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Participation in Software Development:
Experiences and Lessons From the Hin&Weg Project

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ABSTRACT

Participatory planning holds important lessons for improving local government capabilities and responsiveness, but overall procedural regulations and statutory frameworks make its relevance for participatory IT development often just a matter of compliance. Developing analytical visualisations to support local government faces significant challenges because of the complexity and uncertainty about long-term benefits. The authors designed the process and local government staff understood their participation in an organised process. After each segment and the programming implementation, a new version of the software integrates improvements for participants. The participation process involved staff from ultimately 18 local governments. Participation became a verb describing the process that informed the directions to which the authors took up local government input.

KEYWORDS

Germany, IT Development, Participation, Participatory IT Development, Visualization

INTRODUCTION: PARTICIPATION SHOULD BE A VERB

The ideals of participation can rapidly fade when meeting the contingencies and contexts of IT development practice with governmental agencies. Participatory planning holds important lessons for improving local government capabilities and responsiveness. However, overall procedural regulations and statutory frameworks make its relevance for participatory IT development often just a matter of compliance. In particular, developing analytical visualisations to support local government faces significant challenges because of the complexity and uncertainty about long-term benefits and limited time and human resources available in governmental agencies beyond necessary routine tasks. Participation is more than a phase, and in this sense, it is integral to each step of participatory IT development.

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In the article, we consider the project *hin&weg*, which follows the goal of **developing an ultimately open-source software package** for analysing **and visualising users' origin-destination mobility data,** with multiple local governments' involvement. We turn to concepts from participatory IT development, also known as participatory design (Schuler and Namioka, 1993), for ideas on enhancing IT development through **structured participatory input**. The participation process in the *hin&weg* project consisted of alpha- and a beta-phase involving staff from ultimately 18 local governments, followed by a third phase for preparing the software release. Project outcomes were continuously open for refinement and redefinition during the software development. However, we structured participation activities into phases and shorter intensive software development periods built on each other. After each intensive development period, users' inputs became part of project-internal discussions, deliberations, and programming to improve specific software functions.

Further, we drew from the inputs for preparing workshops and other project materials for participants and interested groups. At the end of each intensive period of participation and programming implementation, a new version of the software integrated improvements for participants. We continued to collect their comments, occasionally identified other issues, and motivated participants to remain engaged. As such, local government staff understood their participation as part of an organised process in the project. With this approach, participation describes the process that informed how the IT development took up local government input to achieve project goals.

The context for this participatory software development is the technology transfer project known by its German name, *hin&weg* (a German idiom for *up&away*), taking place from May 2018 to May 2022. The participating local governments volunteered to support this project, which aims to create an interactive and flexible software package for the temporal and geographical visual analysis of origin-destination mobility data (e.g. migration, commuting) on multiple spatial scales. It uses choropleth maps and a range of graphic visualisations integrated with data analysis functions. A previous version of the *hin&weg* software had been developed before the start of the current project, in the early 2000s, to support a limited range of analysis and visualisation functions. It was used by a small number of cities in Germany to analyse registry data (i.e. data collected under existing statutes for all changes in residence and households in Germany and most continental European countries) in collaboration with researchers. This previous version of *hin&weg* was also developed and successfully used for interactive public exhibitions around Germany, but the software architecture and program libraries (some were not supported anymore) needed a prohibitively expensive revision half-decade later. Recognising the interest in the analytical and visualisation potential of registry data, in 2018, the Leibniz Institute of Regional Geography (IfL) received grant funds from the independent Leibniz-Association to develop a new version of the software, which would be made widely available to governments and other interest groups of the broad public. A free and open-source version of *hin&weg* (with both a German and an English interface) will be made available by the end of the project in the spring of 2022.

We recognised that the project's success and long-term sustainability depend on involving governmental staff that regularly works with registry data to assess the impact of mobility and migration flows on local and regional development processes, as they would benefit the most from the analysis and visualisation functions of the *hin&weg* application. With this user group primarily in mind, the *hin&weg* project focused on developing a participatory process that connected government users' needs with the creation and revision of specifications for the external IT developers in a learning process for developers and participants alike. This approach explained further in the paper ensures that the software development receives specific inputs to guide the development of functionalities that serve participating cities' needs and desires.

The next section of the article presents the concepts from public participation and IT-development participation we drew on. It also discusses issues in using participatory design to improve analytical visualisation. The subsequent section describes the participatory software development process the *hin&weg* project used and provides two functions with corresponding interface elements as a specific example for the impact of participation in the software development. An analysis of this approach to

participation, which at its core involves learning by both local government participants and software developers, follows. In the concluding section, we discuss the strengths and limitations of our approach and the lesson learned, which we hope will benefit readers interested in a novel way for the local government and the broader public benefiting from the participation process.

PARTICIPATION CONCEPTS INSPIRING THE APPROACH IN *HIN&WEG*

Participation in Planning: Broad Involvement

Participation, understood as the structured interactions of impacted individuals and executing agency(ies), is common in governmental circles, especially planning (Craig and Elwood, 1998). As such, participation is no novel concept for local governments. While the specific emphasis in supporting participation for citizen involvement highlights other matters, this background still influences how participation in local government IT-Development is understood. The impulse for increasing participation in planning processes comes from enthusiastic responses to technocratic attempts to optimise planning, leaving local needs and local groups often without opportunities to articulate their perspectives and issues in the planning process. Paul Davidoff famously 1965 made the case that planners become advocates for groups and reject a misplaced notion that planners were neutral experts to guide and decide the best course of action (Paul Davidoff 1965). This article signalled a watershed for planning worldwide and continues today to influence participation's potential in planning, mainly through the integration of citizens in the planning process. Broad involvement should, in concept, be able to redress limits of the technocratic approach, constrain undue political influence, and help assure that planning outcomes are in line with citizen values and needs. This conceptual framework held important significance for the development of geographical information systems (GIS) Aitken, 2002; Elwood and Leitner, 1998; Plantin, 2014) as well as critical assessments (Ghose and Elwood, 2003; Warren, 2004) and considerations of challenges participatory planning faced in developing programmatic frameworks to empower citizen involvement (Mukherjee and Ghose, 2009). Programmatic frameworks have vast significance and potential for the development of data resources and services to support citizen participation in planning (Al-Kodmany, 1999; Sieber, 2006; McCall, 2003), for example, through spatial data infrastructure activities (Crompvoets, 2006). These latter developments directly influence how participation is valuable in developing governmental resources for internal use and developing public participation. However, participation in planning often fails to engage sufficiently with the procedural and institutional context in which participation occurs (Thoneick, 2021).

Participation in IT-Development

In contrast to the broad considerations arising in local government participatory planning, IT-Development participation for local government focuses on improving software development and avoiding programming mistakes with consequences for the users. In the *hin&weg* project, we focus on working with participants to develop and improve the interactive and flexible software package through an alpha- and a beta-development phase. Software development and IT management have become significant obstacles in developing the information age capabilities in public administrations (Brooks, 1995; Eason, 1988). Many software engineering approaches to respond to the challenge usually tackle essential issues in coordination of software development, connecting programming objectives to customer needs, assuring institutional settings and regulations support programming needs, among other things. These approaches, addressing the different issues, met a combination of successes and problems, are united by recognising that the persistent gap between programmers and users cannot be resolved by improving software engineering alone. The ideation phase (i.e. developing and refining ideas among the active group), scoping, consensus building in the planning phase etc., have received increased attention as software development steps that can be improved (Pilemalm, 2018; Scholl, 2020; Klonner et al., 2021; Lin and Benneker 2021).

Returning to concepts of participation from these and earlier discussions that echo Davidoff's critique, the concepts of participatory software development, often known under the term participatory design, guide an analogous approach that seeks to directly involve users and potential beneficiaries of the software in every phase of the development process. The emphasis is on the process of IT-Development, which means first and foremost having a clear structure to guide the software development. Often, especially in Scandinavian IT-Development (Schuler and Namioka, 1993), the organisational and institutional support allows for full participation of software developers and users, which means complete cooperation during every design step and often involving full participation in all related work. The resulting organisational challenges (discussed in the following subsection) can be insurmountable, and often structures develop to find the best pragmatic compromise. The insights gained from developing an understanding of participants' activities, needs, and approaches can be of unparalleled benefit and require suitable methods.

Participation to Improve Analytical Visualization

The challenges of visual analysis receive considerable attention in many fields (MacEachren et al., 2005) and are the basis for the participatory software development process in the *hin&weg* project. Visualisation is a very active research domain emphasising studying cognitive and neurological approaches to develop future techniques and deepen understanding of the cognitive and social processes of perception, comprehension, and presentation (Ware, 2013 ; Börner and Polley, 2014). In the *hin&weg* project, we recognised these contributions but faced a practical problem translating them to hands-on approaches in a participatory process. Many people in local governments could abstractly recognise the potential of the *hin&weg* software. After all, they work regularly to make sense of dynamic urban and regional demographic changes processes for a host of issues.

Nevertheless, frequently they could not grasp the potential of new capabilities that *hin&weg* can add to their work. This represents a commonly known problem in software development that needs additional capabilities, despite being regarded as unnecessary by some, can fade for most people when nothing available can help. Therefore, significant for participation is that this need can be somehow addressed with existing approaches, or it can be bracketed away. In other words, only a smaller number of local government staff could see concrete ways in which the efforts to participate in the development process would later be of benefit to support their needs. They often phrased their feedback based on requirements to complete tasks that occur rarely (once per year or once in several years) but are considered onerous due to their time-consuming nature, which we only learned through the participation process. A fundamental challenge throughout the project was to align the public administration staff's understanding of software functionality in this context with the software developers' research background. Taking as a starting point the feedback received in the alpha-phase of the project, we have guided the project's engagement during the beta-phase through a rigorous structuring of the participation.

While the organisation of participation seems to be more of a meta-issue in most IT development, we also understood from feedback in the alpha-phase that the complexity of analytical visualisation (Dennett, 2015) benefits from an organisation of participation that focussed on local government's routine work and the suitability of software functions for those tasks. The approach to supporting software development stands in contrast to many participatory projects emphasising visualisation that are studies of prototypes (for example, Klonner, "Participatory Mapping and Visualization of Local Knowledge: An Example From Eberbach, Germany."), However, lack of considerations of how to integrate the research in local governments (e.g., Pilemalm, "Participatory Design in Emerging Civic Engagement Initiatives in the New Public Sector: Applying Pd Concepts in Resource-Scarce Organizations"). The fact remains that many analytical visualisation packages have performed far worse in Digital Government practice than in a laboratory or university settings, leaving knowledge gaps to be addressed by further research, as presented by Scholl (2020) as well as in thousands of

research papers documenting the general challenge of visualising data complexity (e.g. Wang et al., 2019; Lee-Geiller, 2020; Quintero-Angulo, Sanchez-Torres and Cardona-Roman, 2020).

With the overarching focus of the project on participatory software development and the resources available for this purpose, we understand that we do not offer a systematic approach to address all issues surrounding analytical visualisations. Nonetheless, early recognition of the issues and an approach that enables us to modify our software engineering through input gathered in structured participation gives us a viable framework for successfully developing software up to these challenges.

Participatory Software Development in the Hin&Weg Project

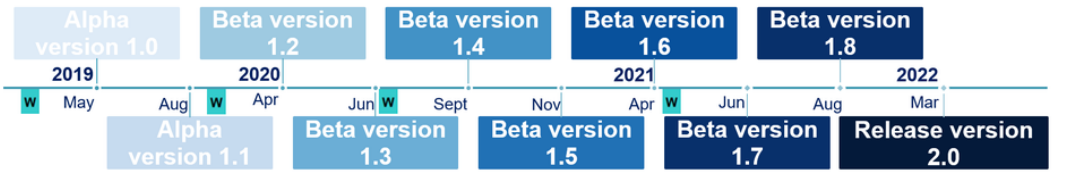
As outlined in the previous sections, we consider how project goals framed the approach to participation before presenting the project's organisation and activities in detail. Since the project is funded through a grant program from the Leibniz Association of research institutes for transferring scientific research to a broad public, the project scope was explicitly defined by the need to open up the usability of the existing software. The new software, developed in the current project, is aimed to become a viable package for longer-term use in German local governments and could also include possibilities to develop civil society uses. We defined participation with local governments as a central project pillar and emphasised it in all project activities. The software engineering challenges were, in this sense, framed by a participatory design approach. However, the participation process structure and a clear separation of participation activities from programming with mediation by the project team could quickly move the approach far from many explicit and implicit values and risk the instrumentalisation of participation, an important point we return to in the following section of the article.

With an emphasis on IT development in the project to create a version of the *hin&weg* software to support visual analysis of mobility data, we primarily draw on concepts and experiences from participative IT development. *hin&weg* is an application meant to improve local administrative capabilities to analyse and present population movements in cities and regions. As such, constraints on the time and the resources of participating governmental staff mandated an approach with fewer, more intensive phases of participation linked to developing a new version of the *hin&weg* software for local government needs and asking for feedback on both new features and (when possible) revisions.

Participation in this project needed to consider multiple types of use – from internal explorative analysis to political decision-making and public reports analysis. The staff perform these types of analysis for many reasons, including analysis of changing demographics, history studies, or assessment of measures for urban development. The software is essential, but only if participation adequately addresses the participants' data management and usability issues. Ideally, we might consider the software a success when it becomes almost second nature for administrative users of the software. However, given the changing nature of local government, and considering that previous work and analysis is often be continued by other staff members, we think that a software package that is quick to learn and re-learn can be even more successful in the long run. These points are hardly the common goals for most commercial software development. However, in pursuing software development for local government, we found that setting such objectives is critical to maintaining participant motivation.

The project is organised in **three phases of participation** (see Figure 1). First, in the alpha-version development phase, nine participating local governments gave feedback that delineated the overall scope and prioritised functionality to focus the initial software development for creating the first beta-version. In the second phase, the project team refined specific functions and user interface (UI) elements through more frequent and intensive periods of participation with 18 participating local governments and added new functionality and interface elements in response to the participants' suggestions. This phase involved multiple beta-versions of the software, each created at the end of an intensive development period and stages of participation over 18 months in total. The third and final phase reduces participation to minor improvements and a total revision of the user interface, which the project will complete by May 2022, when it concludes. This article mainly presents the second

Figure 1. Overview of project phases (alpha- and beta-) and intensive development periods (associated with a new software version); workshops are indicated with a W



phase of participation in the *hin&weg* project, which took place from November 2019 to April 2021. It was the most intensive participation phase and qualitatively the most significant participation for developing the software and assuring its viability.

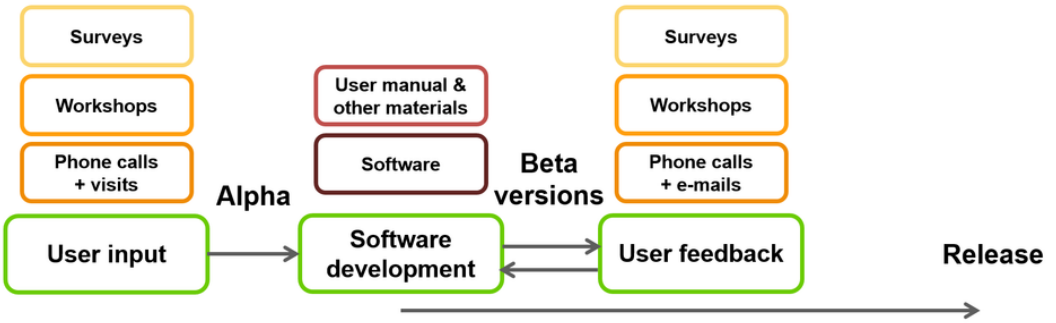
The 18 municipalities voluntarily participating in the second phase of development reflect a wide range of local government types in Germany. They are located all over the country and differ in size, from about 90 000 inhabitants in the smallest participating city to over 600 000 inhabitants in the largest. The sample even includes one county, revealing additional types of use compared to cities. The participants from these local administrations work primarily in statistics, demographics, urban planning or urban development departments, as they most often utilise registry data to assess the impact of mobility and migration flows on local and regional development processes. It, therefore, would have the highest interest in a new software package for this purpose. Most of our participants were staff members, but four participants were the head of their departments. The participants also varied in terms of their expertise on the topic. Most of them described themselves as having just a basic knowledge of GIS software (57%) and data visualisation (50%). Only a minority considered themselves experts in the two fields (14% for GIS software and 7% for data visualisation). These perceptions play an essential part in explaining why they were interested in contributing to the development of a new software package that promised a more straightforward, more intuitive usage than existing GIS-software.

PARTICIPATION IN PRACTICE: ANALYTICAL VISUALISATION CHALLENGES

Concepts of participation in planning have had a lasting influence on governmental approaches. The uptake of participatory approaches to governmental IT-Development seems more limited than that used in government planning, with notable exceptions such as Code For America (https://www.codeforamerica.org). The project's scope in which we developed the new version of the *hin&weg* software allowed us to address these limits through structured, organised participation around intensive software development periods that focus on creating and revising specific functions for local governments. The participants' input was collected in various ways during the software development periods, as Figure 2 shows.

From the project management perspective, the software's functional developments first took shape and priorities in the alpha-phase, which involved an initial version. The initial list of functions was refined based on internal discussions, individual talks, and a workshop with the nine participating municipalities in the alpha-phase, including users of the previous version of *hin&weg* and discussions with the external software development group. Some functions desired by staff from local governments, for example, areal aggregation, received low priorities in the discussions with the software developers as their implementation is highly complex compared to other desired functions. User interface issues, which are often secondary in the usual participant focus on functionality, became an important issue arising in similarities of survey responses, especially for the in-house software developer who worked

Figure 2. Means to collect user feedback for the intensive periods of software development



stridently to improve the user interface elements to balance the contradictory but understandable participant desires for easy-to-use functionality with many customisable configuration possibilities.

The most intense periods of the software development correspond to the four beta versions 1.3 – 1.6 of the software. Each of these intensive software development periods began with distributing the newest beta version of the software and accompanying survey questions about new and revised functions. However, due to cumulative delays in the software development, the feedback on the beta version 1.6 was solicited through a workshop. For the beta-phase, we recognised time as a significant restriction for the participation of local government staff. Asked at the beginning of this phase about the ideal duration of a software development period, in their opinion, the staff of the now 18 participating municipalities identified the four weeks as such. Accordingly, we requested and received their replies, usually in a 2-4 week period. This approach was successful: 56-78% of surveys were returned, with declining response rates. The surveys often were accompanied by additional remarks, comments and screenshots. Additional telephone discussions or email exchanges could, if needed, address complicated problems and gather further relevant information by the people managing the participation process to identify better and address the underlying issue. These emails and phone calls from local government staff enhanced participation. At the same time, they also opened up some issues that went beyond the software development focus of the current development period and required documentation and preparation of materials, which we placed in a user forum to guide people with questions to this resource and encourage other users of the software to post problems and solutions there too.

We systematically considered all inputs (surveys, telephone discussions, email messages) and prepared them for discussion with the programmers. These broad considerations assured an excellent alignment between public administration and software development perspectives. We discussed the received suggestions for improving the software and connected various submitted ideas. Since not all proposals could be implemented with existing project resources, we prioritised their implementation in the current software development period and future development periods, considering how often different users proposed an idea. Then the prioritised feedback was discussed with the external software developers, who assessed the complexity of each issue and finally tackled the implementation in a new software version. Helpful in considering the overall participation process is a more detailed description of the software engineering perspective. The process looks like an additional development cycle that includes and structures user input on first versions of software functionally from this perspective. For the programmers, this cycle started with a brief specification of a function, implemented utilising the functionality known from prior versions of the *hin&weg* software, and reflections on choices and feedback received to that version of the function. The new beta version of the software was made available to all beta participants at the beginning of the IT development period. Input collected from survey questions and telephone or email feedback came after collation and project internal discussions

as specific functional improvement. Programmers implement them in the project ticketing system. The programmers working at the outside company hired to develop the software (Delphi IMM, https://www.delphi-imm.de) would discuss tickets with the programmers involved in development from the IfL and the project managers. Additional infrequent meetings of all programmers and the two project managers (one at Delphi, one at IfL) refined specifications for the implementation as software engineering issues arose and needed resolution. The ticketing system (Redmine) followed software engineering practices. We loosely followed an Agile-Sprint model for implementation, internal testing and revisions before new software versions were made available to participating local governments.

With the focus on participatory software development, we found that this practice successfully counts. Still, we should note that it does not have the breadth of participation to which much literature on participation aspires and commits. While our constraints indeed involve opportunities lost, which could have helped develop further improvements to the *hin&weg* software, the participative approach we pragmatically followed provided a reasonable and timely compromise between involvement and effectiveness.

SELECTED EXAMPLES OF PARTICIPATORY SOFTWARE DEVELOPMENT

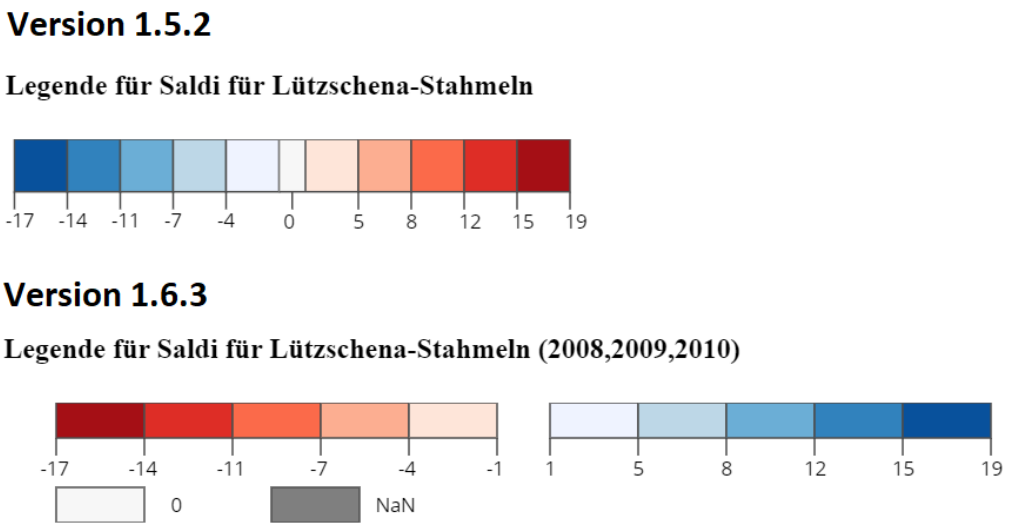
Examples of Participatory Software Development in the *hin&weg* Project

With two intertwined examples, legend colour scheme and classification, we turn to specifics of the software development process. We choose these complex examples to point to the importance of participation harnessed through project organisation in finding pragmatic solutions that follow user needs. The structure of intensive software development periods (see Figure 1) provides a temporal overview of the development process. The process of participation required management efforts to ensure the project organisation retained its usefulness. In the examples of legend colour schemes and classification, the issues and needs are central to analytical visualisation and presentations. Work on them accompanied all other developments, such as new functions and changes regarding how to support a broad range of user needs. For example, the starting value for a sequence of legend classes can be set to "0" (zero) or to the first value (Figure 3). Starting with a value of "0" looks neater and is easier to comprehend but can distort the actual range of values, often beginning with a different value, e.g., 13 or 146. Rounding the values is another option. Thus, we have for this issue alone three strategies, each with strengths and weaknesses. Implementing and testing them all is ideal but makes the programming far more complex and time-consuming.

A more central issue of colour schemes and corresponding legends is determining the colour values for individual legend. Colour is a central issue in map design, and solid cartographic contributions to graphic design literature contain references to colour (Kadavy, 2015). Considering the participatory process here in more detail, we began following previous versions of the *hin&weg* software with a predefined colour scheme in the alpha version and the software's first distributed beta version, v.1.3. This scheme followed a generic temperature scale (high/positive values in red, low/negative values in blue), with 11 classes – five positive, five negative, one "0"-class (as also shown in the upper half of Figure 3). In the alpha-phase conclusion workshop, participants expressed the wish also to have a "traffic light scale" (high/positive values in green, low/negative values in red), as some disciplines see red as positive (e.g. economists) and others see red as unfavourable (e.g. accountants, many city planning offices). Additionally, they asked for the possibility to set their colour schemes based on established local government styles and graphics requirements.

We took these desires to discuss with the programmers. Changing predefined colour schemes and adding different schemes was relatively straightforward, but making the colour schemes editable would be more complicated. Loading specific colour schemes was one option, making the colour legends interactively editable another option to consider. Due to complexities in programming and other priorities for the limited programming resources, in the second distributed beta version (1.4),

Figure 3. The legend in version 1.5.2 showing the first border of the class as "0"(zero) vs. the legend in version 1.6.3 showing the minimum value as the first border of the class and representing the "0"-value in a separate box

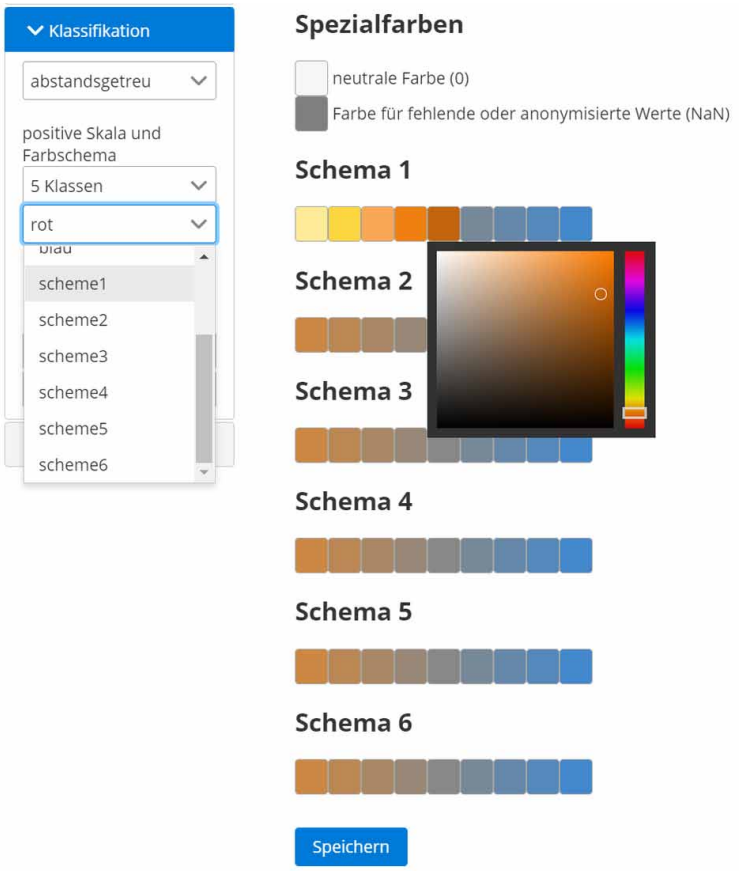


we added only multiple fixed colour schemes (red, orange, blue and green), defined in internal consultation. When asked about the colour schemes in the survey distributed with this beta-version, we received feedback about the intuitive perception of the colour schemes, especially the use of red and blue for both legends going from negative to positive and positive to negative (as also shown in the bottom half of Figure 3). Participants also pointed out a desire to have a consistent colour design for all types of visualisations and graphics. Unfortunately, we could not implement the free colour choice in the same version due to other issues that were more pressing and required substantial programming. Because mappers frequently consolidate the colour schemes and legends for charts and choropleth maps, the programming issues became more complicated, not simply having the colour codes set as variables for all program components.

We merged the feedback from beta versions 1.3 and 1.4 and developed a specification for version 1.5 that made colour schemes and legends consistent across all types of graphics. We also included in version 1.5 the option to manually define colour schemes over a colour picker (Figure 4). Again in the survey, we raised questions about the functionality of the colour schemes and legends.

Unfortunately, users found the additional capacity challenging to use as it was challenging to find the settings among the list of visualisations. The implemented graphic colour picker was deemed insufficient for needs best served by entering specific RGB or Hexadecimal (commonly used in CSS)-colour codes. There was also feedback about the fixed light to dark scaling of colours in graduated colour maps when the number of classes is different for positive and negative values (for the migration balance), as differences in the software-generated values might be hard to recognise between the extreme values linearly. Other issues raised were the possibility of creating a greyscale colour scheme for black and white publications and individually editing the colour of the boundaries of areas in the choropleth maps. We implemented some of these suggestions to improve the colour scheme and legend functionality in beta version 1.6. However, as programming resources for resolving other issues, not all had a higher priority for both the users and in internal project assessment.

Figure 4. User defined color schemes implemented first in the version 1.5, showing the color picker tool to select the colors



CHANGING THE LEGEND PRESENTATION

As they are central to the user experience, feedback on the legend's implementation went beyond colours. It touched even on statistical issues, which go back to the foundation of statistics courses and the first statistics in courses and practices learned during the first employment. For users, colour schemes, classifications and legend presentation become inseparable (Krygier and Wood, 2016). However, the understanding is so variable and contextual that the idiosyncrasies are matters beyond a pragmatic focus for software development without further study. Participation input was crucial to find better implementations of the legend and improve user interaction with the multiple graphical elements and analytical processes that users follow in working with *hin&weg*.

In the alpha version of *hin&weg*, the legend was programmed in a separate window. Feedback from the survey on the alpha version made it clear that the users wanted the legend with considerable detail in chart and map windows. They also highlighted data interpretation and comparison challenges when having separate legends for positive and negative values (such as frequently arise in ratio analyses of population movements among areas). The workshop in which the alpha version was discussed in more detail revealed other suggestions for improvement. These centred on the importance of easily distinguishing years and spatial units when comparing maximum and minimum values among different areas or on time-frames needing excellent clarity and ease of use. Participants wanted to edit the values of class borders, change the number of classes, and change the types of classifications available. For

the beta version 1.4, the programmers implemented the possibility of choosing different classifications while available resources and priorities were required leaving other changes for version 1.5.

Given the importance of classifications and analysis, we kept hearing from participants about them in the beta development. With the distribution of version 1.4 of the *hin&weg* software, we again raised the question about the legend presentation in the survey. The feedback echoed the presence of unresolved issues from the previous version, with participants continuing to point to the importance of manually defining class boundaries for the legend. Additionally, users asked for a consistent format (font and font size) for the legend and desired a flexible placement of the legend to export images. Also, the problem with the display of missing values became a significant issue, as it affected classification calculations and was not transparent to users. This last issue involves how to represent areas with missing values in the chart or map and creating a corresponding symbol in the legend. It is more complex because the possible ways to handle missing values, e.g., as a zero, required some thorough analysis. Given the complexity of some classification techniques, how to handle missing values is difficult to explain even by frequent statistical software users. We considered these points and the programmers essentially implemented them in version 1.5.

In version 1.5 of the *hin&weg* software, programmers added a manual classification type, but users found its configuration challenging to find and to use. Also, users found the setting to configure the legend's position in the graphic window hard to find. Appropriate positioning of the legend remains a difficult challenge for the programmers. Given different geographical layouts and orientations, none of the possible locations in a graphic window can ever be sufficient. A fully customisable version is difficult to implement in the software frameworks of *hin&weg*. The return to a separate window for the legend has become a good candidate for including in the software's next release.

LESSONS OF PARTICIPATORY SOFTWARE DESIGN WITH LOCAL GOVERNMENTS: LEARNING IS A PROCESS FOR ALL INVOLVED

An Overview

As they are central to the user experience, feedback on the legend's implementation went beyond colours. It touched even on statistical issues, which go back to the foundation of statistics courses and the first statistics in courses and practices learned during the first employment. For users, colour schemes, classifications and legend presentation become inseparable (Krygier and Wood, 2016). However, the understanding is so variable and contextual that the idiosyncrasies are matters beyond a pragmatic focus for software development without further study. Participation input was crucial to find better implementations of the legend and improve user interaction with the multiple graphical elements and analytical processes that users follow in working with *hin&weg*.

In the alpha version of *hin&weg*, the legend was programmed in a separate window. Feedback from the survey on the alpha version made it clear that the users wanted the legend with considerable detail in chart and map windows. They also highlighted data interpretation and comparison challenges when having separate legends for positive and negative values (such as frequently arise in ratio analyses of population movements among areas). The workshop in which the alpha version was discussed in more detail revealed other suggestions for improvement. These centred on the importance of easily distinguishing years and spatial units when comparing maximum and minimum values among different areas or on time-frames needing excellent clarity and ease of use. Participants wanted to edit the values of class borders, change the number of classes, and change the types of classifications available. For the beta version 1.4, the programmers implemented the possibility of choosing different classifications while available resources and priorities were required leaving other changes for version 1.5.

Given the importance of classifications and analysis, we kept hearing from participants about them in the beta development. With the distribution of version 1.4 of the *hin&weg* software, we again raised the question about the legend presentation in the survey. The feedback echoed the presence of

unresolved issues from the previous version, with participants continuing to point to the importance of manually defining class boundaries for the legend. Additionally, users asked for a consistent format (font and font size) for the legend and desired a flexible placement of the legend to export images. Also, the problem with the display of missing values became a significant issue, as it affected classification calculations and was not transparent to users. This last issue involves how to represent areas with missing values in the chart or map and creating a corresponding symbol in the legend. It is more complex because the possible ways to handle missing values, e.g., as a zero, required some thorough analysis. Given the complexity of some classification techniques, how to handle missing values is difficult to explain even by frequent statistical software users. We considered these points and the programmers essentially implemented them in version 1.5.

In version 1.5 of the *hin&weg* software, programmers added a manual classification type, but users found its configuration challenging to find and to use. Also, users found the setting to configure the legend's position in the graphic window hard to find. Appropriate positioning of the legend remains a difficult challenge for the programmers. Given different geographical layouts and orientations, none of the possible locations in a graphic window can ever be sufficient. A fully customisable version is difficult to implement in the software frameworks of *hin&weg*. The return to a separate window for the legend has become a good candidate for including in the software's next release.

We started the alpha-phase with participants from nine municipal governments. We had an interactive and flexible software package refined by the beta-phase's participatory process. After the alpha-phase, we were confident of the interest of a core group of staff from local governments to contribute to designing the new *hin&weg* software. Nonetheless, we expanded the group of participants. We began the beta-phase with 18 participants, which remained unchanged despite fluctuations in capacities arising with the Covid-19 pandemic and with elections they had to organise and coordinate.

While this article has not been able to go through a systematic review of original goals for the software functionality, as the two detailed examples show, we have been able to use a structured approach to participation that allowed us to develop goals through participation and assure the software best fulfils user needs. That seems a more important criterion of success than goal fulfilment alone. We were able to do this because the participation structure offered users from local governments great flexibility of how and when they would respond in the four-week window for every new release.

The critical contribution of participation to the software development was the alteration of functionality to respond to participant inputs. The examples of colour schemes and legend presentation show how this process took place\ and even how the process could go from a proposed approach to legend presentation in a separate window, which was rejected at the start of the participation process, but that in the end reappeared to this approach as a possible solution. It also points to a give-and-take between user participatory suggestions, the mediation of the project group, and the programmers' uptake and interpretation. The process dynamics are crucial to developing applications relying on visualisation Dennett, "Visualising Migration: Online Tools for Taking Us Beyond the Static Map".

Limitations

While the facilitation of the programming is a crucial challenge, thus frequently a limitation in software engineering, we have found that issue to be commonplace and just as much a matter of personality and institutions as a matter of epistemological or ontological differences. Given the improvements to the software development and creation of an application that responds to user input, we feel several limitations remain to consider. Most importantly, the function-focused software development periods were excellent for structuring but could have become instrumentalised, leading to narrowing considerations and developing too limited programmed functionality. Scope creep, and the inexorable connections between functions and agency tasks ameliorated the risk, although at the cost of some redundancy and a process of implementing participatory ideas which were not always transparent.

A more fundamental limit pointing to the importance of linking visualisation research with graphic design practice is the problem of colour schemes and legend presentation that become inseparable for

users. However, their understanding is different from almost all idiosyncrasies call for a systematic and theoretically informed study for successful incorporation in the participatory process. Beyond the scope of this project, unfortunately, it remains an important lesson for future projects. Based on participants' feedback, we can say that the current implementation and the version specified for the release version of the software (to be finished for open distribution in spring 2022) is primarily suitable for local government needs. Whether this is sufficient is a question to be asked only in the abstraction of research and academics and in the pragmatic manner related to doing the best possible work with the limits available.

Participation Enables Coordination

Participation is no panacea but approached as a process. It involves continuous engagement and a process that facilitates the cooperation for developing software with local governments, primarily when structured to align with their capacities and resources and with a way for them to learn and adapt to the software's capabilities.

Assuring the viability of a large software package for local government usage demands careful consideration of contingencies and contexts. That said, neither a single person nor an institution is ever in a position to account sufficiently for all issues. This most significant limit in governmental IT development is perhaps the strongest argument for participatory software development in local government. Statutory and administrative regulations provide a resilient and flexible framework for creating IT solutions with local governments. This framework is responsive to their needs and desires with the necessary capabilities to support changing administrative configurations and responsibilities. Participative approaches are a meaningful and helpful way to improve local government IT development coordination.

With the help of participatory approaches in the *hin&weg* project, the application is in a good way ready to improve visualisation of origin-destination mobility data and support presenting information to local government staff, decision-makers and inform the general public. The *hin&weg* software integrates easily into public administration's work routines by providing flexibility for analysing and communicating demographic developments. The customised participatory software development from *hin&weg* turned out to be an excellent way to overcome the hurdles and implement solutions.

This article presents participation not necessarily in the way we usually think of public participation, especially in planning, but as participation in local government IT development. The emphasis on improving analytical visualisation most assuredly contributes to developing local government capabilities and responsiveness. Those achievements made possible with the participatory development of the *hin&weg* software align indeed with participation's underlying goals.

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