Bridging Knowledge Gaps in Policy Analysis with Information Visualization

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Abstract: Today's politicians are confronted with new (digital) ways to tackle complex decision-making problems. In order to make the right decisions profound analysis of the problems and possible solutions has to be performed. Therefore policy analysts need to collaborate with external experts consulted as advisors. Due to different expertises of these stakeholders the whole process may suffer from knowledge gaps. In our approach, we describe a concept to bridge these knowledge gaps by introducing information visualization and visual analytics to the policy analysis domain. Therefore, we refine a standard policy cycle at the stages relevant for the policy analysis. Secondly, we characterize the main stakeholders in the process, and identify knowledge gaps between these roles. Finally, we emphasize the merits of including advanced visualization techniques into the policy analysis process, and describe visualization as a facet bridging the knowledge gaps in a collaborative policy making life-cycle.

1 Introduction

Policy analysis is one of the most critical steps in the policy-making process. The creation and analysis of alternative solutions to a public problem (so called policy options) remains a complex and challenging task with many different stakeholders involved. In order to make decisions on a profound knowledge basis, formal models reflecting the complex dependencies between social, environmental and economical factors have to be included in the analysis process. The application of these models in policy analysis helps to improve decision making. However, a number of challenges has to be addressed. We gained expertise in the field of policy analysis by collaborating with policy makers and policy analysts in several projects. From interviews and discussions with these experts, we identified three main challenges, described as *gaps* in the policy analysis process.

(1) The *competence gap*. In the policy cycle competence gaps appear between stakeholders with different knowledge and expertise. For a collaborative decision making process a transparent and unmitigated information transfer is required. Depending on the type of the communication medium and the intensity of its usage, there is a latent risk of a suboptimal information flow. The problem increases if knowledge has to be communicated via mediators. Then, additional information loss effects may appear.

(2) The *analysis gap*. The results of the policy analysis are one or more alternative solutions to a given problem. Complex results often need to be summarized to a small set of policy options that are communicated to the policy maker, who has to decide which option to be implemented. This bears the risk that either the applied model is not exploited in an optimal way, some results are not communicated, or, even worse, that the model is ill-defined without a sufficient validation by the involved stakeholders. The exploration of analysis results by the policy maker would be a valuable feature in an efficient policy-making process, since it would support rational decision making.

(3) The *iteration gap*. Processes within the policy cycle may not be sufficiently repeated and improved by feedback loops. Only in a few cases, a first draft is already fully developed and workable. Moreover, an iterative improvement of the analysis model and thereby, its results, raises the chance to conclude in feasible solutions. Time-consuming communication efforts contribute to this gap.

In this concept paper, we argue that information visualization can help to tackle the described gaps. Information visualization can contribute to mediate between different stakeholders and keep the communication efforts transparent and efficient. Many works exist in which the value of information visualization interconnected to respective application fields is shown. Still, we claim that the full potential of information visualization for policy analysis has not yet been exploited. With information visualization policy makers can get access to complex models in a user-comprehensive way. Analysis results may become more transparent and understandable for different groups of stakeholders.

2 Background

2.1 Policy Cycles

In the scientific literature a large amount of policy cycles is presented. Most of these share similar steps in the process. Some refine aspects on different levels of detail. Most cycles presented in the literature are based on the concept of Lasswell who compared policy making to problem solving. In 1956, Lasswell introduced the policy cycle divided into seven stages [Las56]). Later, Jones and Anderson simplified this policy cycle to five distinctive stages [And75] [Jon70]. Stakeholders involved in each step of the process were added in [HRP95], which results in the following cycle with stages and stakeholders: 1) agenda-setting by policy universe, 2) policy formulation by policy subsystem, 3) decision-making by government decision-makers, 4) policy implementation by policy subsystem, and 5) by policy evaluation by policy universe. Alternative policy cycles appear in the literature, for example the 6-step cycle by Patton and Sawicki [PS83], or the 8-step cycle in The Australian Policy Handbook [ABD08]. In our approach we adapt the 5-step cycle described above, since it is still the policy cycle to be considered as standard. An adaptation of this policy cycle to the field of eParticipation with a focus on the usage of information and communication technology (ICT) tools can be found in [Mac04]. A first attempt to introduce interactive visualization to the policy cycle is described in [KNRB12]. Here, the

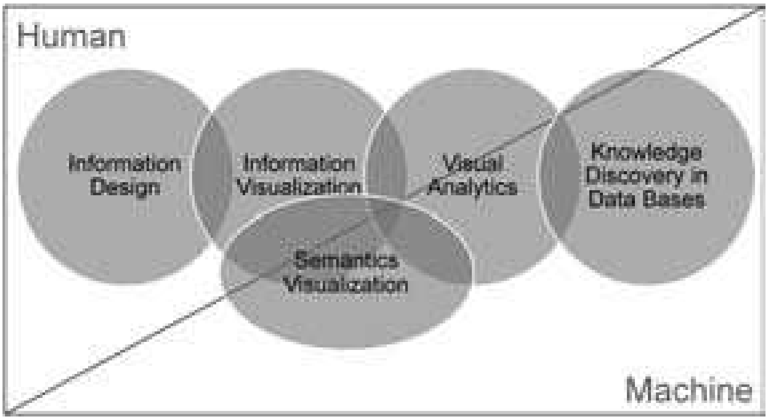

Figure 1: Visualization disciplines categorized by involvement of human and computer [KNRB12].

authors simplify the policy cycle to the steps information foraging, policy design, and impact analysis, and promote the inclusion of different fields of visualization into the policy cycle (see Figure 1).

2.2 Policy Analysis

Within the policy cycle at the policy formulation stage different policy options to address a public problem are generated and compared. Policy analysis is a critical component of this policy formulation stage [HRP95]. Various interpretations of policy analysis exist in the literature. For example, Longo [Lon13] refers to policy analysts as government knowledge workers. A historical overview of policy making starting from the concept of Lasswell, with an outlook to the future of policy analysis is given by Hoppe [Hop99]. He promotes an argumentative turn in policy analysis methodology, that combines the "scientific rationality, and a social constructivist perspective on social reality". In a survey about scientific contributions to the 'Journal of Policy Modeling' Estrada postulates the invocation of new research approaches to the field of policy making [EY12]. He structures policy modeling into predicting, monitoring, simulation, and descriptive approaches. In [WV05], the authors state that policy analysis has to be enriched by craft skills for gathering information, structuring analysis, and cost-benefit analysis among others. Howlett promotes the restructuring of policy processes to evidence-based policy-making supported by analytical techniques [How09]. When we write about models contributing to policy analysis, we mean those from research fields like data analysis (e.g. for information foraging), optimization (e.g. for balancing multiple impact factors), game theory (e.g. for defining incentive strategies), simulation (e.g. for assessing impact), and opinion mining (e.g. for measuring public opinion) among others. However, the access to these complex techniques is a challenge in policy analysis.

2.3 Information Visualization and Visual Analytics

In the following, we will describe the fields of information visualization and visual analytics, and refer to methodologies that explain how techniques from these fields may be adapted to different modeling domains. In Section 3, we provide concrete examples for successful collaborations between visualization research and external application domains in order to underline the feasibility of our concept.

Information visualization is the study of interactive visual representations of abstract data. Complex data sets are visually presented as interactive graphics to reinforce human cognition and amplify thought. [CMS99] The field has emerged from research in human-computer interaction, computer science, graphics, visual design, psychology, and business methods. Information visualization allows to intuitively access results of complex models, even for non-experts while not being limited to intrinsic application fields. In fact, information visualization is increasingly considered as critical component in scientific research, data mining, digital libraries, financial data analysis, manufacturing production control, market studies, and drug discovery [SB03].

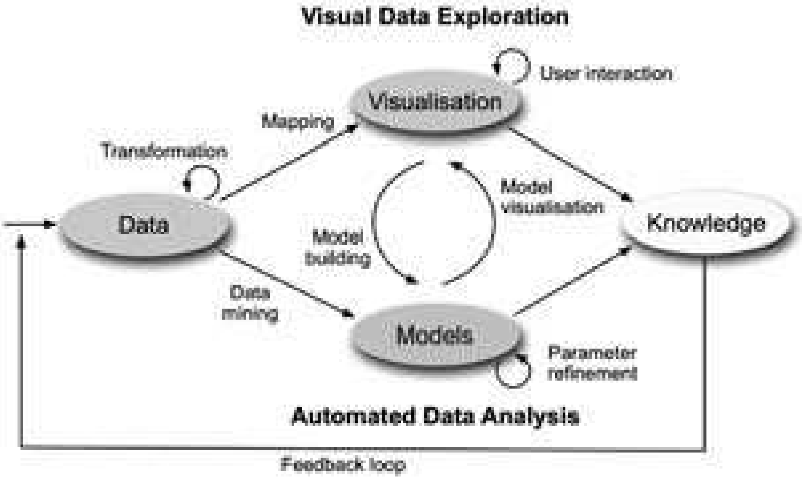

Figure 2: The visual analytics process [KAF$^+$08].

Visual analytics is an emergent information visualization spin-off discipline. The focus is towards visually supporting the sense-making process and thus, of particular interest for the policy analysis process. Visual analytics can be defined as the science of effective understanding, reasoning and decision making on the basis of large and complex data sets facilitated by interactive visualizations [KKEM10]. The goal of visual analytics is the creation of tools and techniques to enable the user to (1) synthesize information and derive insight from massive, dynamic, ambiguous, and often conflicting data; (2) detect the expected and discover the unexpected; (3) provide timely, defensible, and understandable assessments; (4) communicate assessment effectively for action [KAF$^+$08].

Figure 2 shows a widely accepted process model for visual analytics. Interactive visualization and automated data analysis methods are coupled together to provide scalable interactive decision support. The user is directly included in the iterative analysis process. This generic process model makes visual analytics applicable to a variety of data-oriented research fields like engineering, financial analysis, public safety and security, environment and climate change, as well as socio-economic applications and policy analysis, respectively. In its framework programme seven, the European commission emphasizes visualization as a key technology in the objective for ICT for governance and policy modeling [Eur10]. The scope of visual analytics can also be described in terms of the incorporated ICT key technologies like information visualization, data mining, knowledge discovery or modeling and simulation [KMS+08].

Recently, successful methodologies on how to implement visualization design studies for data-driven challenges of domain specialists have been presented [Mun09] [SMM12]. Due to their reflection upon practical experiences of hundreds of information visualization and visual analytics papers, the value of the introduced methodologies is widely recognized. In these methodologies visualization researchers are guided in how to analyze a specific real-world problem faced by domain experts, to design a visualization system that supports solving this problem, and to validate the design. Considering information visualization validation, we refer to [LBI+12]. Another important aspect is the communication between scientists in information visualization and the targeted application domains. The demand for user-centered design [Wij06] has been recognized.

However, information visualization and visual analytics approaches in the policy modeling domain are still surprisingly scarce compared to the number of approaches presented in other analysis-driven fields. Still, the policy analysis domain is an ecosystem with a variety of involved stakeholders that intend to collaborate in the best possible way. This outlines policy analysis as an interesting application field for information visualization.

3 Approach

The goal of our approach is to provide a concept for bridging gaps in the policy analysis process with information visualization. The concept supports the knowledge transfer between stakeholders, and the access to complex analysis models that improve the quality of policies. In the following, we will describe an adapted policy cycle (Section 3.1), identify the stakeholders in this cycle, detect the knowledge gaps between them (Section 3.2), and present visualization as a possible method to bridge the gaps (Section 3.3).

3.1 Adapting the Policy Cycle

In order to clarify the goal of our approach we expand the five-stage policy cycle by Anderson and Jones [And75] [Jon70](see Figure 3a) at the policy formulation and the policy adoption stages. These stages imply the definition of policy options, their analysis, and finally the decision which one to choose (see Figure 3b). Several stakeholders with different expertise are involved in these stages which result in knowledge gaps to overcome.

Agenda Setting and Problem Definition: At this stage public problems that will shape the agenda for policy making are identified. This stage remains as described in the literature. The main stakeholders at this stage are the policy makers who decide which topics and public problems appear on the political agenda. Current approaches postulate an increasing inclusion of the society at this stage [Mac04].

Policy Formulation: The main focus of our approach lies in the policy formulation stage, which includes the policy analysis [HRP95]. We assume that the quality of political decisions relies on profound analysis of the problem, and the policy options to address this problem. The main stakeholders at this stage are the policy analyst and the modeling expert. Based on the output of the problem identification and agenda-setting stage the policy analyst conceptualizes the identified problem. For the analysis of this problem she may consult external experts in modeling. These experts provide analytical models to support the creation and analysis of policy options. Thereby, the abstracted description of the problem serves as input for the model design. The generated domain-specific model produces analysis results, which are communicated to the policy analyst. These may include generated policy options and an evaluation of these options. The policy analyst now has two options: a) accept the analysis results and communicate them as policy options to the policy maker, or b) modify the requirements for the model, and ask for a further refinement of the model, or additional analysis results (first feedback loop in Figure 3b).

Policy Adoption: In the policy adoption stage, the policy maker decides which of the presented options is implemented. Therefore, the policy analyst aggregates the analysis results derived from the policy formulation stage and provides preselected policy options including an evaluation of these to the policy maker, who finally decides on the option to be implemented. Based on the solutions presented by the policy analyst, the policy maker may also decide to refine the problem description, or the agenda setting, and therefore return to the first stage of the policy cycle (second feedback loop in Figure 3b).

Policy Implementation: Since it describes the administrative act in the policy cycle, the policy implementation stage is not addressed in more detail.

Policy Evaluation: The policy evaluation is executed after a policy is fared in action and therefore closes the policy cycle. After the evaluation step the problems and the solutions may be reconceptionalized, which results in returning to the first stage of the policy cycle. In our approach we will not address this stage. Still, it is a relevant step in the policy cycle that can be supported by visualization. To conceptionally address this task remains future work.

3.2 Roles and Tasks in the Policy Cycle

After reviewing the crucial stages in the policy cycle, we identify the types of stakeholders that play a role in the considered policy cycle. We characterize these roles from our perspective.

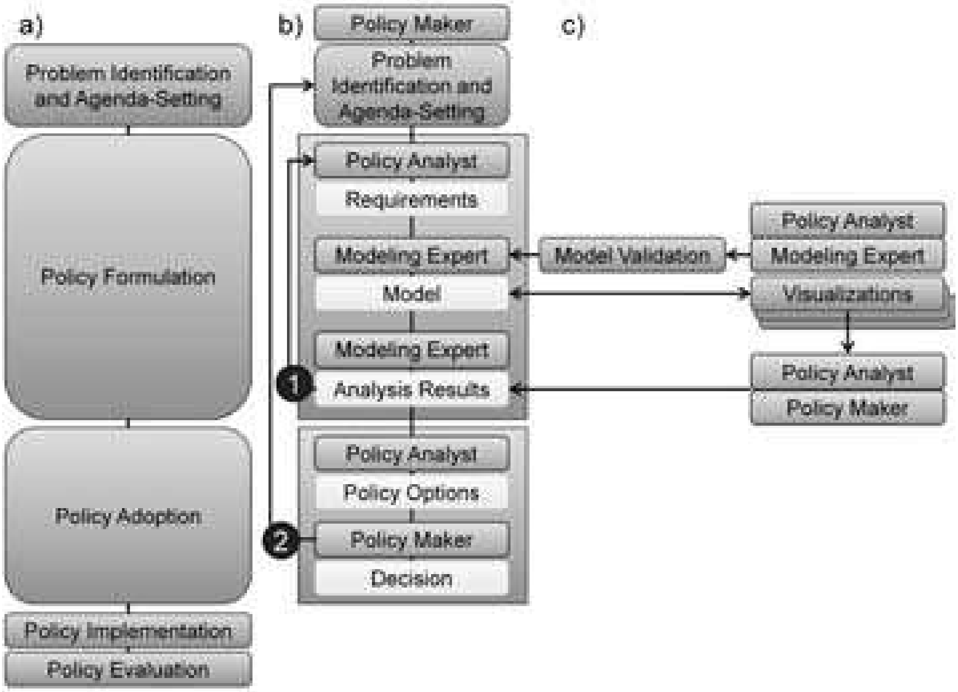

Figure 3: Adaptation of policy cycle. a) Standard policy cycle [And75] [Jon70]. b) Adaptation of policy cycle, providing more detail in the policy formulation and policy adoption stages, and two feedback loops. c) Linking visualization to the model to bridge knowledge gaps.

The **policy maker** is the decision maker in the classical sense. She decides which public problems are addressed, and by which policies they are finally tackled. In most cases, policy makers do not have the time and the technical background to execute the policy analysis. For making profound decisions they have advisors, namely policy analysts, that help in addressing the problem. Still, in the agenda setting and problem definition stage policy makers decide which public problems appear on the political agenda, and how these problems are defined. Requirements for the analysis of policy options are derived from this problem definition. After the analysis process, the policy maker finally decides which of the generated policy options will be implemented.

The **policy analyst** is the coordinator of the policy analysis. His goal is to conceptualize the problem based on the requirements defined by the policy maker. Then, she has to identify information sources, and consult external advisors that help in analyzing the problem. Finally, the policy analyst provides alternative solutions (policy options) to the policy maker.

The **modeling expert** is in most cases an external advisor recruited by the policy analyst. She has a profound knowledge in modeling techniques (see Section 2.2 for examples). Expertise in the policy domain is not necessarily required from the modeling expert. Still, the models have to be adapted to the policy domain, which can be realized by translating the problem to the model domain, or by defining technical requirements on the model. The adapted model supports the policy analysis by producing outcomes, e.g. impact of possible actions that are the basis for the generation of policy options.

The **domain expert** is an optional stakeholder. In many cases, the analytical models have to be fed by domain knowledge and data. If neither the modeling expert, nor the policy analyst can provide this information, a domain expert has to be consulted. She does not necessarily have expertise in policy analysis, or modeling techniques but rather contributes as an information provider.

The **public stakeholders** are not explicitly considered in our concept. Still, they play an increasingly important role in the policy making process. By realizing an intuitive visual access to complex models for the analysis of policy options, even non-experts like most citizens may be involved in the policy analysis. This will increase the transparency of the whole policy making process, improve democracy, and increase the trust in the policy makers.

In our adapted policy cycle, three main stakeholders are identified - policy maker, policy analyst, and modeling expert. The domain expert and the public stakeholder are neglected in our approach. Between each of these roles knowledge gaps exist that impede the policy analysis process. In the following enumeration we describe which knowledge is *exclusively* hold by which stakeholder. This may result in knowledge gaps that induce the analysis gaps defined in the introduction.

1. The policy maker and the policy analyst have knowledge in the policy domain, and detailed information about the problem to be addressed.

2. The modeling expert knows how to build complex models, and how to apply these models in order to produce analysis results.

3. The policy analyst knows how to interprete the results from the model in order to provide policy options to the policy maker.

4. The policy maker may have hidden knowledge or objectives that she cannot provide to the policy analyst.

3.3 Bridging the Knowledge Gap with Information Visualization

We provide a concept to bridge the knowledge gaps described in the previous section. We introduce the field of visualization research to the policy analysis domain. Visualization techniques are connected to the model designed by the modeling expert, and implemented into computational software (see Figure 3c). Different facets of visualization techniques (see Figure 1) are connected to the model to address different users and tasks:

(1) Visual access to analysis results from the model: the analysis results consisting of output data are visualized by **information visualization** technologies. These techniques

enable the visual-interactive access to the output information of the model. The user can visually explore the results of the model by search and filter operations. The information may be visualized in different facets depending on the users' expertise and knowledge. The main focus of these techniques lies on the usability of the system. The intuitive usage of the visualization has to be ensured.

(2) Visual-interactive control of the model: in an advanced mode the user can visual-interactively change input parameters of the model to refine analysis results. The interactive control of the model is realized by using concepts from the field of **visual analytics**, which are coined by Bertini and Lalanne as "white-box-integration" [BL10]. As described in Section 2.3 the concept of connecting visualization to complex models already exists in the field of visual analytics applied to different application areas (see also Figure 2). We propose to introduce this concept to the policy analysis domain.

Methodologies for designing visualization systems for external application domains are described in many design studies in visualization research. We refer to the one presented by Munzner [Mun09] and identify a strong correlation between this methodology and policy analysis, which we encourage to take advantage of.

In the following we will describe how visualization can bridge the knowledge gaps identified above, and which additional benefits will be achieved by combining policy analysis models with visualization techniques. Basically, for every type of stakeholder specific visual designs can be provided adapted to the specific tasks. Therefore, we introduce a new stakeholder in the policy cycle, the **visualization expert**. She does not necessarily have knowledge in the model domain, or the policy domain. Her expertise lies in designing intuitive visual interfaces that help policy makers and policy analysts by understanding, and using the model. She has to execute requirements analyses with the involved stakeholders - the policy maker, the policy analyst, and the modeling expert. For each of them she will provide visualization designs adapted to their prior knowledge.

3.3.1 Visualization for Policy Makers (and Public stakeholders)

The visualization design for the policy maker will consist of easy-to-understand interfaces only depicting the information relevant for the decision process. It enables the policy maker to get quick access to analysis results from the model. This interface will bridge the knowledge gap between policy maker and the modeling expert (see competence gap). Moreover, the policy maker can give feedback to the modeling expert if some information is missing, or if the model has to be refined from a higher level perspective (see iteration gap). As another "gap bridger", the translation of analysis results to policy options can be derived by the visualization. This will bridge the knowledge gap between policy analyst and policy maker (see analysis gap, and competence gap). The considered visualization techniques are mainly infographics, and easy-to-use information visualization techniques. As an example the ManyEyes system enables a user friendly access to visualization techniques with the option for the users to upload and visualize their own datasets [VWvH+07]. In [BBF+11], the authors introduce a visual interface easy-to-use for searching in earth observation data.

3.3.2 Visualization for Policy Analysts

The visualization design for the policy analyst will consist of the basis functionality provided to the policy maker, and advanced interaction techniques, that offer a closer connection to the model. This interface will bridge the knowledge gap between the policy analyst and the modeling expert (see competence gap). The policy analyst will be able to validate the model from the domain perspective, and refine it, e.g. by changing input parameters (see iteration gap, and analysis gap). The communication between the policy analyst and the modeling expert will be supported, since both can work with the same information representation. Again, the access to the complex model is facilitated. This enables the policy analyst to interact with the model, gain an understanding of the model, and finally produce analysis results without the help of the modeling expert (see analysis gap). The considered visualization techniques come from both fields: information visualization and visual analytics. Examples for visual systems designed to support policy analysts can be found in the fishery policy domain [BMPM12], and the energy domain [Hea12].

3.3.3 Visualization for Modeling Experts

The visualization design for the modeling expert will comprise the highest functionality. Depending on the requirements of the modeling expert, a visual-interactive editing of the model can be realized. Visualizing the model input and output may help the modeling expert to refine his model, and validate the functionality of the model (see iteration gap). The refined model will produce new analysis results that are communicated to the policy analyst and the policy maker via their respective visualization design (see analysis gap, and competence gap). This bridges the knowledge gap between policy modeler, policy analyst, and policy maker, who can refine the functionality of the model, and validate the correctness of the model in a collaborative fashion (see iteration gap). The considered visualization techniques for the modeling expert are mainly from the field of visual analytics. In [MK08], a visual system for the data-driven verification of hypothesis is provided. In [IMI+10], an interactive data analysis process is supported with visualization techniques.

4 Discussion

This work was motivated by the finding that visualization as a medium of communication is considerably less applied in the policy analysis domain than in other application domains. We shed light on the value of information visualization for policy analysis, and enumerated stakeholders in the policy cycle that may benefit of an enhanced use of visualization. Based on a review of the currently applied policy cycles, we have identified possible knowledge gaps between subsequent process steps and the involved stakeholders, respectively. We have identified common ground between policy cycles and user-centered design methodologies in information visualization and visual analytics. Our main contribution is a concept to include visualization in the policy formulation and policy adoption stages. This may help to bridge the identified gaps in the policy analysis process.

As a next step, we will apply our concept to actual policy analysis problems being identified in ongoing research projects. A tight coupling between visualization and the models applied in the policy analysis can be enriched by involving more visual analytics capabilities. Furthermore, we will extend the presented concept by incorporating visualization for other possible stakeholders, the domain expert and the public stakeholder, in particular. We offer our concept as one possible method to incorporate information visualization in the policy analysis process, and wish to provide a starting point for an ongoing discussion with further refinements and extensions. We hope that in the near future more researchers from the policy analysis and the information visualization domains contribute to collaborative approaches, and enrich interdisciplinary research.

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References

[ABD08] C. Althaus, P. Bridgman, and G. Davis. *The Australian Policy Handbook*. Allen and Unwin, 2008.

[And75] J. E. Anderson. *Public Policymaking*. Wadsworth Publishing (7th Ed. 2010), 1975.

[BBF+11] J. Bernard, J. Brase, D. Fellner, O. Koepler, J. Kohlhammer, T. Ruppert, T. Schreck, and I. Sens. A visual digital library approach for time-oriented scientific primary data. *Springer Int. Journal on Digital Libraries*, 2011.

[BL10] E. Bertini and D. Lalanne. Investigating and reflecting on the integration of automatic data analysis and visualization in knowledge discovery. *SIGKDD Expl. Newsl.*, 2010.

[BMPM12] M. Booshehrian, T. Möller, R. M. Peterman, and T. Munzner. Vismon: Facilitating Analysis of Trade-Offs, Uncertainty, and Sensitivity In Fisheries Management Decision Making. *Comp. Graph. Forum*, 31:1235–1244, June 2012.

[CMS99] St. Card, J. Mackinlay, and B. Shneiderman, editors. *Readings in information visualization: using vision to think.* Morg. Kauf. Publ., San Franc. CA, USA, 1999.

[Eur10] European Commission. 7th Framework Programme for Research and Technological Development, 2010.

[EY12] M. A. R. Estrada and S. F. Yap. The origins and evolution of policy modeling. *Journal of Policy Modeling*, 2012.

[Hea12] C. G. Heaps. Long-range Energy Alternatives Planning (LEAP) system. Stockholm Environment Institute. Somerville, MA, USA. www.energycommunity.org, 2012.

[Hop99] R. Hoppe. Policy analysis, science and politics: from 'speaking truth to power' to 'making sense together'. *Science and Public Policy*, 26(3):201–210, 1999.

[How09] M. Howlett. Policy analytical capacity and evidence-based policy-making: Lessons from Canada. *Canadian Public Administration*, 52(2):153–175, 2009.

[HRP95] M. Howlett, M. Ramesh, and A Perl. *Studying Public Policy: Policy Cycles and Policy Subsystems*. Oxford University Press, 1995.

[IMI+10] S. Ingram, T. Munzner, V. Irvine, M. Tory, S. Bergner, and T. Möller. DimStiller: Workflows for dimensional analysis and reduction. In *IEEE VAST*. IEEE, 2010.

[Jon70] Ch. O. Jones. *An Introduction to the Study of Public Policy*. Brooks/Cole Publishing Co.(3rd Edition 1984), 1970.

[KAF+08] D. Keim, G. Andrienko, J.-D. Fekete, C. Görg, J. Kohlhammer, and G. Melançon. Visual Analytics: Definition, Process, and Challenges. In *Information Visualization*. Springer, 2008.

[KKEM10] D. Keim, J. Kohlhammer, G. Ellis, and F. Mansmann. *Mastering the Information Age - Solving Problems with Visual Analytics.* Eurographics Association, 2010.

[KMS+08] D. Keim, F. Mansmann, J. Schneidewind, J. Thomas, and H. Ziegler. Visual Analytics: Scope and Challenges. In *Visual Data Mining*, pages 76–90. Springer, 2008.

[KNRB12] J. Kohlhammer, K. Nazemi, T. Ruppert, and D. Burkhardt. Toward Visualization in Policy Modeling. *Computer Graphics and Applications, IEEE*, 32(5):84–89, 2012.

[Las56] H. D. Lasswell. *The Decision Process: Seven Categories of Functional Analysis*. University of Maryland, College Park, 1956.

[LBI+12] H. Lam, E. Bertini, P. Isenberg, C. Plaisant, and Sh. Carpendale. Empirical Studies in Information Visualization: Seven Scenarios. *Trans. Vis. Comput. Graph.*, 18, 2012.

[Lon13] J. Longo. *Towards Policy Analysis 2.0*. PhD thesis, University of Victoria, British Columbia, Canada, 2013.

[Mac04] A. Macintosh. Characterizing e-participation in policy-making. In *37th Annual Hawaii International Conference on System Sciences*, pages 5–8. IEEE, 2004.

[MK08] T. May and J. Kohlhammer. Visual Verification of Hypotheses. In *Intern. Symp. on Advances in Vis. Computing*, ISVC '08, pages 31–42, 2008.

[Mun09] T. Munzner. A Nested Model for Visualization Design and Validation. *IEEE Transactions on Visualization and Computer Graphics*, 15(6):921–928, 2009.

[PS83] C. V. Patton and D. S. Sawicki. *Basic Methods of Policy Analysis and Planning*. Pearson, 1983.

[SB03] B. Shneiderman and B. Bederson. *The Craft of Information Visualization: Readings and Reflections*. Morgan Kaufmann Publ., San Francisco, CA, USA, 2003.

[SMM12] M. Sedlmair, M. D. Meyer, and T. Munzner. Design Study Methodology: Reflections from the Trenches and the Stacks. *IEEE Trans. Vis. Comput. Graph.*, 2012.

[VWvH+07] F. B. Viegas, M. Wattenberg, F. van Ham, J. Kriss, and M. McKeon. ManyEyes: a Site for Visualization at Internet Scale. *IEEE Trans. on Vis. and Comp. Graph.*, 2007.

[Wij06] J. van Wijk. Bridging the Gaps. *IEEE Comput. Graph. Appl.*, 26(6):6–9, 2006.

[WV05] D. L. Weimer and A. R. Vining. *Policy analysis: Concepts and practice*. Prentice Hall, 2005.