearly communicated, thereby supporting DP1.

However, MR4 and MR5 lead to DP2, which requires a high degree of interactivity and proactive communication by an AI-based chatbot (Borchers et al., 2024). DP2 thus focuses on clearly communicating the influence of citizens on the project, creating genuine added value by supporting citizens in submitting meaningful and understandable information. MR6 requires open communication, and MR7 specifies the type of interaction, particularly about the formulation of questions, which should be empathetic. Both lead to DP3, which refers to natural language interaction and emphasizes the need for empathy. ISS9 refers to a lack of linguistic flexibility, which MR8 demands about different languages, and MR9 about linguistic expression and syntax.

DP4 consolidates this and emphasizes usability and flexible interaction with citizens. Thus, an AI-based chatbot should understand a wide range of expressions, terms, and languages. ISS10 to ISS12 addresses the accuracy of responses leading to MR10, which requires that the IT artifact provide sources for its statements to enable citizens to validate them if required. MR11 extends this with project-specific information, ensuring the AI-based chatbot has reliable information about the project and is aware of the local characteristics. Both lead to DP5, which highlights the accuracy and verifiability of responses (Freitas et al., 2023).

20.6 Design and Development

Based on the five design principles, we have developed a web prototype that provides two participation variants for the same participation project. The web prototype enables participation with and without the use of AI. In both approaches, the interface is designed to resemble a chatbot.

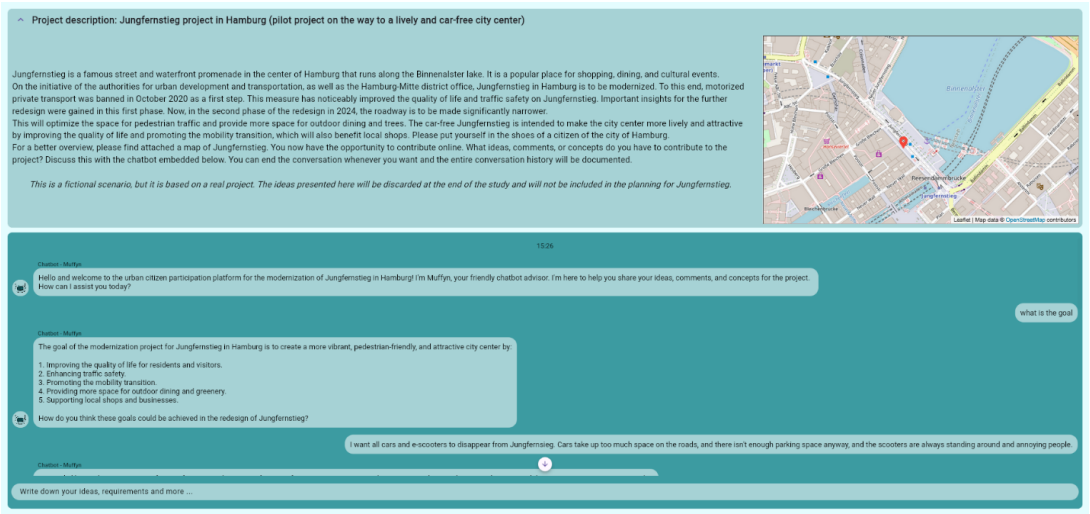


Figure 3. Overview of the AI-Based Chatbot

In addition, both options provide a description of the urban project and a map of the surrounding area where the property is located, allowing for further visual

representation of local information as required by DP1. In addition, in both variants, participants can use text to ask questions, express requirements, wishes, and visions, or describe solutions in detail and submit them. The variant without AI represents an existing urban participation platform, as inputs are recorded as comments. The prototype with AI is structured in the same way, except that an AI process each input to generate a response. The development of the web prototype was conducted in Flutter with the programming language Dart. As an AI system for text analysis, we utilized GPT4 from OpenAI, as it can be easily integrated via an API key and is one of the most widely used and powerful LLMs (Gao et al., 2024) but could also be replaced with a similar solution.

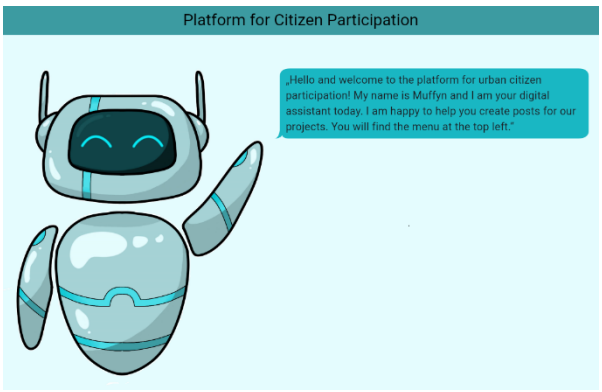


Figure 4. Prototype Welcome Screen

The web prototype considers DP1 with the design as a chatbot. To also include the requirements regarding the expression of AI responses, we predefined a prompt that ensures the AI-based chatbot is aware of the participation projects and their objectives and always provides information clearly and understandably. To achieve that, we formulated a static prompt which contains specification regarding the (a) role of the chatbot, e.g. platform, (b) a knowledge base about e.g. a textual description of the urban participation project, (c) guideline which define the behaviors of the chatbot and expression style, and (d) a description of the target audience as initial proposed by Bono Rossello et al. (2023). This also aligns with the idea of reducing the cognitive load to make participation as easy and enjoyable as possible. Furthermore, the chatbot always receives the entire interaction with the participant, allowing it to refer to early submissions and summarize past interactions and the project participation from different viewpoints. Lastly, it also contributes to DP2 and the overall AI-based approach, as high interactivity requires fast responses to prevent discussions or exchanges from stalling. In addition, the predefined prompt specifies that questions are asked openly and underlines the citizens' impact on the outcome of the participation, which is also considered in the project description. DP3 is also reflected in the predefined prompt, which points this out. This, along with the requirements of DP4, is also supported using an LLM because it understands semantic relationships

and can express itself according to the requirements (MR6 and MR7). In addition, it enables natural language interaction in many different languages and is not confused by spelling or grammar errors, nor by long or short sentences. DP5 was implemented by adding explicit project descriptions to the prompt, along with sources for those descriptions.

20.7 Evaluation

To evaluate the developed prototype, participants were asked to provide feedback through a questionnaire-based user study. Each participant completed both versions of the prototype, thereby enabling an active comparison of approaches with and without the AI-based response. The order was randomized to minimize sequence effects, but we ensured that the distribution among the projects was even (cf. Figure 5). Most questions in the questionnaire passively or directly addressed the design principles if their instantiation could not be proven or fulfilled with the implementation or usage of the LLM system, as was the case with DP4.

In addition to the open questions, nine items were rated using a 6-point Likert scale, where 1 indicated strong disagreement and 6 indicated strong agreement. Both were analyzed, with a special interest in identifying initial significant differences between the two groups (chatbot vs. without chatbot), using the non-parametric Mann–Whitney U test, as a normal distribution could not be assumed. Since separate tests were conducted for each of the nine items, the risk of a Type I error (family-wise error rate) was addressed by additionally applying a Bonferroni correction.

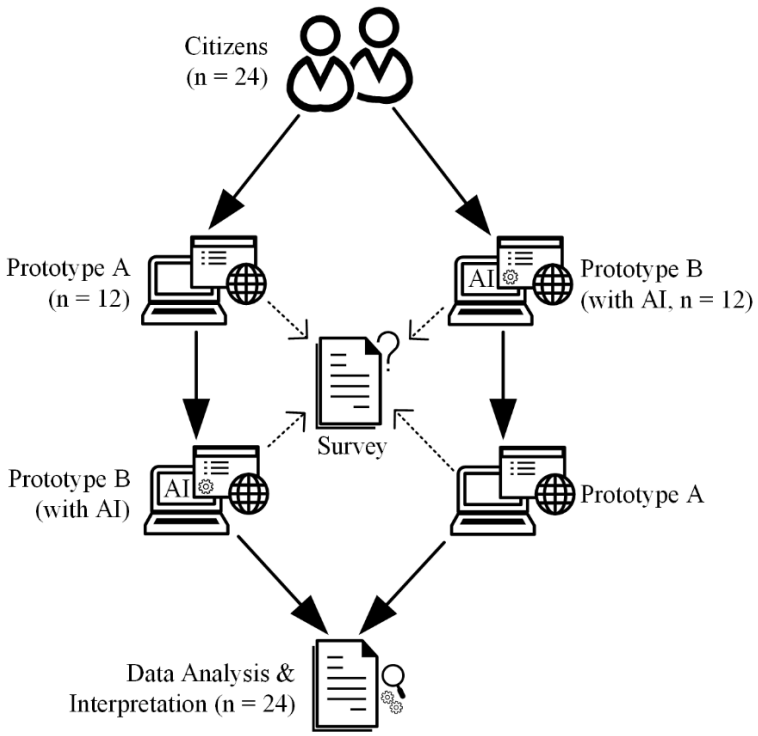


Figure 5. Overview of the Evaluation Approach

The study was conducted with a total of 24 participants, including 13 men and 11 women. The average (AV) age of participants was 34.25 years, with a standard deviation (SD) of 17.38 years. The participants have different backgrounds. Five were students, four were trainees, six worked in IT or IT-related areas, four worked in social areas, and five worked in other areas. In addition, none of the participants worked directly with AI, but many reported that they have tried out tools like ChatGPT or Gemini. Furthermore, eleven (45.8%) participants reported knowing the project location (cf. Figure 3), nine (37.5%) knew it partially, and four (16.7%) did not know it (cf. Section 7).

20.8 Findings

DP1 demands that all information about the urban project is stated clearly and comprehensively, including visualizations. This analysis shows an average of 5.38 (SD = 1.06) for the rating regarding the clarity of the AI responses. Most participants (75%) considered the explanations of the AI-based chatbot to be adequate. A few requested photos or images for a better project overview (8%). Three participants (12.5%) criticized the navigation, with two mentioning unclear workflow and one suggesting clearer icons and a more intuitive website instead of lengthy texts. The integration of the map was seen as helpful for providing a better overview while working on the projects (AV = 4.88 and SD = 0.80). DP1 was overall approved with high validation that was particularly notable for its intuitive aspects. However, multiple participants also criticized the provision of just one map and the absence of further visual elements. They stated that more figures from the project location and, if available, an initial plan regarding possible changes to the roads or trees should be provided. This information should also be made available through the chatbot to enable a request-based exploration based on the participants' interests. As a response to that, we reduced DP1 and created DP6 to consider visual elements in detail.

DP1 (adjusted): Implementers should ensure that the chatbot presents participation content clearly and comprehensively, utilizing summarizations to support citizens' understanding.

DP6: Implementers should provide interactive maps and additional visual content in the interface and through the chatbot to enable open and request-based exploration of the project area by citizens.

Regarding DP2, a total of 11 participants (45.8%) appreciated the constructive nature of the conversation. They noted that the chatbot responded quickly, engaged well with their input, and encouraged further reflection. One participant stated: "... the follow-up questions were a bit exhausting. They led me to provide more detailed information than I would have otherwise. The real idea only emerged through the

interaction with the bot." In response to the open-ended question about what users disliked about the chatbot, 8 (33%) participants expressed no criticism. However, 7 (29%) participants noted that the chatbot tended to repeat user input and did not contribute enough to idea development, often following a fixed response pattern. As one participant put it: "The chatbot's response pattern is somewhat repetitive. The suggestion is rephrased and evaluated as constructive, followed by a request for another idea. I don't find that inefficient. It just takes away a bit of the natural flow of the 'conversation.'" Nonetheless, DP2 is approved, but it should be ensured that the chatbot does not unnecessarily repeat content and does not repeat questions.

DP3 addresses the intuitiveness of the usage, which was rated high for both prototypes (AV = 5.33, SD = 0.92). However, there was no significant difference between the two groups, as indicated by the Mann–Whitney U test ($p = 0.652$). Besides that, participants generally perceived the chatbot's responses as meaningful and coherent (AV = 5.54, SD = 0.51) and felt motivated to interact and develop ideas (AV = 5.08, SD = 0.97). Further, the participants praised the chatbot's empathetic and friendly tone, its clear and human-like language, quick and well-structured responses, intuitive handling, and appealing appearance. The question regarding its human-like and empathetic behavior was rated high, with an AV of 5.0 (SD = 0.98), but without significant differences between the two groups. However, the chatbot encouraged deeper thinking and motivated more idea sharing compared to the non-chatbot project. One participant said: "The format of a conversation makes the interaction with the project much livelier and stimulating, which is why I thought longer and better about suggestions than with the project without a chatbot."

Considering DP4, the flexible interaction and support of diverse and typographically incorrect input in different languages is supported by the LLM. This was not explicitly validated by a survey question but approved, as LLM can handle that, and the interactions in the evaluations have also shown this, supporting DP4.

No.	Shortened Statements (1 to 6)	AV & SD
DP1	Map integration was helpful.	4.88 ± 0.80
DP2	Chatbot responses made sense.	5.54 ± 0.51
DP2	Chatbot encouraged interaction.	5.08 ± 0.97
DP3	Chatbot felt human/empathic.	5.00 ± 0.98
DP3	The platform is easy to use.	5.38 ± 1.06
DP3	Chatbot is easy to use.	5.33 ± 0.92
DP5	Contributions improved by the chatbot.	4.96 ± 0.75
-	Data storage was a concern.	2.29 ± 1.20

Table 1. Overview of Likert-Scale Items with Average (AV) and Standard Deviation (SD)

DP5 affects contextual data, which we provided with the prompt, such as information about the participation process. Participants generally felt that the chatbot improved

the quality of their contributions (AV = 4.96, SD = 0.75), and the explanations were supportive. However, further information would be helpful, and the transparency of responses should be improved. Considering the feedback regarding DP1, we condensed this and derived DP7, focusing on further visual elements. DP7 primarily addresses a technical requirement that goes beyond the use of a simple LLM. This involves retrieving images and other data sources from information or documents, as well as giving the chatbot an idea of the content to be queried.

DP7: Implementers should enable the chatbot to access documents, visual elements, and online sources to provide in-depth knowledge about the participation project and its environments while being aware of the sources to support in-depth citizen exchange.

The implementation of DP7 would extend the usage of the LLM approach, which could be achieved by following the RAG architecture, but could also limit the reproducibility of responses by the LLM (Nikishina et al., 2025). This extends LLM with predefined data corpora, which are typically stored in vector databases. Additionally, algorithms that detect requests and decide whether to utilize the knowledge base, visual data, or online and real-time data, depending on the use case, can also extend this (Gao et al., 2024).

On a more general topic, participants showed low concern about the chatbot storing all their input (AV = 2.29, SD = 1.20), suggesting this was not perceived as a major issue. However, it is worth noting that the mean was higher in the group that started with the chatbot (AV = 2.83) compared to the group that began without it (AV = 1.75). While this difference was initially significant ($p \approx 0.023$), it did not hold after the Bonferroni correction (adjusted $p = 0.21$). When asked which project they would have preferred if only one had been available, 23 (96%) of participants chose the project with the chatbot. Furthermore, 83% of participants expressed interest in participating in digital citizen engagement in the future.

20.9 Discussion

In this paper, we examined the RQ "How should AI-based chatbots be designed to support citizens' engagement and interaction on urban participation platforms?" by conducting a DSR project. We identified issues, formulated meta-requirements, and derived design principles, which we instantiated with a web prototype. This was evaluated in comparison to a baseline prototype, representing existing urban participation platforms.

Our study demonstrates that carefully designed AI-based chatbots can significantly enhance citizen participation in urban planning by bridging interaction gaps and encouraging participant engagement. The evaluation showed that participants generally preferred the interactive chatbot-based approach over a static, non-

interactive alternative, reporting higher levels of engagement, satisfaction, and willingness to participate in future projects. This research advances the existing body of knowledge by deriving design principles (DP1 to DP7) and support the technical requirements and principles proposed by Bono Rossello et al. (2025) for the holistic collective intelligence architecture, as well as the overall impact of interactive digital tools (Becker et al., 2022), by highlighting the chatbot's ability to provide content-specific immediate responses and facilitate more intense interactions (Borchers et al., 2023).

Participants appreciated concise summaries and relevant visualizations yet expressed a need for richer, more interactive materials (Cortés-Cediel et al., 2023), highlighting the importance of multimodal support (DP6). The chatbot encouraged reflective contributions, but limitations such as repetitive replies point to the need for more advanced, adaptive dialogue management using LLM prompts. While most users were unconcerned about data privacy, some requested clearer information on data usage and system logic, underlining the importance of explainability and trust (Hao et al., 2024; Moghayedi, 2025). Robust language capabilities in the chatbot lowered participation barriers, supporting findings in the literature (Cortés-Cediel et al., 2023). Participants also felt better informed with the provided urban projects information. However, greater transparency of information sources remains desirable. Several implications emerge from these insights. Our design principles, particularly the newly introduced DP6 and DP7, which concern multimodal data and access to supplementary project materials, offer value for the development of future urban participation platforms in terms of specific functions. To address the demand for contextual depth and enhanced visual information, we recommend the exploration of RAG architectures, coupling LLMs with curated knowledge bases and multimedia assets (Gao et al., 2024; Nikishina et al., 2025). Further, as AI-chatbots become increasingly central to participatory processes, it is essential to conduct human-centered evaluations focusing on trust, inclusivity, and deliberative quality (Becker et al., 2022).

Our results reinforce the importance of intuitive, empathetic interaction, suggesting that design strategies should prioritize natural discourse and adaptive support. Also, promoting transparency and explainability in AI systems, such as enabling citizens to query information sources and understand automated decision-making processes, will be decisive in ensuring legitimacy and acceptance (Freitas et al., 2023). Finally, while our study demonstrated feasibility and potential with a small, diverse group, broader investigations across different demographic groups and urban settings are needed to generalize and optimize design principles.

Regarding the limitations, our participant pool (n=24) was sufficient for the first DSR cycle but not large enough to reflect the complexity and heterogeneity of urban populations and ensure the design principles were comprehensible. The scope of our

prototype was also limited, and we did not integrate real-time data or more advanced visual or multimedia capabilities in our chatbot (Nikishina et al., 2025).

To build upon our results, future DSR cycles should focus on expanding technical capabilities by implementing a knowledge base according to the RAG architecture, as further information about the current project, but also general knowledge about citizen participation in urban planning and the interaction with citizens, could further increase engagement and interaction (Nikishina et al., 2025). Furthermore, in the second DSR cycle, as the focus and complexity of the IT artifact is increasing, to consider the AI-based chatbot as part of a hole urban participation platform, we will plan to specify echelons e.g. subsystems and different technical units, layers for all decision-making areas and strata, to specify dynamic elements, to provide a holistic view (Tuunanen et al., 2024). This also affects cross-disciplinary research to develop standards for AI explainability, to ensure that AI-supported participation can uphold core democratic values (Arana-Catania et al., 2021).

20.10 Conclusion

This study demonstrates that AI-based chatbots in urban planning can enhance citizen participation by fostering more interactive, inclusive, and engaging dialogue. Through a design science research approach, we identified key requirements, including clear information, empathetic and adaptive interaction, flexible language input, and transparent sourcing. Our evaluation showed that participants preferred the chatbot-driven system to traditional platforms and felt more encouraged and supported in developing their ideas. However, challenges remain in providing richer visual materials, refining dialogue management, and ensuring transparency in data usage. Future research should focus on integrating advanced AI architectures and evaluating these solutions with larger, more diverse user groups to optimize inclusivity and trust. Overall, our findings provide proper design principles for practitioners and lay the groundwork for future research in AI-supported citizen participation on urban participation platforms.

20.11 Acknowledgment

We want to express our sincere gratitude to the Federal Ministry of Research, Technology and Space (Bundesministerium für Forschung, Technologie und Raumfahrt) for supporting the project RESCUE-MATE. The project examines innovative approaches to support civic engagement in urban crisis scenarios. The funding of RESCUE-MATE, with grant number 13N16836, enabled us to carry out this research.

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21 Publication C16: Analyzing Data from Urban Citizen Participation by Applying the Retrieval Augmented Generation Architecture

Hawaii International Conference on System Sciences (HICSS)

Track: Emerging Topics in Digital Government
Completed Research
Ranking: B

Research Question

How should RAG-based IT artifacts be designed to support urban experts' analysis of participation data?

Contribution to the Dissertation

This publication contributes to the overall RG, and especially RQ2 and RQ3. In this study, a web prototype was developed using the retrieval augmented generation (RAG) architecture for large language models (LLMs) to support urban experts in analyzing citizens' contributions. To develop the prototype and RAG, we used insights, data, and information from real-world urban participation projects, which directly address RQ2. Furthermore, as the tool enables intuitive interaction with data to analyze it for subsequent processes, we demonstrate how data can be automatically analyzed, as requested in RQ3. The publication describes eleven issues, twelve meta-requirements, and four design principles, which were extended to six as a result of the evaluation with urban experts from different domains.

Citation

Borchers, Marten; Milutzki, Enrico; Oelgschläger, Simon; Magdych, Valeria; Semmann, Martin; & Bittner, Eva (2026). Analyzing Data from Urban Citizen Participation by Applying the Retrieval Augmented Generation Architecture. In: *Proceedings of the 59th Hawaii International Conference on System Sciences* (HICSS). https://hdl.handle.net/10125/111679. Completed Research.

Abstract: *This study explores the application of the retrieval-augmented generation architecture for large language models in analyzing citizens' contributions from urban participation. Existing literature highlights the potential of large language models to streamline analytical processes. However, challenges regarding required functions, domain expertise, and transparency remain underexplored. This research addresses these issues through a design science research approach. We identified eleven issues with a systematic literature review and twelve expert interviews, formulated twelve meta-requirements, and derived four design principles on which we developed a web prototype. We evaluated it with 42 experts from a crowdsourcing platform. Our findings demonstrate that retrieval-augmented generation models can enhance efficiency in automated categorization, sentiment analysis, and summarization by focusing the model's attention. However, transparency limitations persist as an ongoing challenge. Our findings contribute to existing knowledge by illustrating how hybrid intelligent systems can improve urban experts' ability to analyze and interpret participation data in smart cities.*

Keywords: Citizen Participation, Data Analysis, Retrieval Augmented Generation, Large Language Model, and Design Science Research

21.1 Introduction

The ongoing digitalization of urban spaces presents new opportunities for enhancing citizen participation in urban development (Smith & Martín, 2021). Citizen participation is often conducted in response to local tensions and community conflicts due to urbanization (Caragliu & Del Bo, 2022). Digital tools like participation platforms (Royo et al., 2020) and mobile applications are increasingly utilized to expand citizen participation and support their scalability, creating public value (Borchers et al., 2023). However, as these approaches expand, so does the volume of collected citizen contributions. This growth poses significant challenges for local authorities, urban planners, and decision-makers, who face difficulties in analyzing and evaluating large and heterogeneous amounts of textual data (Royo et al., 2020). The literature highlights the critical need for effective methods to process and utilize these vast quantities, as manual evaluation methods are increasingly impractical given the scale of citizen inputs, prompting the exploration of advanced computational approaches (Arana-Catania et al., 2021). One promising approach involves the deployment of Artificial Intelligence (AI), particularly Large Language Models (LLMs), and the newly emerging Retrieval Augmented Generation (RAG) techniques (Shi et al., 2024). RAG extends LLMs with additional contextual data and has shown potential for automating the analysis of domain-specific textual data (Nikishina et al., 2025). While previous studies have explored Machine Learning (ML) methods for analyzing citizen contributions (Cai, 2021; Romberg & Escher, 2023), applying general-purpose LLMs remains underexplored (Williams et al., 2024), which is why we propose the following research question (RQ).

RQ: How should RAG-based IT artifacts be designed to support urban experts' analysis of participation data?

We answer the RQ with a design-oriented approach (Peffers et al., 2007) and continue with the Related Work, Problem Identification, and Method sections. Afterward, the issues are described in the Identification of the Problem section. Meta-requirements and design principles are elaborated in the Objectives of a Solution section. The development of the IT artifact is specified in the Design and Development section, and in Demonstration and Evaluation, we describe our evaluation. Afterward, we present our findings, discuss them, and then summarize the paper.

21.2 Related Work

Urban development is shaped by numerous factors that increasingly require integration into city planning. As urban areas and cities grow more complex, decision-making becomes more challenging (Fu et al., 2023). To face that, active citizen engagement, through mechanisms known as citizen participation, is vital and today requires digital tools to increase effectiveness and efficiency (Cai, 2021).

21.2.1 Citizen Design Science Model

The Citizen Design Science Model integrates the three dimensions of Citizen Science, Citizen Design, and Design Science, serving as a tool to support citizen participation (Mueller et al., 2017). Each dimension is a combination of two areas of citizens, design, and science, as these are crucial and induce each other, as shown in Figure 1 (Torrecilla, 2019).

Citizen Science involves eliciting citizens' requirements, needs, and ideas, considering the existing contextual and local conditions of projects and the methods of participation employed (Nicolas et al., 2021). This encompasses on-site (analog), digital, and hybrid participation modalities, such as interviews, workshops, and surveys (Mueller et al., 2017). Therefore, Citizen Science addresses how to include and enable participation in a representative and, depending on the objective, valid approach to ensure the elicitation of citizens' contributions (Mueller et al., 2017).

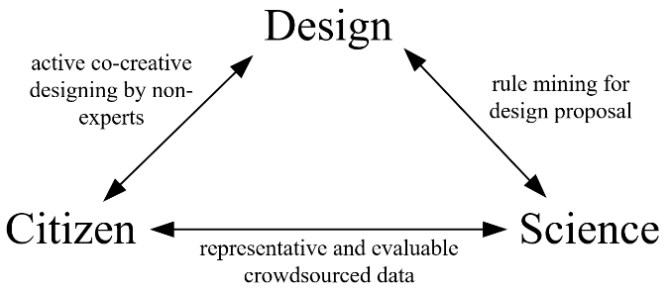


Figure 1. Citizens Design Science Model

Citizen Design determines how citizens actively contribute to the design of a project's vision during participation. This can address the development of buildings, parks, districts, and communities where social interactions, places, and factors like safety, openness, and new living projects are relevant. The possibilities for citizens to contribute their ideas and requirements vary from simple text to 2D and 3D approaches (Munz et al., 2023). In terms of scalability, Citizen Design is influenced by Citizen Science, which defines how citizens can express themselves and impacts Design Science through the analysis of collected data (Mueller et al., 2017). Design Science delineates the methodology of analyzing citizen contributions into actionable insights to support architects and urban planners in developing projects (Altrock, 2022). Empirical evidence from prior research shows that converting these contributions into specific project goals is very complex (Cai, 2021). It underscores the necessity of establishing the requirements for urban initiatives and the technical frameworks for participatory engagement and data analysis before initiating participation activities to ensure the process's feasibility (Repette et al., 2021). Typical data formats are Excel, CSV, JSON, and GEOJSON. Depending on the amount, AI or ML-based approaches are required to support feasible, cost-efficient, and comprehensible data analysis (Borchers et al., 2024), which directly relates to our **RQ**.

21.2.2 LLMs and RAG for Citizen Participation

The increased application of LLMs promise a paradigm shift in supporting citizen participation and data analysis in urban planning (Gao et al., 2024). LLMs are trained on vast natural language corpora and can be used to perform tasks such as sentiment analysis, topic detection, summarization, and translation with increasing accuracy (Fu et al., 2023). In the context of citizen engagement, LLMs, especially RAG, could support the automatic evaluation of thousands of contributions, assisting experts in grouping and prioritizing issues, identifying key themes, and assessing the overall sentiment of public opinion (Cranefield & Pries-Heje, 2023).

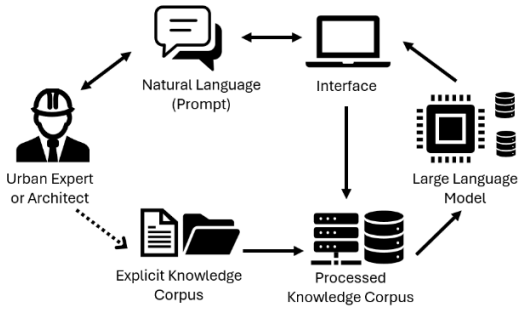


Figure 2. Basic Retrieval Augmented Generation (RAG) Architecture

The RAG architecture may facilitate information control by integrating a domain-specific corpus, such as participatory processes, as part of a processing pipeline, as shown in Figure 2 (Li et al., 2022). Therefore, RAG systems combine the generative

power of LLMs with retrieval mechanisms by including a domain-specific knowledge corpus. This must be predefined and could include expert knowledge about analyzing participation data. Additionally, it is possible to incorporate knowledge about the project, such as local names for various places, restaurants, museums, points of interest, and geographic characteristics (Fu et al., 2023). This hybrid approach could enable more effective and efficient data analysis compared to pure LLM-based analysis tools (Kandpal et al., 2023).

21.3 Method

As we follow a design-oriented approach, we conduct a Design Science Research (DSR) project. DSR is a well-known paradigm in systems science, which can be used to gain knowledge by developing justified IT artifacts based on derived design principles (Hevner et al., 2004). DSR is an iterative approach that leads to new design theories and practical solutions addressing real-world problems (Kuechler & Vaishnavi, 2008). We implemented the DSR activities for this work according to Peffers et al. (2007), as shown in Figure 3.

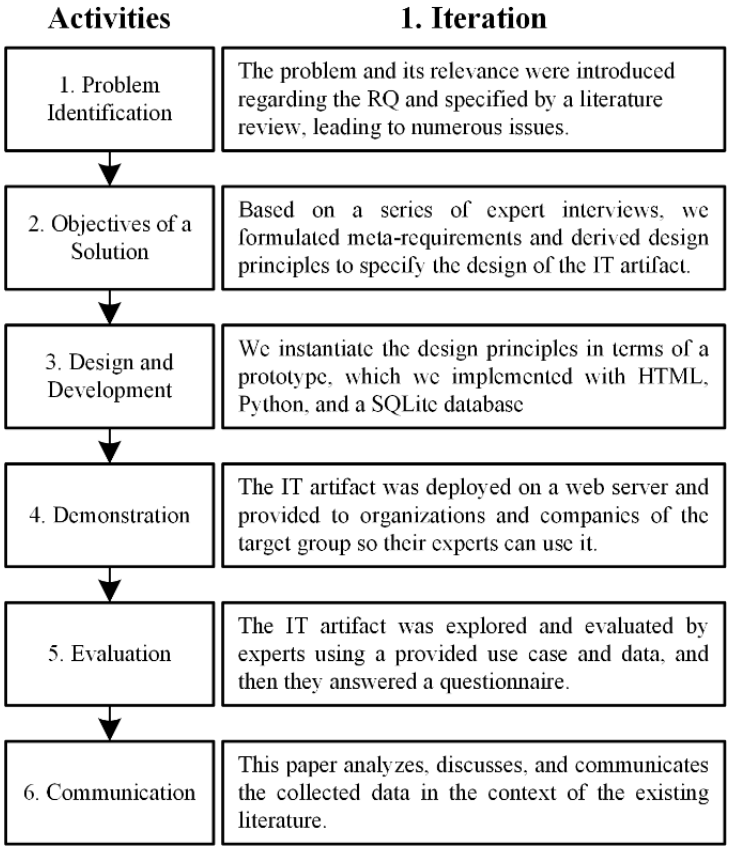


Figure 3. Applied Design Science Research Activities

The introduction section explains and argues the problem and its relevance, leading to the RQ. To explicitly define issues, we conducted a systematic literature review (Cooper, 1988). In the second activity, we conducted expert interviews to formulate

meta-requirements and derive design principles to specify a solution (Peffers et al., 2007). Afterward, the core artifact is developed and integrated into a web prototype (Shi et al., 2024). We hosted the prototype on a web server to enable the demonstration and the systematic evaluation, which was conducted by experts acquired through a crowd-sourcing platform. The evaluation process adheres to the guidelines by Venable et al. (2016), combining both practical tests and theoretical validation. All collected results were analyzed inductively-deductively, according to Mayring & Fenzl (2019), to validate and elaborate on the derived design principles. Finally, all results are communicated in this paper.

21.4 Problem Identification

For the identification of the issues (ISS), we conducted a literature review according to Cooper (1988) and defined the (1) focus, which the RQ and the domain of citizen participation define. The (2) goal is to identify issues. The (3) kind of representation, which is neutral and well-founded, and the (4) coverage, which lies on the pivotal central, as LLM and especially RAG systems, are quite new. Regarding the (5) organization of the review, we focus on conceptual works, and the (6) audience consists of specialized scholars and practitioners. For the literature review, we used the following search string and focused on the databases of the AIS and ScienceDirect.

- *„large language model“ AND urban planning AND citizen participation AND data analysis*

The initial search yielded 171 results, from which we excluded 29 due to a lack of access, 126 due to a lack of relevance based on the abstract, and three due to quality issues, so that 19 papers remained, which revealed several issues. One of these issues (ISS1) is the lack of intuitive analytical tools (Bono Rossello et al., 2024; Fürstenau et al., 2021). The literature highlights that current solutions do not offer user-friendly interfaces that enable non-technical users to interpret and explore large datasets. Automated and efficient analysis tools also have a significant deficiency (ISS2).

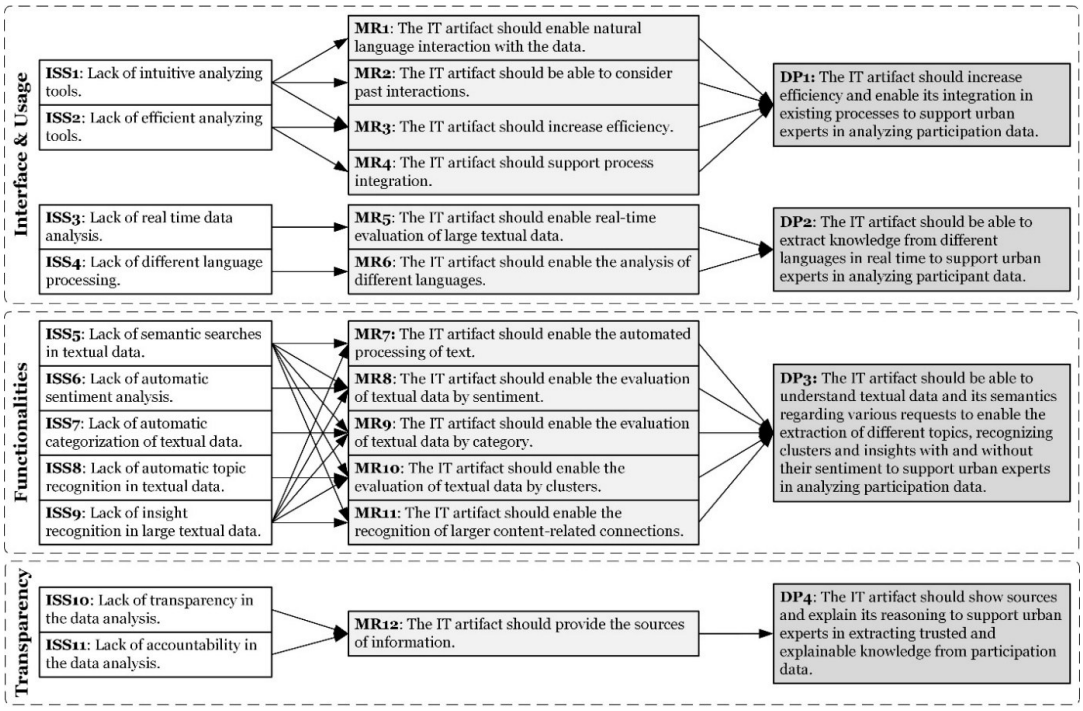


Figure 4. Overview of Issues (ISS), formulated Meta-requirements (MR), and derived Design Principles (DP)

Tasks such as categorizing citizen contributions or filtering large volumes of responses remain predominantly manual, laborious, and time-consuming, which hampers scalability (Bhattarai et al., 2023; Hao et al., 2024). Furthermore, the capacity for real-time data assessment (ISS3) is absent (Huang et al., 2025; Ludzay & Leible, 2022). The literature emphasizes that timely evaluation of ongoing participation, such as early detection of misinformation or emerging themes, is crucial for adaptive and responsive processes. Multilingual processing (ISS4) challenges these issues, as urban populations often speak multiple languages (Moats & Ganguly, 2025). There are also significant challenges related to the analysis of textual data, specifically in semantic search and understanding (ISS5). Conventional keyword searches prove inadequate when dealing with large datasets filled with indirect descriptions (Cai, 2021). The lack of automatic sentiment analysis (ISS6) further hampers understanding of public mood (Cranefield & Pries-Heje, 2023). Additionally, the automatic categorization of textual contributions (ISS7) remains an unmet need (Borchers et al., 2024; Moats & Ganguly, 2025). Manual classification is inefficient and inconsistent, but LLM automation could enhance scalability and consistency. Recognizing key themes and patterns (ISS8) also remains challenging without automated summaries (Borchers et al., 2024; Graf-Drasch et al., 2023; Hughes et al., 2023). This also applies to extracting meaningful insights from vast textual information (ISS9), which is hindered by the volume and complexity of citizen contributions (Becker et al., 2022; De Vreede et al., 2021; Rehm et al., 2022). The issues of transparency and accountability (ISS10 and ISS11) are equally critical. The literature expresses concerns about the opacity, the so-called "black box" nature,

of LLMs and other AI models, which complicates the validation and verification of results (Díaz-Rodríguez et al., 2023; Dwivedi et al., 2023; Huang et al., 2025). This lack of explainability diminishes trust, especially when the outcomes influence public or political decisions. Many urban experts worry that the inability to trace how models reach conclusions undermines legitimacy and hampers acceptance by political stakeholders and citizens (Mohammed et al., 2024).

21.5 Objectives of a Solution

For the formulation of the meta-requirements (MR), which are also based on the issues and derivation of design principles (DP), we conducted twelve expert interviews, as shown in Table 1, with an average experience (Exp.) of 11.3 years. The phrasing of the design principles was conducted according to Gregor et al. (2020), who define that these should include the recipient, context, aim, and a short rationale. ISS1 highlights a deficiency in intuitive analysis tools, which necessitates MR1 to ensure natural interaction, enabling experts to communicate with the system using human language. This aims to mitigate usability barriers and promote an intuitive analysis (E1, E2, and E5).

MR2 is formulated to ensure the IT artifact can consider past interactions to support a continuous conversational flow (E1, E2, and E5). Thus, MR3 explicitly states that the artifact should enhance operational efficiency by reducing manual effort and streamlining workflows for urban experts, as based on ISS2, E2, E3, E4, E7, E8, and E11. ISS2 also supports MR4, which demands process integration in existing workflows (E1, E4, E6, E9, E10, and E11). Together, MR1 to MR4 lead to DP1: "The IT artifact should increase efficiency and enable integration in existing processes to support urban experts in analyzing participation data."

No.	Exp.	Role	Type
E1	18	Employee	Company
E2	7	Urban Planning Expert	Company
E3	4	Junior Data Analyst	Company
E4	17	Urban Planning Expert	Public Service
E5	21	Communication Expert	Public Service
E6	10	Urban Planning Expert	Public Service
E7	2	Participation Expert	Company
E8	18	Participation Expert	Public Service
E9	20	Participation Expert	Company
E10	4	Participation Expert	Company
E11	6	Developer	Public Service
E12	9	Urban Project Manager	Public Service

Table 1. Overview of Expert Interviews

ISS3 highlights the absence of real-time data analysis capabilities, posing a significant obstacle to making timely decisions during participation. To address this challenge, MR5 is formulated to facilitate the evaluation of large textual datasets, providing urban experts with immediate insights (E1, E2, E3, E4, E5, E7, E10, E11, and E12). Furthermore, ISS4 points to the deficiency in processing multiple languages, which restricts the application of IT artifacts in diverse urban contexts. In response, MR6 specifies linguistic diversity (E3, E6, E9, and E10) and, together with MR5, leads to DP2: "The IT artifact should be able to extract knowledge from different languages in real-time to support urban experts in analyzing participant data." ISS5 highlights the lack of semantic searches, which is why we formulate MR7 to ensure that the IT artifact supports the automated processing of textual data (E1, E2, E9, E10, E11, and E12). Building on this, ISS6 highlights the lack of automatic sentiment analysis. Therefore, MR8 emphasizes that the system should enable the evaluation of textual data based on sentiment (E2, E3, E4, and E11). ISS7 identifies the absence of automated categorization, supporting MR9 (E1, E2, E3, E7, E8, E9, E10, E11, and E12). ISS8 points to a deficiency in recognizing underlying topics within texts, which is essential for inductive topic recognition and clustering (MR10) to identify key content areas and conceptual groupings (E1, E2, E3, E7, E8, E9, E10, E11, and E12). ISS9 lacks insight recognition, uncovering latent connections and overarching narratives (MR11), and providing context-aware analysis (E1, E3, E5, E9, E10, and E11). In combination, MR7 to MR11 led to the derivation of DP3: "The IT artifact should be able to understand textual data and its semantics regarding various requests to enable the extraction of different topics, recognizing clusters and insights with and without their sentiment to support urban experts in analyzing participation data." MR12 development is directly informed by ISS10 and ISS11, which identify critical shortcomings related to transparency and accountability. ISS10 highlights the lack of clear information regarding the origins of data and analytical outputs. Similarly, MR12 is formulated based on all experts' opinions, except E3 and E9, to ensure that the IT artifact provides clear sources of information for all data and analyses. This requirement mandates that the system explicitly indicate where data originates, leading to DP4.

21.6 Design and Development

The web prototype was developed using Python, employing the Flask web framework to facilitate its deployment as a web application. The front-end leverages web technologies including HTML, JavaScript, and CSS. The design of the prototype is based on the design principles (cf. Section 5) and the RAG architecture (cf. Section 2.2), utilizing OpenAI's GPT-4 model as its foundation. We chose that model because it is already quite capable and can understand text on a high level. Thus, the explicit knowledge corpus can be free from semantic limitations that a less capable model

would have, negatively affecting the usage experience. The prototype considers DP1, opting for an intuitive design and chatbot solution, recognizing that this could also be integrated into existing solutions, which we do not have access to. The interactions with data are ensured, as the user can upload one or more datasets, such as Excel, CSV, or txt files. Using RAG ensures real-time evaluation, which, depending on the amount of data, can still require a few seconds (DP2).

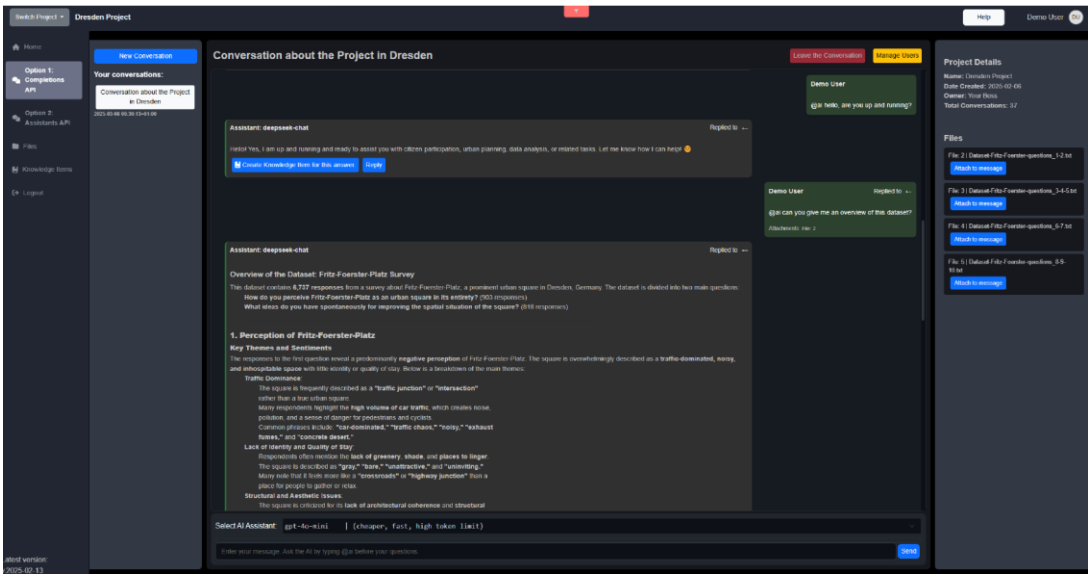


Figure 5. Overview of the Prototype and its Functions

Two chat modes are revealed. Completions API and Assistant API (cf. Figure 5, top left). The first supports the interaction in which text is uploaded and analyzed based on submitted requests, enabling semantic searches and more general interaction (DP3). The Assistant API enables specific tasks and is based on an explicit knowledge corpus to support classification, clustering, and sentiment requests (DP3). For both approaches, we also extend the prompt with a role description for the model to ensure that it behaves in a professional, objective, and understandable way. Accordingly, the role description, selected parts of the knowledge corpus, and the uploaded data are processed for each prompt to obtain a comprehensible and accurate response (cf. Figure 5). This also considers DP4 as the role description, which strongly emphasizes the transparency of the statements by communicating examples, the file names, and the lines on which they are based. In cases where queries lead to highly explicit information, this can be implemented in a technically convincing manner. However, this is more difficult for requests that lead to summaries because the sources are more semantic and extensive, which can aggravate transparency, unless reduced to specific parts of citizens' data.

21.7 Demonstration and Evaluation

For the prototype's demonstration and evaluation, we hosted it on a web server, allowing external experts to inspect and explore it. To receive feedback, we recruited urban experts, data analysts, and architects from the Prolific crowdsourcing platform and compensated them for their participation.

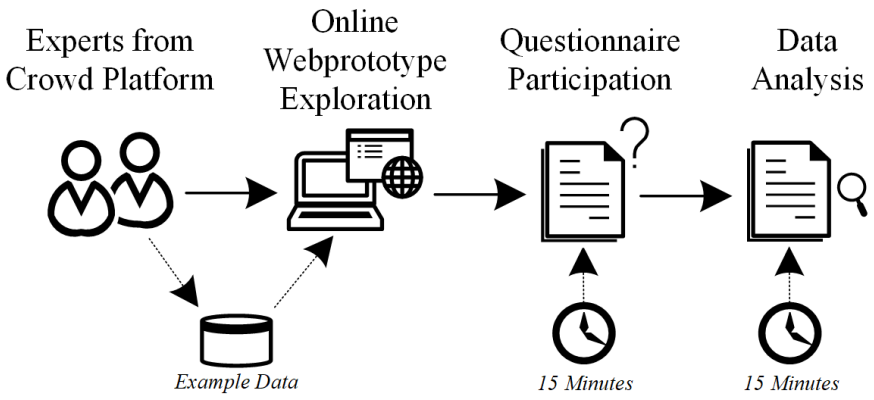


Figure 6. Evaluation Procedure

The demonstration and evaluation were two-fold. All participants received a weblink, a description of a task, and two example data sets from past citizen participation from a larger city, which they should use to achieve and explore the prototype and its function (Venable et al., 2016). All participants had 15 minutes for that. In the second part, all participants completed a survey that required an additional 15 minutes. The questionnaire included statements that participants had to answer according to a 6-point Likert scale (Hartley, 2014) and an open-ended question, where they were asked to describe their experience and provide feedback on the prototype. We acquired 47 participants from Prolific, who successfully explored and answered all questions. We excluded five, as they failed the attention checks that were part of the questionnaire (n = 42). The data analysis was conducted by paraphrasing similar textual statements regarding the design principles (Mayring & Fenzl, 2019).

21.8 Findings

All participants (n = 42) rated their expertise in citizen participation, urban planning, data analysis, and AI using a 6-point Likert scale, ranging from 1 (lowest) to 6 (highest). The average (AV) expertise score for citizen participation is 4.02 with a standard deviation (SD) of 1.62, 3.90 for urban planning (SD = 1.69), 4.79 for data analysis (SD = 1.35), and 5.05 for AI (SD = 1.15). The above-average values indicate that participants generally considered themselves knowledgeable, particularly in AI, which supports the credibility of the subsequent findings. Regarding DP1, the answers show that the prototype was perceived as very efficient overall. The tool was rated as timesaving compared to traditional citizen contribution analysis methods

(AV = 4.90, SD = 1.39). Its learning curve was seen as moderate (AV = 4.55, SD = 1.52), though with relatively high variance. Integration into existing workflows (AV = 4.71, SD = 1.11) was approved positively, even if it was evaluated as a standalone prototype. Overall, these results indicate high practical usability for participation experts and urban planners. The idea of combining automated analysis speed with human interpretation to enhance overall workflow received strong agreement (AV = 5.10, SD = 1.14). The application's assistance was also rated positively (AV = 4.62, SD = 1.15). Regarding whether the application caused additional work, confusion, or errors, it received a moderate rating (AV = 4.05, SD = 1.65), indicating that while some disruptions occurred, they were relatively limited overall, approving DP1. DP2 was only noticed to a limited extent and was quickly taken for granted, as translations are widely known and a common functionality of LLMs. With the implementation and evaluation, the technical feasibility was proven, as the sample data also included a small number of other languages. However, no expert explicitly highlights this demand or complains about it.

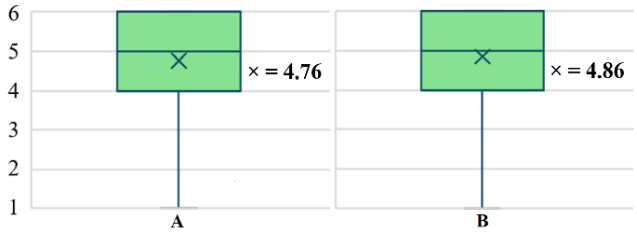


Figure 7. Fulfillment of the functional Requirements (A) and Accuracy of the generated Insights (B)

Regarding DP3, the prototype’s ability to fulfill the functional requirements for evaluating citizen contributions was rated quite positively (AV = 4.76, SD = 1.25), as shown in Figure 7. Additionally, the AI’s responses to the queries received favorable evaluations in terms of summaries, insights, and overall content (AV = 5.10, SD = 1.21). The coherence and structure of these responses were also viewed positively (AV = 4.86, SD = 1.20), indicating that the system provides well-organized and plausible outputs that support meaningful analysis (cf. Figure 7). The final design principle, DP4, focuses on providing sources and explanations to ensure trustworthy and explainable insights. Correspondingly, participants agreed that the concept of "Talking to Data,” implemented with RAG, is very useful for understanding large datasets (AV = 5.02, SD = 1.14). Additionally, participants rated their trust in the accuracy of the AI’s answers as moderately high (AV = 4.64, SD = 1.16). They also found that the application provided a reasonable level of transparency in how outputs were generated, such as explaining conclusions or showing the analysis process (AV = 4.43, SD = 1.30). Nevertheless, just over half of the participants (57%) did not ask the RAG any questions specifically about the origin of its responses. Regarding potential improvements, three participants wanted faster responses from the RAG, while four emphasized the desire for more personalized responses. Overall, the desire

for a better user interface and usability was mentioned 19 times, indicating a need for improvement. About 98% of participants agreed that human-AI collaboration brings more benefits than drawbacks. The statement that the application improves collaboration between citizen participation experts and urban planners was also rated positively on average (AV = 4.90, SD = 1.21). Participants also expressed confidence in the application's potential for real-world integration (AV = 5.05, SD = 0.94).

21.9 Discussion

To answer the RQ, "How should LLM-based IT artifacts be designed to support urban experts' analysis of participation data?" we identified 11 issues, formulated twelve meta-requirements, and derived four design principles. Our findings highlight the approval of the design principles and the implemented prototype. The implemented prototype is supportive and can also be integrated into existing processes, as many experts currently evaluate data manually using Excel and do not utilize existing tools, as the expert interviews at the beginning revealed (DP1). Besides that, three experts stated that faster AI responses are required, as well as increased usability. DP2 is feasible and was appreciated, as supported by the literature (Cai, 2021). DP3 specifies the functions of the prototype and was approved. However, the implementation was also criticized as experts expressed a desire to individualize responses further, not just based on the explicit knowledge base but also on personal preferences. In addition, experts suggested the possibility of giving and collecting feedback to further adjust and personalize the RAG, enabling it to act as a personal agent (Fu et al., 2023). Both lead to the following new design principles.

DP5: The IT artifact should offer settings to urban experts, allowing them to individualize responses and terminology to increase interaction and usage explicitly.

DP6: The IT artifact should provide feedback options for urban experts to collect behavioral data, supporting the development of personalized assistance agents.

Experts also approved DP4, but the ideas of how to reach transparency differ, as pure textual descriptions of data sources are limited, which is why visual representations should be examined. In summary, the prototype achieved good results, as reflected in general satisfaction, evaluated quality and performance, as well as usability and interaction design. Additionally, we want to emphasize that 83% of participants preferred collaboration with AI over fully automated analysis, as indicated by a very high level of agreement among participants that AI will play a central role in data-intensive tasks in the future (AV = 5.64, SD = 0.58). The strong consensus, reflected in both the high mean and the low standard deviation, underscores a consistently high perception of AI's potential.

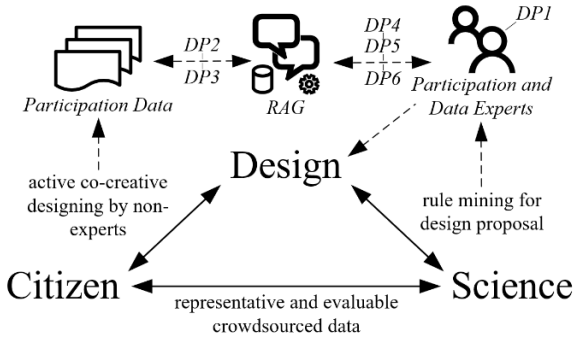


Figure 8. Positioning the Design Principles in the Citizen Design Science Model

We also want to elaborate on our results regarding the citizen design science model (cf. section 2.1). The six design principles are arranged as shown in Figure 8. While DP2 and DP3 focus on analyzing data from citizen design, DP4 to DP6 specify the interaction between RAG and urban experts, as well as how information can be queried, read, and utilized to extract design for urban projects as part of the model. Rules from design science can be considered, as the interaction with the RAG is up to the experts (Mueller et al., 2017), and operationalizing these rules is only necessary for automating the evaluation, which the experts have spoken out against. With the derived principles and implemented prototypes, we contribute to theory and practice. While the prototype can serve as an explicit orientation for practitioners, including the meta-requirements and issues, the design principles extend the knowledge bases and shift the urban informatics literature in the direction of individualized LLMs, e.g., RAG and personal agents (Cai, 2021). The arrangement of design principles in the context of citizen design science extends their applicability and enhances operational usage and framework development. However, our findings have some limitations. In DP1, it remains unclear to what degree efficiency is increasing, which would require comparative studies. These should be considered as an outlook to quantify this in percentage terms in the context of governmental activities, as well as companies and business models that offer data analysis as a service. Additionally, DP5 and DP6 should be further investigated in the context of the human-in-the-loop model and participation processes (Wiethof & Bittner, 2022). Moreover, both could also aggravate DP4 as the RAG responses are becoming increasingly difficult to compare when they are individualized, which should be considered in the second DSR cycle.

21.10 Conclusion

In this paper, we presented the first cycle of our DSR project, exploring the development of LLM-based IT artifacts by following the RAG architecture to support urban experts in analyzing citizen participation data. This is necessary due to the increasing complexity and volume of citizen contributions that challenge manual analysis. Following the DSR methodology outlined by Peffers et al. (2007), we systematically identified eleven key issues through a structured literature review and

expert interviews, formulated twelve meta-requirements, and derived four initial design principles. These were instantiated in the development of a web-prototype, enabling intuitive, real-time, multilingual, and semantically rich data analysis (Shi et al., 2024). The prototype was evaluated in a two-step process by 42 experts in urban planning, AI, and data analysis, whose feedback validated the fulfillment of the core design principles, particularly regarding efficiency, usability, and AI-based functions. Based on their inputs, two additional design principles regarding individualization and feedback mechanisms were derived. Our findings extend both theory and practice in the fields of urban informatics, citizen design science, and AI-driven participatory platforms (Borchers et al., 2024). The proposed design principles not only provide orientation for practitioners developing similar tools but also contribute to the theoretical foundation of AI in citizen participation (Cai, 2021). At the same time, the results highlight ongoing challenges such as measuring efficiency gains quantitatively, advancing individualization without compromising transparency, and integrating human feedback (Romberg & Escher, 2023). Looking ahead, future research should include comparative efficiency studies, further investigation into personalization and explainability trade-offs, and the operationalization of human-in-the-loop models for participatory processes. With this and the findings presented in this paper, an important step toward enabling more effective, efficient, and transparent data analysis through citizen participation is possible.

21.11 Acknowledgment

We want to express our sincere gratitude to the Federal Ministry of Research, Technology and Space (Bundesministerium für Forschung, Technologie und Raumfahrt) for supporting the project RESCUE-MATE. The project examines innovative approaches to support civic engagement in urban crisis scenarios. The funding of RESCUE-MATE, with grant number 13N16836, enabled us to carry out this research.

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