Participatory technologies in smart cities: what citizens want and how to ask them

***Abstract* —** This article deals with the process of prioritization of requirements on one selected participatory technology, which is citizen reporting on issues of public infrastructure (CRIsPI). Reporting is the activity that expresses the interest of citizens about the place they live. Traditionally, older citizens are more active in this activity, but modern technologies have the potential to motivate also young people to become active participants in public issues. There are two objectives of the article: 1) determination of which CRIsPI features would motivate young citizens to higher participation, and 2) comparative analysis of six prioritization methods to select the most appropriate method for engagement of this group of citizens. In total, 155 respondents (students) participated in the study. Results revealed that respondents require easy-to-use tools and positive feedback from the local government. Moreover, they prefer mobile solutions. The most suitable prioritization method, according to five given criteria, is adjusted cumulative voting ($100).

Keywords — requirements prioritization; citizen participation; smart city; participatory technology; citizen engagement

1 Introduction

Smart cities use technologies to make life in a city more comfortable, healthier, and more sustainable (e.g., de Jong et al., 2015; Cocchia, 2014; Nam and Pardo, 2011; Neirotti et al., 2014; Vanolo, 2014). Participatory technologies can be given as an example of smart technologies that engage citizens in public issues. They encompass an alignment between technology, citizens, and city government bringing a citizen-centric approach to the smart cities. For example, tools Open IDEO and Mind Mixer can help generally solicit all types of problems, SeeClickFix is specialized on reporting of problems in city services, Crowdbrite focuses on online collaboration (Kopackova, 2019).

The success of participatory technologies is highly dependent on user acceptance, as described by several models. Information system (IS) research has been studying the process of user acceptance since the eighties, e.g. TAM – Technology Acceptance Model (Davis et al., 1989; Chintalapati and Daruri, 2017), UTAUT - Unified Theory of Acceptance and Use of Technology (Venkatesh et al., 2003; Kabra et al., 2017), resistance theories (Markus, 1983; Coetsee, 1999; Ford et al. 2008). All the models show that technology, which is accepted by users, is used for a long time, and therefore, the benefits are higher and more visible.

Davis et al. (1989) proposed TAM and showed that perceived usefulness is a key factor influencing people's intention to use computer-based systems. It is followed by ease of use as the second key factor. Chintalapati and Daruri (2017) validated TAM as a useful model to evaluate the adoption of YouTube as a learning resource in India. They demonstrated the suitability of TAM for new technologies. They revealed a new variable, which is deeply connected to data quality: the perceived risk of using YouTube for learning purposes in terms of quality of content, accuracy, and appropriateness. This variable corresponds to the DeLone and McLean Model of Information Systems Success (DeLone and McLean 2003). Information quality was identified as a significant variable, measured in terms of accuracy, timeliness, completeness, relevance, and consistency.

Unified Theory of Acceptance and Use of Technology model was formulated to integrate eight existing acceptance models (Venkatesh et al., 2003). It focused on four core determinants of the intention of use and usage itself, and four moderators of key relationships. It was empirically tested by the authors to be confirmed. They pointed out age and gender as moderators of performance and effort expectancy as independent variables influencing behavioral intention. User experience is another revealed moderator. Kabra et al. (2017) extended UTAUT by integrating personal innovativeness and trust in technology with the behavioral intention to adopt new technology.

Markus (1983) focused on resistance to management information systems. The poor system design was mentioned as one of the resistance factors. The Resistance to commitment continuum model proposed by Coetsee (1999) after arguing that commitment (acceptance of a change) and resistance (rejection of a change) were closely linked. He specified particular phases of resistance and commitment, starting from apathy in the middle. Additionally, he pointed out participation and taking part (doing) as elements of involvement, which is a stronger form of acceptance. This conclusion supports the importance of citizens' involvement in requirements prioritization, as demonstrated in this article. Ford et al. (2008) emphasized the importance of change agents to communicate the change better and to support recipients with accommodating to changes. Next, they emphasized the importance of resistance itself for the change as far as the resistance may support the change in the end.

The IS research has confirmed that engagement of future users into the process of requirements elicitation and prioritization brings a higher level of acceptance of such technology (Schuler & Namioka, 1993; Halskov, & Hansen, 2015). However, only sparse resources deal with specific methods of engaging citizens in this process. What is missing in contemporary research is the evaluation of methods for the requirements prioritization based on various criteria, e.g. the ease of preparation of the questionnaire, the ease of evaluation for the respondent, the ease of processing the data collected, selectivity of the method, and the ability of a method to distinguish requests that

the user does not want. This article introduces the evaluation of five methods (Kano, Top ten, $100, Ranking, Likert scale, and AHP) according to the above-stated criteria.

The rest of the article is organized as follows. The next chapter shows the importance of citizen participation in the smart city concept. The following chapter introduces one particular participatory technology - citizen reporting on issues of public infrastructure (CRIsPI). This technology is the subject of the requirement prioritization task in the case study. The methodology part describes the conditions of the case study and the way of processing results. These results cover the evaluation of proposed methods and selection of features of CRIsPI technology that respondents would prefer. The discussion part shows the limitations of the study and the possibility of future research.

2 Smart cities and citizen participation

The concept of smart cities has become very popular, so the term itself has almost become the buzzword in today's world. Despite the popularity of the concept and the term, it is challenging to say which city is smart and which is not. The main problem is that there is no unified definition or measure available for comparing cities and saying how much the city is smart. It is not possible for two reasons. At first, there are many different views on the smart cities' principles from the research community, government initiatives, international organizations, or corporations. The second reason is the dynamics of the issue. Definitions mentioning results of the development of the concept and its implementation (i.e., listing resulting smart services available within a city) become obsolete very fast because advances in technologies bring new options almost every day.

That is the reason why this part of the article concentrates on the process of shaping smart cities, not on its result. The process of shaping means the whole process of enhancing a city as a smart city. The process starts with a development of the concept, i.e., preparation of policies and particular programmes/projects, which includes requirements of citizens and which should be based on city characteristics. It is followed by an implementation of the concept in the form of particular programmes/projects (Adnan et al., 2016). An important question is what the main principles are, on which smart cities are built. Technical report Smart sustainable cities: An analysis of definitions (ITU-Ta, 2014) covers more than 100 definitions. Authors used it to distil the main principles of the smart cities. The results can be found in table 1.

Table 1. Main principles on which smart cities are built

Main principles	Source
General principles	
Creativity, intelligence	Hollands (2008), Toppeta (2010), Schaffers et al. (2012), IBM (2013), Lee et al. (2014), Baycan (2016)
Sustainability, wise management of natural resources	Munier (2007), Toppeta (2010), Jingzhu (2011), Kehoe et al. (2011), Lombardi (2011), Dixon (2012), Schaffers et al. (2012), Meijer et al. (2013), Baycan (2016)
Governance principles	
Participation, engaging citizens	Giffinger et al. (2007), ARUP (2011), Lombardi (2011), Nam and Pardo (2011), Meijer et al. (2013), Lee et al. (2014)
3E, proactive government	Toppeta (2010), Lombardi (2011), Kehoe et al. (2011), Schaffers et al. (2012), DFID (2013), IBM (2013), Lee et al. (2014), Hu et al. (2016), OGCR (2017)
Transparent/trustworthy government	Lanthrop and Ruma (2010), Toppeta (2010), Lombardi (2011), IBM (2013), ITU-T (2014) Lee et al. (2014)

There are two key categories of principles mentioned in the literature (see Table 1):

- General principles – with a focus on general development principles, namely creativity, and sustainability
- Governance principles – with a focus on the good governance trends, namely participation, transparency, and economic/efficiency issues

2.1 General principles

Creativity and intelligence mean thinking in a new way when designing new services, solving old problems by new methods, or finding new ways of citizen participation. It is an expression of human energy (Baycan, 2016). However, it also means support for the creativity and knowledge transfer at the level of citizens and businesses.

Research centres, innovation incubators, different forms of public-private partnerships, and communication platforms for citizen's engagement are examples of such activities (Baycan, 2016; Hollands, 2008; Lee et al., 2014). As Baycan (2016) states, there is no single or simple definition of creativity. In summary, creativity refers to the creation of something new.

Nevertheless, most cities are not made from scratch. They have a history that needs to be preserved and resources that must be protected from depletion. **Sustainability**, which is the second general principle, means such a way of urban development leading to preservation of social-economic-ecosystem equilibrium. The three-pillar concept of sustainability has been used many years, differing in approaches to the understanding pillars, their interactions, and their integration (Purvis et al., 2019). Many different issues are falling under the umbrella of sustainable development, for example (Purvis et al., 2019; Toppeta, 2010): waste management, transportation efficiency, energy utilization efficiency, clean atmosphere, water management, preservation of nature and natural resources, infrastructure, and cultural heritage preservation. Social welfare and economic development are deeply connected to other issues (Purvis et al., 2019. Creativity can support sustainability as far as it offers new approaches to problems solution, managing cultural heritage, design new services, and products (Baycan, 2016).

2.2 Governance principles

The second type of principles revealed through analysis of definitions is a group of governance principles. The process of shaping of smart cities includes, besides others, the diffusion of innovations into the public sector and to the public. The successful diffusion requires people who can manage and coordinate the whole process. Unrestrained and uncoordinated purchase of technologies makes integration of systems complicated or even impossible; that is why some principles influencing this process must be defined. The cornerstone of the smart city shaping process is a **strong leadership** as an essential part of a good government. Capable, committed leaders with vision, who demonstrate the support and have enough power can force the change (Lee et al., 2014). There is no one right answer to a question, who should be a leader in this process. Certainly, foremost leaders should be within public administration offices (IBM, 2013; Lee et al., 2014).

Smart city governance is based on the involvement of new ways of the collaboration of people. The collaboration is supported by new information and communication technologies, and it is aimed at more transparent governance processes and better outcomes (Meijer and Bolívar, 2016). They emphasize that technology itself does not make a city smarter, but political understanding, good management, and focus on public values and economic gain are necessary too. Bouckaert and Van de Walle (2003) emphasized that trust and satisfaction belong to necessary indicators of good governance. However, they are not sufficient because the government-citizen interaction and many other internal and external factors play an essential role as well.

Three pillars of smart governance identified by the analysis of the literature summarized in Table 1 are participation, transparency, and 3Es. 3Es stands for the economy, efficiency, and effectiveness, as described by DFID (2013), Hu et al. (2016), and OGCR (2017). 3Es were used by Hu et al. (2016) to evaluate the transformation of selected cities towards eco-cities. The **3Es of management** represents the concept of transforming inputs into expected results. Economy means the lowest possible expenditure, efficiency means achieving the maximal outputs for minimal money, and effectiveness expresses the degree of progress towards the set of objectives. Together they set criteria for smart spending of public money.

Transparency is highly related to the 3Es principle. All activities, especially spending public money, should be clear and transparent. There is another dimension in the transparency concept, which is the subject of interest of the research community and even public, it is openness of data. Cities are owners of a high amount of data that can be freely available to everyone, without restrictions from copyright, patents or other mechanisms of control. Transparent governance means enabling citizens to access the documents and proceedings of the government to allow for effective public oversight (Lanthrop and Ruma, 2010). Support for transparency by open data has increasing importance (IBM, 2013; Lee et al., 2014).

Participation means that citizens, businesses, NGOs, and other parties can participate in smart city development processes. Participation can take many forms. Cardullo and Kitchin (2017) reworked Arnstein's (1969) ladder of participation by the addition of the ninth rung (choice) to the level of participation to explain how participation can manifest in smart cities. The final model contains Manipulation, Therapy, Choice, Information, Consultation, Placation, Partnership, Delegated Power, and Citizen Control. Manipulation and Therapy represent non-participation; the citizen is only a passive recipient of services. At the Choice level citizen has the right to choose what service to use. At the Information level citizen gets the information, Consultation gives one the power to express his opinion, and Placation offers him the possibility to suggest new ideas. The top three levels empower

citizens to be real contributors. The Partnership means co-creation, Delegated Power means decision-making, and the topmost Citizen Control passes all power to citizens.

3 Smart City Shaping Model

All principles revealed by the analysis of definitions and described in the previous text are incorporated in the Smart City Shaping Model (SCSM) depicted in figure 1. Pillars, holding the top, represent described principles. At the top, results of the shaping process can be found: smart services (services that respect natural resources and provide actual data gathered by sensor devices). The smart services are visible to all stakeholders to be used and evaluated by them.

On the other hand, there is something not visible, although it has a significant impact on the formation of smart cities. It is an ability and willingness of individuals, organizations, and the government to behave according to smart principles. Implementation of smart services needs the support of providers and future users; therefore, it is necessary to change the way of thinking and learn new things. Willingness, in this model, means that all stakeholders want the change or at least do not sabotage it. Ability encompasses different views. At first, it is the knowledge about the existence of particular service and available options. Second, it is the knowledge on how to implement it and use it.

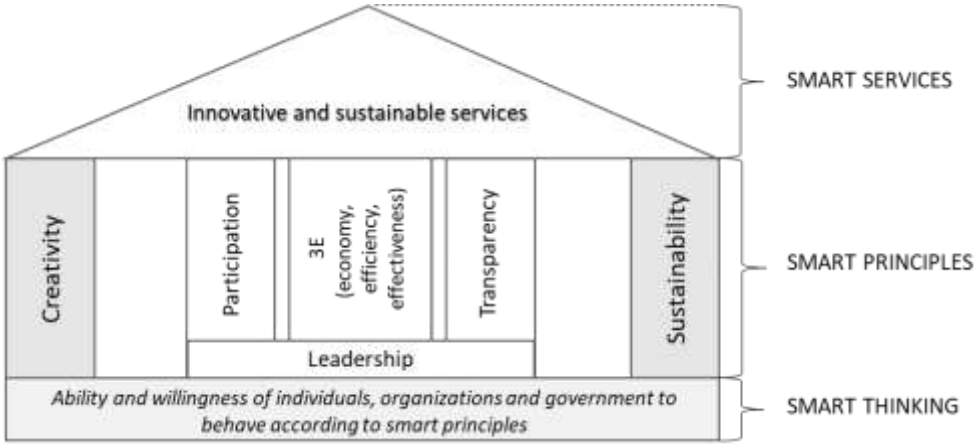

Figure 1. Smart city shaping model (SCSM)

Citizens in this model have two roles – contributor and recipient. In the role of **recipient**, citizens consume smart services and get information. In the role of **contributor**, citizens act mainly at the lowest level. If they are ready and keen to try new services, these services would be successful. At the level of principles, a citizen can take leadership, express opinion, participate in decision-making, etc. At the top level, services are in use; thus, a citizen can evaluate them and act as a live sensor.

4 Citizen reporting on issues of public infrastructure (CRIsPI)

The previous chapter revealed that participation is one of the main principles of a smart city formation. Participatory technology thus becomes a vital game-changer that could bring a real citizen-centric approach into smart cities. One such participatory technology is citizen reporting on issues of public infrastructure (CRIsPI). This technology is part of an information system that helps people to report problems in their neighbourhood. The amount of literature about this type of technology is quite extensive. The problem is that almost every author uses his or her name for it. Some of them use broad term Citizen Relationship Management (e.g., Vaerst, 2015; Hartmann et al., 2017), another used 311 number as the name for all channels to report the issue (e.g., Clark and Shurik, 2016; Lu and Johnson; 2016; Nam and Pardo, 2014), and the rest use names that are descriptive and explain the purpose of the technology (e.g. Tsampoulatidis et al., 2013; Blecic et al., 2013; De Filippi, 2016). In Kopackova et al. (2019) can be found a complete comparison of different names as well as the derivation of the CRIsPI abbreviation.

Citizen reporting means that citizens actively report some incidents or issue they witnessed. Different urgency of such reports distinguishes emergency and non-emergency incidents. Although there can be emergency issues on public infrastructure as tree or lamppost fallen on the street, the technology described here as CRIsPI falls into non-emergency reporting. It comes from 311 hotlines introduced in many US cities to report non-emergency incidents.

Those incidents or issues can be, e.g., damaged benches, mess, broken pavement, uncut grass, landfills, potholes, broken lights, or abandoned vehicles. These issues lower the quality of life in the city, but they are not life-threatening. Due to this fact, citizens can have more options on how to report them. Besides phone calls, they can use e-mail, electronic forms, webGIS, social networks, or mobile applications. The city can use either one or more channels for reporting. Each type has its pros and cons considering costs, usability, availability, or the structure of data.

A phone call is the easiest way to report the issue, but at the same time, there must be someone hearing and processing the call. It means that either city deploy hotline (costly solution) or citizens can report only in working hours, which downsize the usability of this channel.

All other channels of CRIsPI technology are asynchronous, which means that the presence of someone on the city side in real-time is not necessary. The environment of e-mail is well known for citizens; moreover, they are not restricted in the form it has. On the other side, the unstructured form of the report makes processing much tricky. The problem with the structure of data is better handled by electronic web form, webGIS, and mobile application because the structure of the report is predefined. Two latest forms of reporting also bring other advantages. WebGIS brings the possibility of geolocation and displaying reports on the map. Mobile applications allow users to add a photo of an issue right from their phone or use GPS location to locate the issue.

On the other hand, not all citizens have smartphones, and some of those who have it are not familiar with new applications. Another option is the use of social networks. Cities can use this channel to get reports in the form of messages. The added value of this type is using likes as an indicator of the relevance and importance of the issue.

Almost all cities face the question of what type of CRIsPI technology to implement. The typical scenario is that city representatives search for possible solutions and compare them to identify which of them use cities of similar size and conditions. Next, they identify the availability of financial resources. Then they select an appropriate solution. However, this practice conceals the danger that citizens would not accept the selected solution; thus, CRIsPI technology would not be successful. This is the reason why citizens should be given the possibility to choose the features available in the CRIsPI tool.

5 Engagement of future users

Participatory design (PD) is a research approach that emphasizes users' needs in the system development process by the active engagement of users. PD, as a research discipline, was born as a response to the changes in work systems. These systems employed more and more computers into the work routines of an end-user who had no chance of how to influence the design as controlled by the management. The history of PD started in Scandinavian countries and dated back to the seventies (e.g., Bjerknes, Ehn & Kyng, 1987; Greenbaum & Kyng, 1991; Schuler & Namioka, 1993). Kensing and Bloomberg (1998) explain: "in spite of the results of these early projects, workers continued to find it difficult to argue for alternative ways of using technology, in part, because management's goals and strategies often were built into the new systems and were reinforced by organizational distributions of power, making it difficult to alter the technology to fit workers' needs and interests".

Recent PD research is based on two assumptions, one practical and one democratic: 1) people play a critical role in design by being experts in their own lives, and 2) people who are affected by decision or event, should have the opportunity to influence it (Namioka, and Schuler, 1990; Schuler & Namioka, 1993; Halskov, & Hansen, 2015). An important PD aspect is that users actively contribute to analysis, design, prototyping, and implementation of an information system (Kensing and Bloomberg, 1998). During each phase, different methods can be used to identify how to engage users (e.g., ethnographic work, ideation, reviews, workshops, prototyping).

The term co-design is mostly accepted as a successor to the PD concept, but it misses grounding in theory, so we stick to the PD concept. Another related concept is user-centered design, which originated in the 1980s and became widely used after the publication of the book, User centered system design: New perspectives on human-computer interaction (Norman & Draper, 1986). Norman's work emphasized the need to fully explore the needs and desires of users and the intended uses of the product. The need to engage real users, often in an environment where they would use the proposed product, was a natural evolution in user-centered design. Users have become a central part of the development process.

Although the user-oriented design and participatory design have a common basis, and the needs of the users overlap in many areas, there are still some differences. The user-oriented design does not necessarily require direct user participation. User quality can also be achieved in other ways, for example, by following specific ergonomic rules or with expert-verified heuristic criteria. The difference can also be seen in the way users are involved. The user-oriented design usually engages users in the final design phase, i.e., testing. In PD, users are involved in all

phases of the design process, participating in the planning, goal setting, design, and testing. User-oriented design can be considered as a set of methods for designing IS that meet the requirements of users. Participative design is a subset that requires direct user involvement.

This article deals with the direct user involvement of young people in prioritization of requirements on the CRIsPI tool to reveal what features are essential for this group.

6 Prioritization of requirements

IS design needs a thorough specification of requirements to deliver a solution that is accepted by users. Requirement engineering (RE) is the process that leads to the specification of requirements. Prioritization of requirements, together with elicitation, analysis, and validation, is part of RE. Prioritization is an activity where the main features are selected to be available in the system. There are two main reasons for requirements prioritization. At first, it is the necessity to differentiate between more possible alternative solutions. The second reason is a constraint in time and resources.

The process of prioritization would comprise as many stakeholders as possible because they usually do not share the same view on the system. For example, end-users provide essential information about the user value, and developers are better suited to deal with the technical details, whereas financial personals can estimate the costs, budgets, and related risks (Davis, 2003; Khan et al., 2015). Moreover, the customer who pays for the system and the end-user may not be the same entity. Thus their priorities can differ. Due to this fact, it is highly advisable to engage end-users in the prioritization process together with customer (Berander, 2004; Regnell et al., 2001).

Existing literature on the prioritization of requirements offers a vast pool of methods and techniques. For example, a systematic literature review (Achimugu et al., 2014) evaluated 73 studies and revealed 49 prioritization techniques. As the most cited were: Analytic hierarchy process (AHP), Quality functional development (QFD), Planning game, Binary search tree, and $100 cumulative voting. However, according to this research, most of the techniques suffer by high computational complexity and bad scalability, which are the reasons that these techniques are often not implemented for real-life scenarios (Achimugu et al., 2014; Sher et al., 2014).

The design of IS in the public sector (e-government services) is challenging due to the number of stakeholders with different points of view (e.g., citizens, employees, administrators, politicians at all levels). Politicians and administrators usually have enough power to influence the design, whereas employees and citizens have only exceptionally a decisive say in the IS design. E-government services that are obligatory for citizens can be designed in this way because the possibility of resistance is low. However, optional e-government services need a high level of acceptance, thus the voice of citizens, as future users, should be heard. CRIsPI is such an optional service that needs citizen acceptance. This article focuses on the methods that would be appropriate for citizen engagement into the prioritization process according to five evaluation criteria (the ease of preparation of the questionnaire, the ease of evaluation for the respondent, the ease of processing the data collected, selectivity of the method, and the ability of a method to distinguish requests that the user does not want).

7 Methodology of research

This chapter explains the design of the case study covering the process of prioritization of CRIsPI requirements by young potential users. In total, 155 respondents (students) participated in the study. This study had two objectives; 1) identification of most important CRIsPI features that would motivate respondents to higher participation, and 2) comparative analysis of six prioritization methods. To fulfil these objectives, we assigned five easy-to-use methods (Likert scale, Kano, Ranking, $100, and Top Ten) to second-year students (30 participants per method) and AHP method to fourth-year students (5 participants). The list of requirements for prioritization was the same for all methods. Justification for the study lies in the effort of some Czech cities to enrich the channels of citizen reporting to engage more citizens, especially the young ones. The participation of this group of citizens is usually very low.

The study was held in the spring of 2019. In January, preparatory work on the project started, namely planning, setting objectives, and selection of the respondent group. Students were involved as respondents in the study. The first meeting with them took place in February. They learned the essential facts about CRIsPI technology and checked what tools are available in selected cities. Most of the respondents never used this type of technology nor reported anything to the city government. This activity was, therefore, necessary to make sure that respondents understand the functioning of the CRIsPI technology, and they would be able to participate in the prioritization of requirements in the next round.

In February, the list of requirements for prioritization was prepared. Representatives of the University of Pardubice (researchers), representatives of selected cities (local government employees specialized in IT), and representatives of non-profit organization Open Cities, who met at the conference "Public administration practically" were involved in the process of requirements elicitation. At first, we identified the whole set of decision criteria on CRIsPI technology (quantity and types of information channels, solution acquisition and management, feedback on the state of the report, possibilities of connection of information channels to internal IS, and the level of anonymity of the reporter). At second, we extracted criteria eligible for end user's evaluation, that is why we intentionally omitted requirements on costs, compatibility with the legacy system, transfer of data, etc. Then we specified these criteria in more detail and reformulated them into twenty requirements. Elicitation of requirements was a demanding task due to three facts. At first, the list had to be concise. Second, non-functional and process requirements had to be incorporated as we elicited requirements on the whole system. Third, the list should contain features of both types of technology (web-based and mobile-based) to see what type is preferred and why. The final list containing 20 requirements is depicted in table 2.

Table 2. Description of elicited requirements

ID	Parent classes	Requirement	Description
R1	Method of entering reports	Possibility of a user to log-in to the system	The logged-in user gets individual feedback (e-mail, phone, in-app after login)
R2		Possibility of anonymous reporting	The user does not need to be logged in to send a report
R3		Easy entry of the report	The entry of the report is precise and fast with a minimum of clicks
R4		Entering of a report from a web application	The user uses the application in the internet browser
R5		Entering of a report from a mobile application	The user uses the mobile app on the smartphone
R6	Properties of CRIsPI tool	Simple operation of the CRIsPI tool	Users evaluate the application environment as understandable with clear navigation
R7		Reliability of CRIsPI tool	System failures are up to within hours
R8		The ability to search reports in the list (map). by type or location	The user can find out if someone has already reported the problem or what types of incidents are reported
R9		Ability to add a photo	User can add a photo as attached file in web application
R10		Ability to add a photo from a mobile phone	The user can add the photo directly to the mobile app. without having to download the photo and upload it to the web application
R11	Localizing the issue	Word entry of location	The user describes the location of the incident/issue
R12		Entering a location by selecting on the map	The user selects the location of an issue by clicking on the map
R13		Automatic positioning	Location of the incident is inserted into the report based on the GPS of the smartphone
R14	Overview of submitted reports	View the status of all reports in a list	The user can see how reports are handled in the form of a list
R15		View the status of all reports in a map	The user can see how reports are handled in the form of a map
R16		View the status of all reports as open data	The user gets an overview of incidents and their states in a machine-readable format
R17	Local government activity	Individual information about the status of his/her report	The user receives feedback either via e-mail, phone or in the app after logging in
R18		Report status information within one week	The user receives feedback within a week
R19		Repair of a reported issue within a week	The remedy took place within a week
R20		Transmitting the report to the responsible authority	The authorities will hand over the report to each other, the citizen no longer needs to develop another activity, only be informed of the status change

Non-functional requirements in the list are represented by R3, R6 (usability), and R7 (reliability). Requirements R18, R19, R20 are process requirements on the functioning of the whole system. Other requirements are functional, whether on a web-based solution, mobile-based solution, or both. Requirements R10 and R13 serve as the verification of R5, which is the entering of a report from a mobile application. If most respondents select R5 without prioritization of R10 or R13, then it means that respondents require mobile app only because they are used to use their mobiles more than computers. However, they do not need a specialized mobile app as a CRIsPI tool because all other functions are present even in a web-based solution, which can be used on mobile phones too.

Most prioritization methods do not need a division of requirements into a hierarchy. However, the AHP method is time-consuming for more than seven requirements; therefore, we divided them into parent classes:

- the method of entering reports – R1, R2, R3, R4, R5;
- properties of a CRIsPI tool – R6, R7, R8, R9, R10;
- the way of localizing an issue – R11, R12, R13;
- overview of submitted reports – R14, R15, R16;
- local government activity – R17, R18, R19, R20.

The next step was the selection of prioritization methods. The aim was to evaluate methods with significantly different characteristics that are frequently used in the requirements prioritization process. In total, six methods were evaluated. Two methods are based on an individual evaluation of each requirement (Likert scale, and Kano model), which means that the evaluation of each requirement is not influenced by the evaluation of others. The evaluation is more comfortable as the respondent is not required to make a comparison, but it brings the risk of insufficient selectivity of the method. It is especially true for the **Likert scale,** where respondents can choose all requirements as being the top priority. On the other hand, this is the most common type of questionnaire so that the lowest demands on respondents can be expected.

Kano model also evaluates each requirement separately, but it brings more information from the respondent. Respondents answer two questions for each requirement - how you would feel if the CRIsPI tool: 1) would have this feature, and 2) would not have the feature. The evaluation for each part is similar to the Likert scale. However, by a combination of these two values requirements can be ranked into six categories: 1) attractive, 2) must-be, 3) one-dimensional 4) indifferent, 5) questionable, and 6) reverse (Kano et al., 1984). Kano model is mostly used in TQM (Total quality management), where only the first four categories are evaluated. However, in this type of requirement prioritization, we can use all of them. If respondents evaluated the requirement as questionable, it could mean that they did not understand the feature. Reverse requirements mean that users do not want them at all. The basic requirements are those in the must-be category. Users are not satisfied without them, but improving them would not bring higher satisfaction. Fulfillment of one-dimensional requirements helps to enhance satisfaction and vice versa. Attractive features lead to better satisfaction, whereas it is not expected to be in the product. For indifferent requirements, users do not care; therefore, they can be omitted. In comparison with the Likert scale, respondents need to answer double the number of questions.

Four other methods are based on the comparison of requirements. The first of them is **AHP**, which introduces a pair-wise comparison between requirements. Respondents are asked to compare how much more is one requirement important than others. During the evaluation, respondents need to stay consistent, which makes a comparison of many requirements demanding. 20 requirements need 190 comparisons ((R*(R-1))/2). If requirements are divided into meaningful parent groups, the complexity of the task is lowered. Therefore, we have created five parent groups, as described earlier. By this adjustment, the complexity of the task dropped to 39 comparisons. Now the task is easier, but still, we expect this method to be the most demanding one.

The second method is **Ranking**. Respondents are asked to rank all requirements from the one being the most important to the twentieth requirement being the least important one. This type of evaluation requires respondents to make a comparison in their mind and then set the ranking. It is easier if there is some tool that checks for double entry of the same ranking and missing values. Ranking can sort requirements according to preferences, but it does not force respondents to select only desired ones.

The third method, **Top ten**, restrict respondents in their selection. This method is useful if only a small set of requirements should be evaluated. In this case study, we used the adjusted Top ten method with a ranking of ten selected items. The process of respondents' evaluation started with a selection of the ten most essential requirements. It was followed by their ranking.

The last tested method is adjusted cumulative voting - **$100**. This method gives respondents the highest level of freedom. Respondents got a budget of virtual $100 with the explanation that they can spend the budget on as many features as they want with the only condition of spending the entire budget. By this method, respondents can omit as many features, which they do not care, as they want. Only those requirements that respondents perceived as necessary got any budget. The results of this method show us if respondents prefer more features or if they are focused only on some of them.

Questionnaires for each method were prepared in MS Excel during March 2019. The pilot evaluation involved five respondents, with the purpose to reveal problems in understanding of the questionnaires. Except for the Likert scale and Kano method, all others were sources of some problems. Respondents found it challenging to remember what values they assigned in ranking and the top ten methods. By using a $100 method, users requested to see the sum of already spent money. The main problem was caused by the AHP method. The first part of the problem was that respondents complained that it took a long time. The second part of the problem was the quality of the completed data. Respondents failed to maintain consistency in responses, which is crucial for this method.

Modification of questionnaires included adding control fields for ranking, top ten, and $100 method. According to the AHP method, we were considering removing it, but this is a well-established method in requirements prioritization. That is why we only added a consistency ratio field into the questionnaire to check the consistency. Moreover, we have decided to engage only those students who passed the subject Theory of decision-making to this part of the process of evaluation. It was the smallest group in the case study (5 students).

Prioritization of requirements was held at the end of March. Students evaluated requirements according to an assigned method and filled three more questions: 1) duration (start and finish time), 2) if they have ever reported an incident, and 3) if they would be motivated by a modern CRIsPI tool to higher participation.

8 Case study results

The study is split into two parts to follow two given objectives of the article.

8.1 Research question one – what CRIsPI features would motivate young citizens for higher participation

The first part of the results considers the search for requirements that respondents prefer regardless of method. To get such results, a common ground that distinguishes preferred requirements was established. Table 3 contains conditions for classification into preferred requirements for each method. Results of four methods are transformed into z-score, whereas the Kano model is represented by satisfaction and dissatisfaction coefficient, and AHP by the average weight of each requirement. Using z-score gave us the possibility to compare results with incomparable values but only for those methods, where it is meant to determine the mean and variance. Top ten and $100 methods assign higher values to preferred requirements. This is why we can select only items with a value higher than zero. On the opposite, ranking and Likert scale uses lower values for more preferred requirements. Kano method uses a specific process of evaluation of results; therefore, we used two coefficients. The satisfaction coefficient indicates the extent to which satisfaction increases if a requirement is met. The dissatisfaction coefficient explains how much respondents would be dissatisfied if the requirement is not met. For the AHP method, we use average weights calculated for each requirement (higher value means higher preference).

Table 3. Conditions for classification into preferred requirements

Method	Value	Preferred
Top ten	Z-score	> 0
$100	Z-score	> 0
Ranking	Z-score	< 0
Likert scale	Z-score	< 0
Kano	Satisfaction coef. (SF)	> 0.5
Kano	Dissatisfaction coef. (DF)	< -0.5
AHP	Average weight	> 0.05

The selection of preferred requirements was divided into two rounds. At first, we selected requirements that would cause high dissatisfaction if they are not fulfilled (Kano DF < -0.5). Failure to meet these requirements would lead to rejection of the CRIsPI tool. Three requirements fell into this selection R3, R6, R20. Two of them (R3, R6) are usability requirements, and one is a process one (R20). This result is in accordance with Scherer et al., (2010) „usability of e-participation platforms is of significant importance for the success of the project… e-participation features must base on easy-to-use tools in order to avoid usability flaws that could discourage people from online participation “. The importance of these three requirements was confirmed by all other methods. The result is understandable because citizen participation is a voluntary act that people are only willing to do so if it is easy for them. The mode of operation is not as important.

In the second phase of the selection of preferred requirements, we have chosen items that were preferred at least by four methods. Five requirements appeared in this phase: R5, R8, R10, R13, and R19. R5 is the use of the mobile application, which is confirmed by R10 and R13. This means that the preference of the mobile app is justified, and young citizens are aware of the benefits that are specific for mobile apps. R8 explains that respondents request search function to see if the issue was reported before, which is almost the only way how to prevent double entry.

The last selected requirement was R19, which requires repair of a reported issue within a week. This is an expected requirement, but it also makes the evaluation of the CRIsPI tool difficult. CRIsPI tool itself is intended for processing reports, so the measure of its success should be the processing time of response. Repair time is not dependent on the quality of the CRIsPI tool but the solving capacity of the maintenance team. However, citizens do not care about the way of processing the issue. They want it to be repaired; otherwise, they would not use any reporting tool. This is an important fact that emphasizes the complexity of the success of the CRIsPI tool. The introduction of new forms of the CRIsPI tool has to be accompanied by the enhanced solving capacity of the maintenance team; otherwise, the investment would be wasted. The appendix contains the results of all methods.

Besides the evaluation of preferred requirements, described methods also bring the possibility to select items, which users do not want. Kano model distinguishes reverse items, which existence is perceived negatively by respondents, whereas a $100 method use zero for requirements, which users do not see as important, and it is up to them to select how many zeros they assign. The slightly different option offers a Likert scale. Respondents can answer strongly disagree with the presence of the feature. Table 4 shows which requirements are perceived as unwanted. Likert scale method revealed only two unwanted items, R16 and R2. R2 is questionable, as other methods did not prove such a negative vote. Moreover, other methods evaluated this item as desirable (see appendix). On the other side, R16 received negative votes even by other methods. R16 relates to the open data format of reports. Although this feature is recently emphasized in the research literature (e.g., Walravens, 2015), our students had no opportunity to use them yet; therefore, they do not see them as necessary. R11 is another negatively perceived item. It is the word entry of location, which is the most difficult way to locate the issue in comparison with a location on the map and automatic positioning by GPS.

Table 4. Requirements evaluated as unwanted

	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20
100$ - no. of zeros	13	7	4	4	6	5	10	6	5	6	14	5	6	10	10	12	6	14	3	5
Kano - reverse	3	2	0	1	1	0	1	2	1	0	5	1	3	1	1	6	3	2	0	1
Likert scale - strongly disagree	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0

This part of the case study also included the question on the motivation of respondents to higher participation if they had a modern CRIsPI tool. Respondents answered two questions: 1) have you ever reported an issue on public infrastructure, and 2) would you be motivated for higher participation by the modern CRIsPI tool. In figure 2, there are two charts. The first one shows past reporting activity, which is very low (10%). In contrast, the second chart shows that almost 80 % of respondents strongly agree or agree with higher participation if they could use the modern CRIsPI tool. Although the intention is not the same as actual use, which is dependent on other factors, we still can take these results as a positive outcome of the prioritization task. At least, respondents got familiar with CRIsPI tools, so they would know how to use them when they need it.

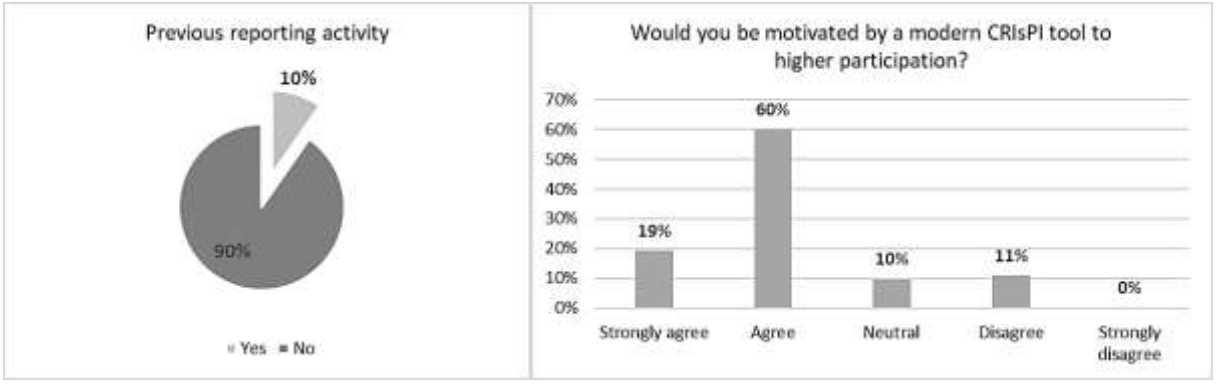

Figure 2. Respondents' past and expected reporting activity

8.2 Research question two – a selection of the suitable prioritization method to engage citizens

The second part of the case study considered an evaluation of methods as being suitable for citizen requirements prioritization. During the discussions with city representatives, we have obtained five criteria - ease of preparation of the questionnaire, ease of evaluation for the respondent (median), ease of processing of collected data, the

selectivity of the method, and the ability of a method to distinguish an unlimited number of items that the user does not want. Table 5 shows the characteristics of all methods according to defined criteria.

Table 5. Evaluation criteria values for selected methods

	The selectivity of the method	Ability to distinguish an unlimited number of unwanted items	Ease of preparation of the questionnaire	Ease of evaluation for the respondent	Ease of processing of collected data
AHP	Preference expected	No	3:27:00	0:22:50	0:13:30
Kano	Gives the possibility but do not force	Yes – reverse requirements	0:12:30	0:05:56	1:12:00
Likert scale	Gives the possibility but do not force	Yes – strongly disagree	0:07:00	0:05:02	0:28:00
Ranking	Forced preference	No	0:08:30	0:07:57	0:20:00
Top ten	Forced preference and selection of a given number of items	No	0:07:30	0:06:56	0:21:00
100 $	Preference expected	Yes – items with zero budget	0:06:00	0:05:23	0:14:00

The most important criterion is the ease of evaluation for a respondent, measured by time spent on the task (0.428). The simplicity of the task influences the willingness of respondents to be a part of the process. Column five in Table 5 represents the median of task duration. Each respondent wrote down, start and finish time individually, and duration was calculated after that. Figure 3 shows the box plot chart depicting task duration for five methods. AHP method was not included in the chart as the results are much higher, so it would distort the chart. Moreover, only five respondents were involved in this method. It would bring another source of incomparability. Results show the lowest variation of results for the Kano method and the highest for ranking. The methods, where respondents did not have to make comparisons between requirements, proved to be faster with a lower variation. Results of methods, which require comparison, are dependent on the higher mental capacity of a respondent. This causes the variation in duration. According to displayed results, Ranking was the most demanding method unless we count for AHP, which is out of the scale. The reason for this result is a large number of requirements that the respondents had to compare with each other. If the duration of the task were the only criterion for selection, we would recommend Kano, Likert scale, or $100 method.

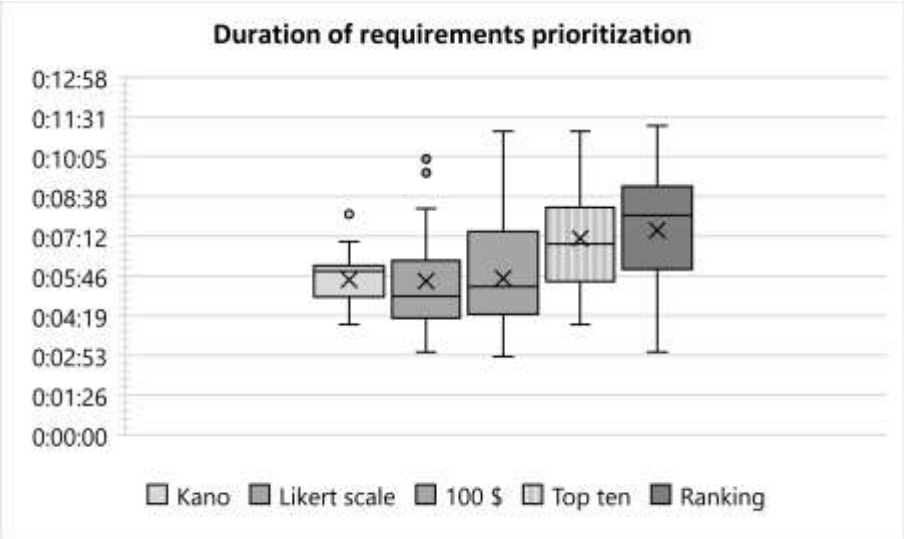

Figure 3. Ease of evaluation for the respondent measured by the duration of the task

The duration of the prioritization task is the most important but still only one of five criteria. The selectivity of the method was chosen as the second most important criterion (0.233). This criterion examines how much it is possible to apply control mechanisms into the questionnaire assuring that respondents make a selection.

Respondents sometimes tend to choose all requirements as desirable, but it does not help in the prioritization process. That is why the selectivity of the method is so important. According to this criterion, methods were divided into three groups: 1) methods that do not force respondents to select (Kano and Likert scale; weight 1), 2) methods that do not force but expect selection ($100 and AHP; weight 5), and 3) methods that force respondents to select (Ranking and Top ten; weight 10). Ease of preparation and processing of questionnaires obtained the same weight (0.141). These two criteria relate to the necessary effort on the public administration side. The last criterion with the lowest weight is the ability of a method to distinguish an unlimited number of items that the user does not want (0.057). In contrast with the selectivity of the method, which is about must (if respondents must make a selection), this criterion is about the possibility (if respondents can select unwanted items). It shows the freedom of choice for respondents. For example, Top ten method forces respondents to make a selection, but it is not possible to influence a number of unwanted items. Table 6 shows criteria weights, weighting per method and criterion, and total weights for each method. The $100 method has obtained the highest score. This method is sufficiently easy for respondents and public administration, the selectivity of the method is at the medium level, and it brings great freedom of choice to respondents.

Table 6. Results of the evaluation process

Criteria weights	Criteria	Ranking	Likert scale	Top ten	100 $	Kano	AHP
0.141	Ease of preparation of the questionnaire	0.182	0.221	0.207	0.258	0.124	0.007
0.428	Ease of evaluation for the respondent	0.145	0.229	0.166	0.214	0.194	0.050
0.141	Ease of processing of collected data	0.171	0.122	0.163	0.244	0.047	0.253
0.233	Selectivity of the method	0.313	0.031	0.313	0.156	0.031	0.156
0.057	Ability of a method to distinguish unlimited number requests that the user does not want	0.000	0.333	0.000	0.333	0.333	0.000
	Total weights of methods	**0.185**	**0.173**	**0.196**	**0.218**	**0.134**	**0.095**

9 Conclusion and discussion

The main goal of this article was to find out what features of CRIsPI technology would attract young citizens to become active participants. Results of the prioritization distinguish requirements that respondents perceive as highly relevant, and those they do not want. The essential requirements revealed in this study consider usability and process issues. Respondents require easy-to-use tools and positive feedback from the local government. They are willing to help and participate in issues of public infrastructure but only on the condition that it is fast and straightforward. The second condition is that they can see the results of their effort (repair of the reported issue). According to the technical solution, they prefer mobile application and want to see what issues were already reported. The limitation of the results is based on the selection of requirements. Other cities can use different requirements with different specifications.

This part of the study also considered the intention of respondents to use CRIsPI technology. The results show that intended use reaches almost 80 % after prioritization in comparison to 10 % of previous reporting activity. Such results are promising but with limitations. At first, we compared actual use with the intended use, which is not the same. It would be necessary to run a long-term study to see if actual use grows in this group. Second, a group of respondents was quite small to generalize the results. Another limitation is anchored in the process of evaluation. We used two phases in the evaluation process: 1) introduction of CRIsPI technology and checking of available tools in selected cities, and 2) prioritization of requirements. That is why we are not able to distinguish if the rise in the intention is due to the introduction of CRIsPI tools features or the process of prioritization. It would be useful to divide respondents into two groups - one passing only the initial phase and the second one passing both phases. We did not choose this option because of the low number of available respondents.

Prioritization of requirements can be based on different methods. Therefore, we tested six methods to be suitable for requirements prioritization by citizens. Our results show that the adjusted $100 method is sufficiently easy for preparation and subsequent processing. The evaluation with this method is quite fast, and respondents are free to choose as many or as few requirements as they want. On the other side, the AHP method, which is the most cited in prioritization literature, is not appropriate for this task, because it places high demands on respondents (time,

consistency). Limitations of the result cover a low number of respondents, a defined set of criteria, and a set of weights of criteria. Other cities can set different weights or prefer different criteria.

The results of the study provided a view on the requirements of young people according to one type of participatory technology. This view suggests that young people are able to participate in prioritization of requirements and thus express their needs and desires. However, a group of respondents was composed of university students that are well-educated and more technologically savvy than the average young citizens. This fact may limit the conclusions; on the other hand, it opens the space for future research.

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Appendix. Results of requirements prioritization

ID	100$	Ranking	Likert scale	Top ten	Kano - SC	Kano - DC	AHP
R1	-0.265	0.150	-0.098	-0.437	0.556	-0.222	0.017
R2	0.027	-0.132	0.329	0.215	0.571	-0.500	0.017
R3	0.418	-1.698	-0.909	1.067	0.567	-0.633	0.051
R4	0.391	0.222	-0.098	-0.330	0.414	-0.241	0.043
R5	0.295	-0.648	-0.399	0.303	0.828	-0.241	0.015
R6	0.360	-0.972	-0.998	0.402	0.400	-0.667	0.094
R7	-0.371	0.163	0.661	-0.846	0.276	-0.276	0.024
R8	0.299	-0.294	0.168	0.151	0.536	-0.250	0.039
R9	-0.354	0.453	-0.156	-0.727	0.517	-0.138	0.042
R10	0.039	-0.148	-0.455	0.819	0.700	-0.300	0.116
R11	-0.562	0.600	0.481	-4.580	0.083	-0.250	0.028
R12	0.049	0.113	0.199	0.113	0.586	-0.310	0.038
R13	0.244	-0.013	-0.377	0.073	0.346	-0.423	0.118
R14	-0.283	0.351	0.122	-0.913	0.414	-0.276	0.054
R15	-0.462	0.243	0.232	0.265	0.379	-0.310	0.096

R16	-0.746	0.947	0.772	-0.936	0.261	-0.087	0.016
R17	-0.065	0.276	-0.359	-0.017	0.607	-0.393	0.042
R18	-0.429	0.827	0.031	-1.595	0.333	-0.444	0.019
R19	0.358	0.040	-0.045	0.188	0.533	-0.367	0.046
R20	0.068	-0.815	-0.433	0.472	0.533	-0.567	0.085