Facilitating Mixed Reality Public Participation for Modern Construction Projects: Guiding Project Planners with a Configurator

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Abstract. Digital public participation formats are an emerging and accessible way to involve diverse groups of citizens in construction projects in their local area. Particularly, mixed reality can help project initiators to visualize the planned changes to the city landscape in an easy and understandable way, enabling people to participate in a creative manner. However, this technology is challenging for most project initiators, as it requires an extensive technical and/or domain experience. Besides that, specialized hardware and experienced staff is required. An easy on-boarding process, which introduces mixed reality step-by-step and offers assistance by external service providers could promote both adoption and usage. In this paper, we present the design process and resulting concept of a configurator for a public participation platform, that aims to guide initiators with different levels of technical knowledge. Besides detailing the design and development process of the prototype, we will present the preliminary results of our evaluation. The interview partners provided positive feedback on the usage of our configurator. Moreover, different approaches are necessary for the public and private sector when configuring and purchasing their participation solution. Finally, we highlight areas that are still in need of further work, such as the compliance with the regulations for public institutions and address further promising areas of research.

Keywords: Public participation · Mixed reality · Construction projects · Product configuration

1 Introduction

Eliciting citizen's participation in public projects has remained a challenge. Although construction projects and urban planning directly affect everyday life of many individuals, it is difficult to motivate people to engage with the projects more in-depth [1].

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Visualizing ideas using augmented reality and virtual reality seems to be a promising approach to arouse interest and provide information, as well as to foster participation in the form of ideas and discussion about a project [2, 3]. City planners and project initiators are often faced with the complex task of delivering different types of information to distinct audiences [4] that need to be made available. Participation requirements may vary across projects, initiated by the same client. For instance, the extent and kind of information to be provided, and whether citizens ought to be involved in a consulting role or rather as a customer might differ. Participation is seen today as a spectrum [5] of different activities that ranges from informing to empowering citizens by placing decisions in their hands. Although several approaches have been highlighted for modular and configurable e-participation architectures [6, 7], there is a dearth of examples that are suited for construction projects employing visualization techniques such as mixed reality (MR). In addition, although several of these platforms can be customized for different projects, there are few examples that function as a configurator as well as a market place for services and providers in case of insufficient competencies by the initiating institutions. In this paper, we present the concept, design and development of a platform configurator. Project initiators can configure their participation process, customize it by choosing relevant participation modules and features. In addition, they can use the platform to interact with as well as offer interaction opportunities to their target population.

Since MR is still regarded as an emerging technology, the willingness to utilize it is an important factor in our research. The current adoption of MR and more specifically virtual reality (VR) devices is still low, as can be illustrated with the Steam Hardware Survey[1]. According to the reported owner numbers among users of this digital video game store, one of the key target groups of this technology, currently ~2,3% own such a device. This is significantly higher than the adoption in the general US population[2,3], where virtual reality still struggles to gain traction [8]. Accordingly, it must be assumed that less technology-savvy users do not yet have any experience with MR systems, therefore it needs to be introduced to them and its benefits must be demonstrated.

Additional to a flexible configuration, project initiators can be supported with external service providers during the configuration process and find support for competencies (such as mixed reality content) that are not readily available. The prototype is developed as part of the research project Take Part[4]. The design process is described in detail, followed by the presentation of the prototype, and an overview of the evaluation by means of qualitative interviews. First results show the need to adopt different on-boarding processes for private and public sector construction projects.

[1] https://store.steampowered.com/hwsurvey (last accessed 2021/06/30).

[2] https://www.emarketer.com/content/us-virtual-augmented-reality-users-2021 (last accessed 2021/10/07).

[3] https://omdia.tech.informa.com/pr/2020-dec/six-and-a-half-million-consumer-vr-headsets-will-be-sold-in-2020 (last accessed 2021/10/07).

[4] https://takepart-projekt.de/take-part/ (last accessed 2021/10/18).

2 E-Participation and the State of Configurators

E-Participation emerged in the 2000s as an interdisciplinary research area in between computer science, information systems, political science and public policy [9, 10]. Our early exploration of the topic took place in the field of various small-scale experiments, local governments and small startups conducted with the involvement of citizens through basic tools, which were often developed only for a specific use case [11]. With the general shift towards a platform economy, the development of e-participation artifacts also shifted towards more elaborate concepts, which were no single purpose tools but suitable to be easily rolled out and modularized by non-experts. The European platforms CitizenLab[5], Adhocracy+[6]and Dialogzentrale[7] are well-known examples based on the described business model and marketed accordingly. These platform services were then adopted by cities like Berlin, Utrecht, Seattle and London. The content is maintained by employees of the respective city and the software is either operated by the cities or the platform providers themselves. In addition, although several marketplace examples exist for shared cloud computing providers, there is a dearth of configurable platforms that are tied to an appstore and a marketplace-like concept for different types of service and content providers [12, 13]. The technological options, therefore, heavily depend on the platform providers and an extension of the existing modules with new functions is not intended.

With the research project Take Part, we would like to propose an e-participation platform that offers more flexibility for the initiators of public participation processes through its configurability. Therefore, we are suggesting the use of a configurator with integrated marketplace for e-participation, where initiators can both select participation modules as well as commission third parties with technical and domain expertise. In our case studies, we examined this marketplace model with particular attention to the integration of MR in e-participation. The basic assumption was that the technical capabilities of these initiators would neither allow the creation of high-quality 3D models, nor the creation of separate MR applications. To allow them to keep up with major shifts in the technological market, like the mainstream use of augmented reality (AR) on smartphones, we propose a collaborative marketplace [14] where external service providers can be hired by the respective initiator itself. Subsequently, those external providers can then create content in the specified format, which is then seamlessly integrated in the existing e-participation ecosystem. Depending on the digital maturity of the project initiator, if 3D models in required formats are available from the design phase, these can be directly uploaded on the system and be prepared for consumption in virtual or augmented reality. In case new models have to be created, suitable service providers can be suggested by the system, which the project initiator can choose from and collaborate with, to create their design alternatives for public participation.

We see an advantage in shrinking the existing interdependence between the cities and the individual companies, by arguing that project initiators could then more easily start a participation process with a small selection of modules and later move on to more

[5] https://www.citizenlab.co/de (last accessed 2021/06/30).
[6] https://adhocracy.plus/ (last accessed 2021/06/30).
[7] https://www.zebralog.de/node/275 (last accessed 2021/06/30).

complex forms of participation (like MR visualizations). Thereby, they would not be committed from the beginning on towards a specific kind of participation process and could respond in a more agile way to the citizens' wishes. A collaborative marketplace could therefore simplify the implementation of e-participation. This flexible and simple on-boarding process could be attractive for project initiators, that first want to get to know the platform and get comfortable with all the possibilities offered. Furthermore, due to the enormous price differences that can arise from the use of MR visualizations, comparing different agencies and configurations at the time of purchase can help local government agencies to be more cost efficient. The design and development process of the configurator with a collaborative marketplace for e-participation will be detailed in the following section.

3 Design Guidelines for the Platform Configurator

In order to develop a configurator for the participation platform Take Part, an analysis of successful, existing configurators was carried out. Patterns applicable to the configuration problem at hand were identified. For this purpose, the technique reverse wireframing [15] was applied. In reverse wireframing, a system, such as a website or an app, is reduced to its elementary structures and elements and all aesthetic designs, images, and content is omitted. Analysis of the desired design is hence possible without visual noise and distractions, since the focus is only on the structure of the system and its elements. With the technique, also used in re-engineering of existing systems and structure, considerable time can be saved in the development of a new system. The tool "Balsamiq" was used to create the wireframes (see Fig. 1).

3.1 Usability Guidelines

To achieve the goal of guided configuration, the configurator should have a good usability [16, 17] and therefore be intuitive and easy to use. To this goal, we derived a number of principles from existing configurators, the criteria laid out by the "Konfigurator-Verzeichnis"[8] and considered similar existing research [18]. The following central design principles resulted from analysis as well as the evaluation of the wireframes:

Navigation. First, the user should be aware at any time in which step of the process they are situated in, what has already been configured, which options are still available and which attributes of the product are being changed at the moment. The various configuration options should be clearly grouped and, if necessary, divided into steps.

Support. Second, to improve support and guidance during the configuration process, descriptive texts in the form of tooltips or info pop-ups can be utilized to guide and support the user. In each step of the configuration, an info button is available. An info pop-up can be opened, to see a description of the current step. However, reading these texts should not be a prerequisite for easy and correct use of the system. The system should assist the user in observing restrictions. These should either be considered automatically; matching

[8] https://www.konfigurator-verzeichnis.de/ (last accessed 2021/06/30).

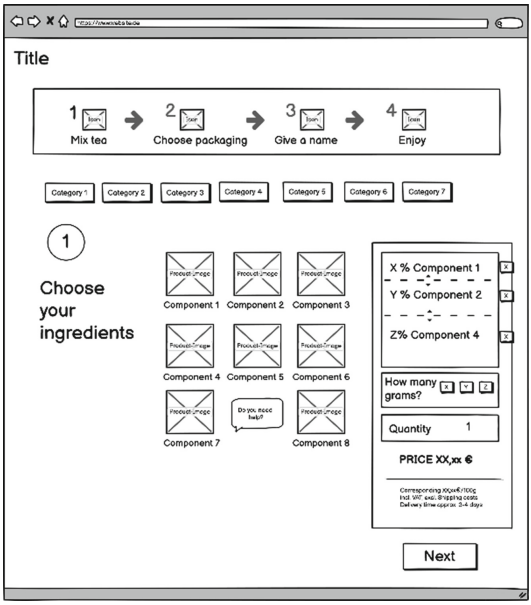

Fig. 1. Mockups using reverse wireframing for the pilot study.

components should only be shown so the user can choose, or a warning message should emerge showing an incompatibility.

Look & Feel. Third, to promote usability, intuitive operating concepts such as drag-and-drop functionalities can be used when appropriate. Another commonly used concept is card design [19–21], where the focus is on the product image and a headline. Further, important information such as the current total price of the configuration, the individual components and important technical characteristics should always be available. In the best case, there should be a list or an information sheet on which the information about the current configuration is displayed.

Short Loading Times. Fourth, short loading and waiting times can have a positive impact on the user experience (UX) in addition to usability. To achieve a short waiting time, data transfer should be efficient. In the configurator, this can be achieved by loading only new page content and keeping the rest of the layout constant. This concept is implemented, for example, in a one-page design, in Progressive Web Apps [22], or a single page application [23].

3.2 Design Dimensions

Decision Support Systems are already extensively researched and sophisticated models exist to represent the use of these systems [24–28]. These, however, are beyond the scope of this research and a simplified model was created instead. This model was based, in addition to the usability findings from the evaluation, on the following design dimensions.

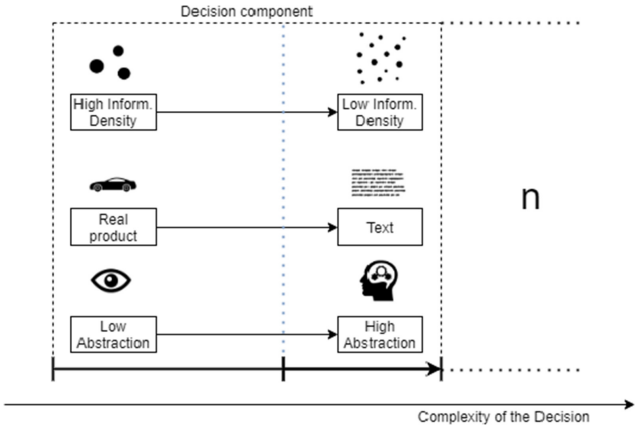

Fig. 2. Design dimensions for user decision complexity.

As illustrated by Fig. 2, a decision consists of one or more decision components that influence it. For example, choosing a set of modules contains multiple decisions about the need of specific single modules. The complexity of a single component is determined by the following dimensions which we applied in our design process.

Information Density: Low - High. The first dimension concerns the presentation of information. It can be decided that the user of the configurator should be provided with as much information as possible on a topic. The more information is offered, the better is the awareness for the topic. However, with more information, cognitive fatigue increases, as the user has to repeatedly decide whether the provided information is relevant to him or not. Hockey refers to this process as "management of control" [29], the decision to do the right thing, which is a major cause of cognitive fatigue. Therefore, the amount of information must be appropriately balanced. In the configuration process, there should always be enough information about a component, an element, a decision step, and the product. However, the user must not be inundated with too much text, whereas product photos are helpful, as they can be easily understood. The analysis revealed that many configurators interact with information tools to provide customers with access to further information if required. This enables non-expert users with a greater need for information to use the configurator better, whereas experts can ignore this functionality.

Product Representation: Textual Description - Real (End) Product.
Another dimension lies in the product representation. The product can be presented to the user in detail. The most accurate presentation is the actual product. For example, in the presentation of a "virtual reality" module, the product can be visualized and presented to the user with VR glasses. This presentation is both time and cost intensive, since technical aids may be required, a demonstration must be possible, or the product might not even be fully developed before a customer places an order. The other extreme is a preview image or textual description of the module. A balance must be found between insufficient product description and marketing cost. The closer the representation is to the real product, the higher the associated cost. For some modules, a demonstration does

not require much effort because it is an available or easily represented software product. This dimension is expected to correlate inversely with information density and abstraction, as an accurate demonstration is more dense in comparison to a highly abstract description of the product.

Decision-making Process: Simple (Binary) - Complex (Non-binary). The problem of making the right decision can be facilitated or encouraged by the complexity of the decision process. The user could be required to make only binary decisions at each step. For example, when selecting suitable components, they could be presented one choice at a time and the user only has to decide whether they are needed or not (yes/no). This, however, lengthens the configuration process by a considerable margin. If several decisions are made in a step, the process shortens but the user has also a higher cognitive load. In summary, the higher the number of decisions in one step and the higher the complexity of each decision, the more complex is the overall decision process. However, in the individualization of a product, the user should also be given the feeling of having a wide range of choices. The number of available options per component should not be too low, but also not too high, as the user could quickly feel overwhelmed [30], whereas a low number may be insufficient for experts. When presented with many configuration options, the user should be supported in the decision-making process by a filter function or automatic preselection. In Fig. 2 this is represented by the number of decision components that are part of a decision.

The dimensions presented were taken into account in the development of designs and the selection of suitable patterns.

4 Platform Configurator Development

After analyzing existing configurators, a process for configuring the Take Part participation platform was developed. The designs and ideas developed were evaluated in a pilot study to determine the most appropriate approaches. The results of the analysis were used to design the process with suitable UI elements and to develop drafts for a prototype. In this section, the different steps and UI decisions made for the configurator that resulted out of the pilot study are described. For the evaluation we chose a combination of a quantitative and qualitative approach. Based on a questionnaire we created polarity profiles and determined the preferred designs. For this we used the "user experience questionnaire" (UEQ[9], short version) and a slightly adapted version of the "system usability scale" (SUS) [31]. Additional to the questionnaire we conducted one-on-one interviews and applied the thinking aloud method [32]. With a few exceptions, the participants were employees of a leading mid-sized software firm and experts in the field of UX and interface design. A detailed summary of the procedure and the results have been published [33]. In the following steps, "user" refers to the project initiator and/or the project coordinator handling the construction process as well as the publicity, marketing and participation experts in charge of the processes.

[9] https://www.ueq-online.org/ (last accessed 2021/06/30).

4.1 Concept

The following steps were derived for the configuration process. At the beginning of the configuration, the user is taken to a start page where the participation platform Take Part and the app are briefly described. A video can be found in which the platform is concisely explained and demonstrated.

Step 1: General Information about the Project. At the beginning of the configuration, the user defines general information about the project needed to advise the user later in the configuration process. This includes, for example, the purpose they are pursuing by providing the participation platform, as well as the geographical range of people they wish to reach. In order to be able to create a basic version of the project page on the platform or to facilitate subsequent consultation, information such as the name of the contact person, the project name, the location of the construction side and the planned project duration, already existing website or brief description are gathered. This information can be used, for example, to determine which citizen groups are notified about the new project on the platform. The range is determined by specifying a radius around the location of the construction project on a map, which is compared to the location of registered citizens. Other definitions of outreach could include specifying a particular city, country, or even targeting a user group, such as a company's employees. If necessary, it must be specified here whether the project is publicly available or should only be visible to a specific audience.

Step 2: Goal of Participation. In the second step, the goal of public participation can be defined using the mentioned Participation Spectrum [5]. It consists of five successive stages in which the citizen's influence on decisions increases progressively, accompanied by promises to citizens, which are communicated implicitly or explicitly. The user selects the desired participation level. These are briefly described and are used to recommend modules in Step 3, *module selection.* In the next step ("module selection"), to give a complete overview, all non-recommended modules are nevertheless present and displayed to the user regardless of their choice.

Step 3: Module Selection. In the module selection step, the project initiator can select the required participation formats that will be available for participating in the project. These are described briefly in the overview to be comparable at a glance, but more detailed information is available as well. A video can be provided for each module, to support the users' understanding. In addition to the attribute-level constraints, there are some inter-module dependencies to consider from a business perspective. For example, the "Surveys" module is only relevant if citizens have previously been informed by the "Information" module or an MR element about the topic on which they are to vote on. However, it is possible that a project initiator may still wish to purchase only one of the modules. The module options should therefore be available and only a recommendation should be given by the configurator.

The modules are thus divided into two lists: recommended modules and other modules. An overview of the modules in the basic package is also provided (Appendix Fig. A). The modules can be filtered by price, interaction options and participation level. Each module is assigned to a participation level. All modules whose assigned level is

less than or equal to the level previously selected by the user are displayed as "Recommended". In addition, the user should have the opportunity to get a preview about the available modules and what is offered even before the configuration. This can be provided on a regular website external to the configuration process. Finally, an analysis of the previous configuration indicates the extent of various aspects (information for citizens, feedback collection, interactivity, opportunities for participation). These aspects have to be explored and improved in future research.

Step 4: Additional Functionalities. Once matching modules have been selected, their functionality can be configured. Additional features for each module, such as displaying a video or photo gallery, are presented to the users and they can decide which of them are needed and which remain deactivated.

Step 5: Marketplace for External Service Providers. For a participation process and most modules, certain specific competencies may be required, which the project initiator can fulfill on his own or which an external company can provide in the form of services. For example, the project initiator may already have received a 3D model from an architect and does not need any support in this regard. However, if this is not the case, they must find a provider/a specialized company who can create the required 3D models - compatible for augmented and virtual reality displays. The configurator thus shows the user which skills, content, or even technical equipment they need for the selected modules. The users can then decide whether they provide these themselves or obtain them from a provider.

In the configurator, providers can be suggested from which the project initiator can obtain an offer, or a service can be booked directly during the process (Appendix Fig. B). For this purpose, a partnership can be entered into with providers, or the "Competence Atlas" product from CAS Software AG can be linked via an interface. Similar to the project "farmshops.eu - direct marketer map"[10] of the Open Knowledge Foundation Germany, providers with certain competences can be found via a map. A special focus can thereby lie on local providers, with promotions to support them. The Competence Atlas hence functions as a marketplace, for users to find providers with specific domain expertise or technical competencies in a specific domain.

All available service providers and partner companies are displayed in a list, in case the user needs support. The name of the company and its distance from the project location are displayed. In addition, a short advertising text is available, as well as a link for references, through which the user can further inform himself about the provider. In addition, the location of the providers can be viewed on a map.

Step 6: Summary. The last step of the configuration process is a summary of the selected components (modules, additional functions, service providers) and the purchase. In order to offer the project initiators more flexibility and assurance, the user can send a non-binding appointment request for a consultation. An analysis similar to that during the configuration process is shown at the end of the configuration, which illustrates the selected modules and summarizes the expected participation effect. The various modules (apps) are bundled as a software package and made available through

[10] https://farmshops.eu/ (last accessed 2021/06/30).

the platform. Authorizing other users to assist in managing the project site and publishing content should be possible by default. In addition, a dashboard should be available for project initiators to view a summary of participation results.

There are several approaches to designing the configurator and the individual steps in the configuration process. Mockups were created for each step and the process flow as a whole. Since there are no technical dependencies between the individual modules and the definition of the exact contents is not considered within the scope of this research, a configuration in the direction of a "pick-to-order" configurator is possible. However, since the modules have to be configured with respect to the activated additional functions and added providers, the complexity of the configuration problem is more like an "assemble-to-order" problem. There are simple dependencies that have to be taken into account and the functions are available as prefabricated modules. The entire configuration process can be iterated several times by the user by adding new modules and new content in an agile fashion.

5 Prototype and Evaluation

5.1 Programming the Prototype

The designed configuration process is implemented as a web application in the CRM cloud solution SmartWe[11] [34]. The configurator should enable project initiators to create a new project in the Take Part app for making it available to citizens (horizontal scalability). The project data and activated modules and additional functions are transmitted to SmartWe via a REST API[12] as a JSON object. In the prototype, the Java library "smartdesign" is used to access the Web API of SmartWe. The Take Part app retrieves all the data records located in the database. The newly created project can thus be seen directly in the app, and further content can be added and maintained. After configuring a project, if the construction initiator wishes to book additional modules, the configuration process shown can be run through again.

Each page and some of the UI elements, such as the shopping cart or analysis are organized as components. Communication between the components is carried out with the help of a service. The "Module", "Additional function" and "External provider" features are products that can be purchased by the user during configuration. Additional functions and modules contain a list of jobs: for example, the "Live chat" function which can be activated in the "Discussion" module might require a moderator. The resulting job of moderating the chat can be done by the project initiator himself, or by an external service provider. Each job contains a list of service providers that can be considered for the task, considering inputs such as latitude and longitude, and range (in km) of service providers. Results are aggregated from external databases of third-party providers in Germany and depicted as hotspots and routes on the Yellow map[13] solution. After a project has been successfully created on the platform, the project initiator can manage

[11] https://smartwe.de/ (last accessed 2021/06/30).

[12] https://partnerportal.cas.de/SmartDesignSDK/SmartWe/ (last accessed 2021/06/30).

[13] https://www.yellowmap.com/ (last accessed 2021/06/30).

the content on the platform environment. In further development, the project should only be made public at the request of the project initiator after the content of the project has been completed.

5.2 Evaluation

To evaluate the prototype, the target group – project initiators – were identified and interviewed to assess feedback and potential improvements to the app. To this end, twelve semi-structured qualitative interviews were conducted with experts from different construction project contexts to evaluate the platform. Methodically, we followed a research approach suggested by Kaiser [35]. The interviews began with an introduction into the Take Part app and MR technologies to make the interviewees acquainted with MR. This was followed by concrete questions on specific topics concerning the initial and long-term usage of the app (such as desired participation levels by the initiator, use of configurator, relevant modules, interest in MR, and so on). Although, in this chapter preliminary results of those interviews, based on notes created from these interviews are presented, a detailed analysis based on a full transcription of the interviews could give more insights. For the complete analysis of the study, the interviews will be transcribed and a structured content analysis based on Kaiser [35] performed, using the software MAXQDA. In this paper, we present the qualitative interviews' preliminary results.

The interviews recognized, that the developed configuration process is well accepted by project initiators from the private sector and is suitable for this purpose. The participants rated the prototype as easy to use, well-structured and user-friendly. Further, they evaluated the configuration of the platform as intuitive and all steps were comprehensible. The interview partners stated that a filter option in the list of available service providers would be important to them in the provider selection process. In addition, detailed offers for the required services were reported to be missing. With a detailed service description, which was not available in the prototype, the interviewees reported that they would publish their project on the platform via this channel. However, all initiators insisted on a consultation appointment before making a final purchase decision, in which the contractual framework conditions and modules of the platform would be explained in greater detail. They would only waive this condition if a comparatively low investment value was required. Large companies that want to use the platform in the long term prefer an individual purchase agreement. It is therefore recommended that different price models be made available for SMEs and large companies, and that individual offers will be made possible.

The situation is different for project initiators from the public sector. In this case, cities that want to use the platform for their own projects are bound by the public procurement law that applies in Germany, particularly when commissioning service providers to fulfill its public tasks(Bundesgesetzblatt[14]). Therefore, project initiators from this area cannot select and commission any external service provider as designed but must publish a call for tenders for the required service. The same regulations apply to the platform itself. Take Part's offer therefore must be compared with similar participation platforms before a city can use the platform, unless they are below a certain cost limit. In future

[14] https://www.gesetze-im-internet.de/vgv_2016/ (last accessed 2021/06/30).

development, it must be examined to what extent the public sector can be supported in the tendering of required services.

Regarding the importance and acceptance of MR technologies in public participation processes by project initiators, at least four out of the twelve interviewed initiators found it essential to provide a good "media mix" to citizens, and perceived the introduction of MR elements in public participation processes as an "interesting" element. One initiator reported that for long term usage of public participation, more intelligent interaction methods for users would be necessary, and mixed reality is a promising approach in this regard. More than 50% of the initiators were not convinced of the necessity of MR for a digital participation process, of which two interviewees reported this being potentially owing to ow low levels of experiences with MR technologies. Initiators expressed concerns on acceptance owing to the ability of MR to reach the masses, particularly reaching citizens who are not mobile or techno-affine. The availability of accurate 3D models, achieving a high quality of MR experiences, and maintenance of 3D data in the planning process, were also perceived as hurdles in long-term usage of MR. In summary, the mixed reality aspect was not reported to be the key deciding factor that determined the use of the platform[15]. However, one initiator reported, that he/she believed sufficient marketing and an appealing, suitable presentation of MR content, would pave the way to increase acceptance of MR for public participation processes. Given that citizens had a very positive reaction to the use of MR for visualizing public construction processes, as shown from pilot studies and in final evaluations [36, 37] of the prototype, the move towards MR technologies for public participation could be driven by the increasing acceptance and usage amongst citizens.

6 Next Steps and Outlook

In this paper we developed design guidelines and a simplified dimensional model for designing and developing a platform configurator for public participation. Although the model was only tested specifically in our use case, we achieved good results in the prototype in terms of usability and acceptance. Even if there are additional dimensions to be considered, in our case it was sufficient to only focus on the three main dimensions summarized. In a more detailed analysis the interrelationship between the components and the decision complexity should be investigated further.

[15] Most of the initiators assumed, that they would use first the simpler, more familiar modules (such as providing surveys, information, photos, etc.) and found the networking effect of the platform useful (the ability to find service providers through the marketplace, as well as to connect with citizen pools of projects made publicly available by other initiators).

From the preliminary analysis of the interviews, we developed several insights for the future development of the configurator. The legal framework for citizen participation is major design driver for such platforms. There is considerable difference between the approaches for the public and private sector, both in terms of procurement processes as well as legal requirements for citizen participation. This applies to both using the platform services as well as the marketplace functions. Project initiators from the public sector have more restrictions during the configuration of the platform than those from the private sector. In the future, especially project initiators of the public sector should be able to specify a service description in the configurator, which is then automatically put out to tender. Suppliers can then send bids to the city management. The configuration process and the platform must be checked for conformity with regulations on participation processes applicable in Germany and the EU.

Furthermore, during the development and evaluation of the configurator it was recognized that the use of the levels of participation is not optimally suited. Rather than using a simple linear model for describing participation along several stages, it has become more promising to use a pattern-based approach in which configurations are chosen "by example" and based on successful configurations, which are selected based on similarity. Moreover, in the configuration process, it is important to ensure that the project initiator has thought about the intended participation process in detail in advance in order to avoid unconsidered selection of modules. Hence, a more generic approach of selecting modules based on categories or templates is recommended for specific use cases.

Support and recommendations for the project initiators can be further improved by using data on participation processes that have already taken place. For instance, a knowledge catalog on already completed reference projects can be provided. With this, project initiators can find out about similar projects that used the platform in the participation process and understand which modules were used at what stage of participation in the project. The result of the participation and the acceptance of the modules by the citizens involved can also be described there. A presentation of selected reference projects can also increase trust in the platform. Further, guidance during the process can be improved by providing recommendations for the use of certain modules and functionalities. In future work the effects of modules and functionalities on a participation process and citizens need to be analyzed. After that, an analysis of the participation platform based on the users' configuration and recommendations supported by artificial intelligence, can be implemented. In the later development of the participation platform, the required data to derive recommendations can be drawn from usage analysis during participation processes. For the start, studies on publicly documented participation procedures can serve as the initial data basis.

The availability of external service providers through the marketplace reduces the effort for initiators to develop as well as maintain the participation process on the platform long-term. Our configurator concept introduces initiators to the specialized technologies virtual reality and augmented reality in the context of public participation, which can increase acceptance and use of mixed reality in the long term.

Appendix

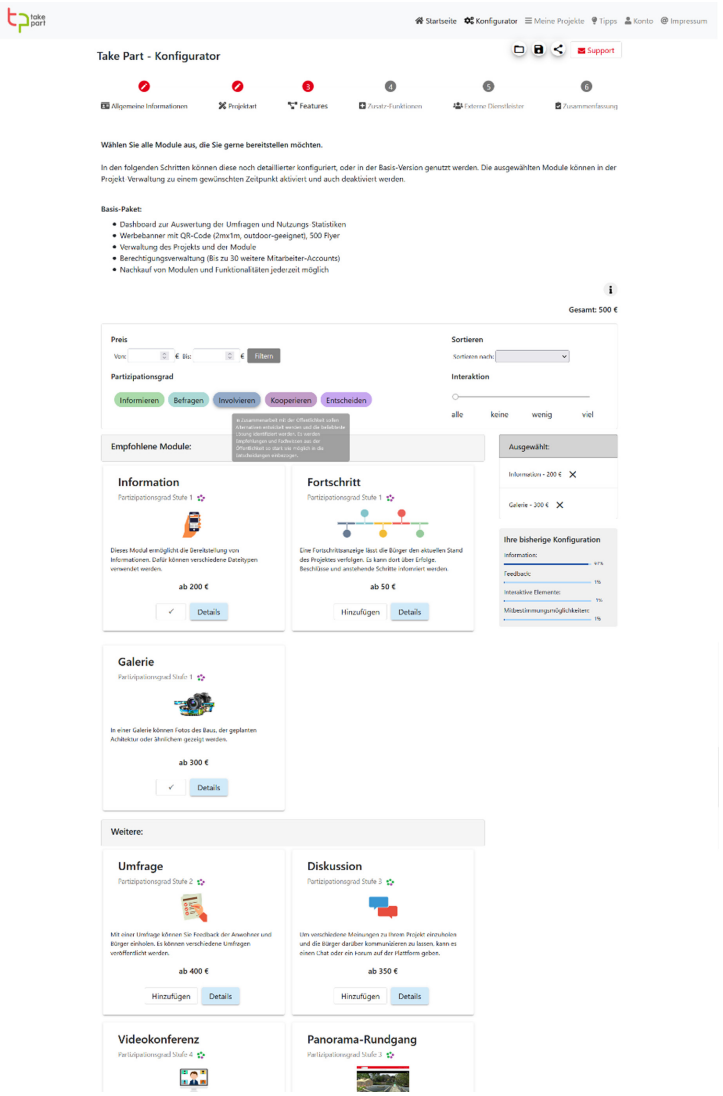

Fig. A. Step 3 (Module selection)[16].

16 https://github.com/LenaS16/TakePartPaper/blob/b2796b0e68bdf9b7d06744157da64bfe09d850de/Modulauswahl-Screenshot.png (last accessed 2021/10/29).

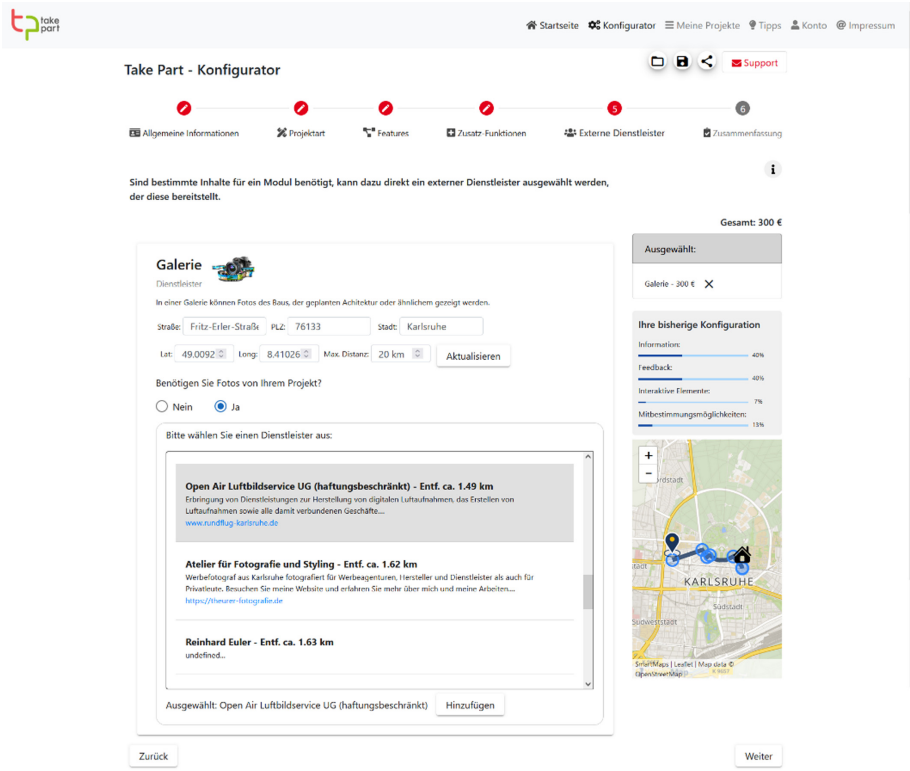

Fig. B. Step 5 (External service providers)[17].

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[17] https://github.com/LenaS16/TakePartPaper/blob/b2796b0e68bdf9b7d06744157da64bfe09d850de/Externe%20Dienstleister-Screenshot.png (last accessed 2021/10/29).

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