

Contextualizing Planning Support (Systems)

*Co-designing to fit the dynamics of
spatial strategy making*



Carissa Franken-Champlin

**CONTEXTUALIZING PLANNING SUPPORT (SYSTEMS):
CO-DESIGNING TO FIT THE DYNAMICS OF SPATIAL STRATEGY MAKING**

*Contextualiseren van Planning Support (Systemen): Co-designing voor
de aanpassing aan de dynamica van ruimtelijke strategievorming
(met een samenvatting in het Nederlands)*

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CO-DESIGNING TO FIT THE DYNAMICS OF SPATIAL STRATEGY MAKING**

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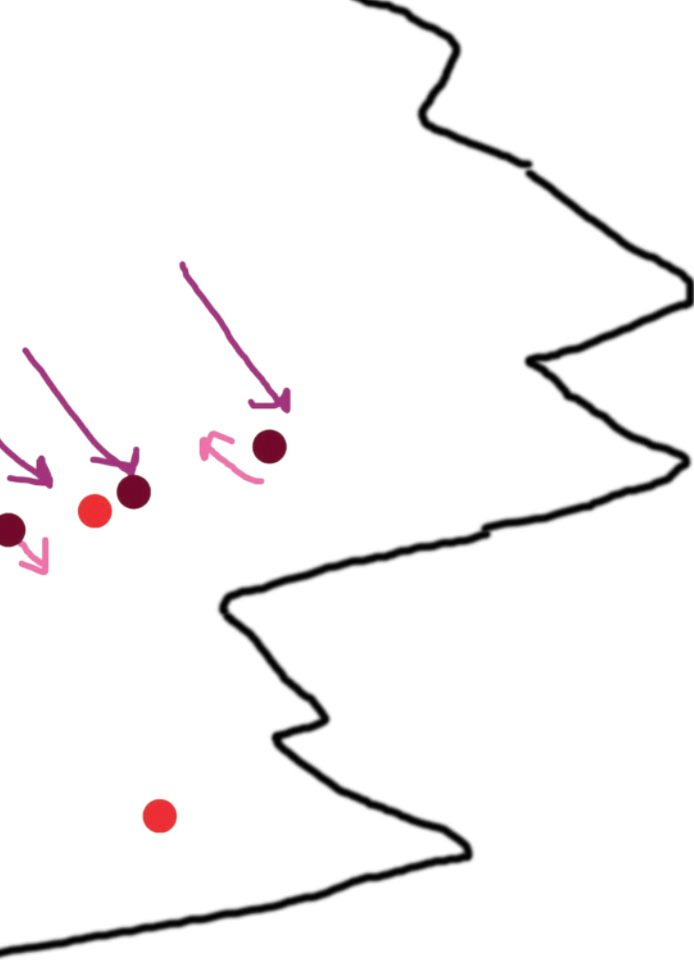
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Chapter 1

General Introduction

The search for an appropriate role for computer-based information and methods in planning must begin not with a particular technology (or set of technologies) but rather with a conception of planning (Klosterman, 1997, p. 46)

The field of spatial planning has benefited in recent decades from rapid advancements in computer technologies, particularly those that incorporate geographic information systems (GIS) such as many planning support systems (PSS). PSS can, however, be defined more broadly as 'any kind of infrastructure which systematically introduces relevant (spatial) information to a specific process of related planning actions' (te Brömmelstroet, 2010a, p. 28). In a departure from research aimed at advancing the technological aspects of PSS, recent studies increasingly encourage researchers to pay attention to the demands of users and their support needs (Pelzer, 2015). An increased understanding of user and task-related support requirements, however, has not translated to a substantial improvement in the uptake of PSS in spatial planning practice. This implementation gap is most evident during the strategic stages of the planning process (te Brömmelstroet & Bertolini, 2008; Vonk et al., 2005). Consequently, PSS are not fulfilling their intended role of supporting the non-routine planning that is responsible for the development of strategies that guide routine planning tasks (Batty, 1995). By focusing on the dynamics of strategy making, this dissertation aims at contributing a new perspective to the current PSS debate. The proposed perspective recognizes spatial strategy making as a complex communicative process responsible for the adaptation of planning issues that, if better understood, could guide the search for the appropriate role of PSS case by case and contribute to the contextualization of models used by these systems.

To ground this perspective in planning practice, the introduction to this dissertation begins with an exploratory study that illustrates the complexity that planning actors often encounter during the strategic stages of spatial planning. It then turns to scholarly literature to review applications of complexity theory to spatial planning and the current state of planning support research, with particular emphasis on the PSS debate. After identifying the research gap, a summary of the research questions and methodology that guide the studies featured in Chapters 2 through 5 will be presented.

1.1 Exploring complexity in a field study

At the beginning of this doctoral research, a preliminary study was conducted to better understand the complexity that planning actors encounter when they launch a new project. In 2009, two neighboring German and Dutch municipalities signed a memorandum of understanding to expand an industrial terrain situated approximately 1km southwest of the German municipality and about 500m from the border with the Netherlands. The 120-hectare terrain is a major employer for the German municipality and it generates 41 % of the city's renewable energy. The Dutch municipality proposed the collaboration to its German counterpart for two reasons: (1) to develop an industrial terrain without infringing on a regional anti-competition agreement with neighboring municipalities in the Netherlands and (2) to protect the integrity of the natural landscape surrounding the Dutch municipality by instead revitalizing and expanding a nearby existing terrain on the German side. This project was selected as a case study because it embodied the characteristic features of a spatial planning project in its early stages where, although trust and commitment among planning actors were high, efforts to reach consensus on a development strategy had been unsuccessful.

To gain insight into the complexity that planning actors encounter during strategy making, interviews were conducted with six experts involved in the project. A network diagram was developed based on the interviews to illustrate the complexity of the project (Figure 1.1). The diagram components are categorized based on elements of urban development (actors, facilities, investments, issues, forces, objectives, etc.) upon which Hopkins (1999) suggests PSS should be built. There are in total 124 nodes and 293 edges that link the nodes to the experts who were interviewed. The node size indicates the number of experts who mentioned the component. The diagram shows a concentration of components that were communicated by multiple experts compared to components that are peripheral, most of which are linked to only one expert. Many of the planning issues with multiple links to experts appear to be non-spatial, such as 'Local economy', 'Profit model', 'Incremental development' and 'Land use plan'.

An analysis of the interview recordings provides some explanatory value to relationships visualized in the diagram. Some components with linkages to multiple experts reflect uncertainties among the actors involved in planning concerning project objectives and development strategies. Others reflect differences in how the experts interpret the meaning of the component based on their different framing of a planning issue. For example, according to German planning policy, municipalities have a high level of autonomy regarding land use decisions. The preparatory land use plan (in German: *Flächennutzungsplan*) permits incremental development and the municipality profits

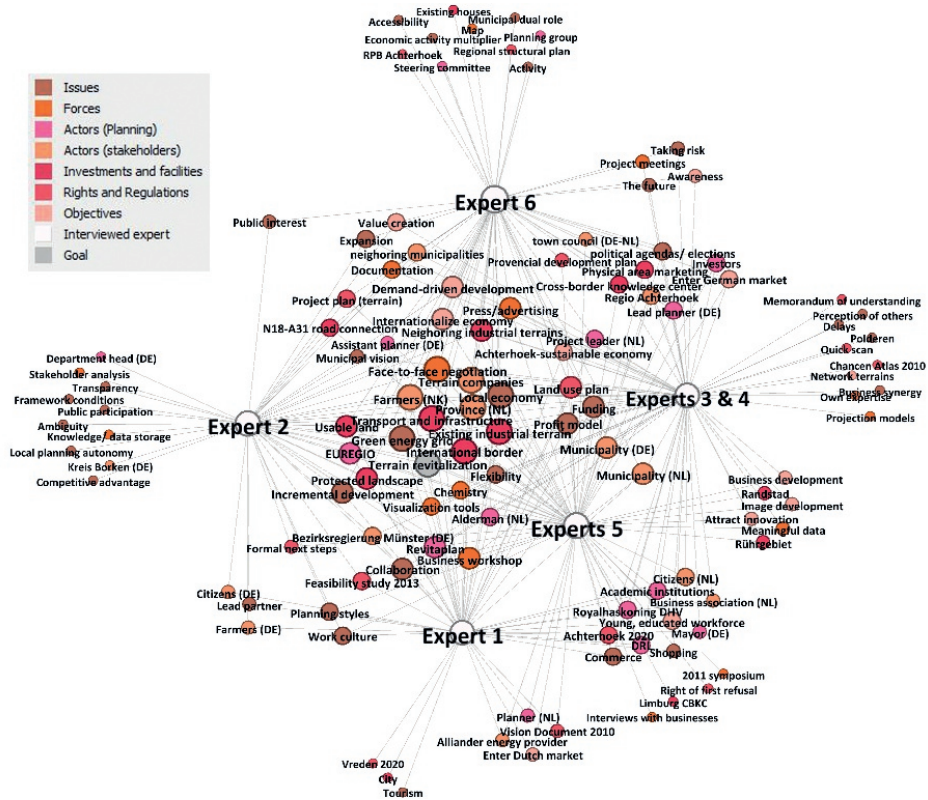


Fig. 1.1 A systems view of the terrain revitalization project from different actor perspectives

from a commercial tax (in German: *Gewerbesteuer*) generated from taxing local businesses. In contrast, in the Dutch system, regional authorities such as the province have a strong influence on the regulation of land use. Decisions about the land use plan (in Dutch: *bestemmingsplan*) are made centrally leaving little room for local authorities to make changes and the Dutch property tax (in Dutch: *onroerendezaakbelasting*) is generated from the renting or selling of property.

One planner from the German municipality explained:

What I did not expect was that the [planning] cultural differences are so big. ...the way things work on the German side is when a municipality presents something it is accepted to the greatest extent possible...On the Dutch side, there is a very centrally dictated notion of where what should be.

Thus, the process of understanding the differences between the context-specific issues of the two municipalities added substantial complexity to the initial strategic stage of their project.

The analysis also revealed several strategic objectives that give direction to the project and forces for moving the planning process forward. Objectives ranged from attracting a 'young, educated workforce' to 'demand-driven development', 'internationalizing the economy' and 'accessibility'. In total, 14 of these objectives were identified. This finding indicates a lack of consensus concerning a strategy for moving forward and the need to prioritize options among many development alternatives. Most of the forces that supported the planning process can be characterized as informal or non-technical. In addition to the 'chemistry' between the planning actors and promoting the terrain through 'advertising', forces such as 'face-to-face negotiation', 'business workshop' and 'visualization tools' were mentioned by four or more of the experts.

In summary, the four years that planning actors spent sharing, exploring, discussing and contesting their knowledge about a large set of planning issues culminated in a multitude of strategic objectives. However, the generation of these options seems to have prevented the actors from making the choices necessary to move closer to consensus on a terrain revitalization strategy. The findings indicate a need for a more structured means to explore options and make choices and that group sessions may be the preferred setting for conducting a planning support intervention. There are, however, limitations to this preliminary study that prevent drawing conclusions. For example, the interviews reflect knowledge about the revitalization project at a discrete moment in the planning process and are based on input from only a handful of actors. Consequently, the content of the network diagram does not reflect the full extent of system complexity. Still, this exploratory study exemplifies the complex network of relationships among actors and their issues that is present even in comparatively small spatial planning projects. A systems view of spatial planning takes into account this complexity.

1.2 A systems view of spatial planning

Spatial planning is inextricably linked to the spatial systems it seeks to influence. It is an adapting and evolving collaborative process that entails engagement with knowledge that is socially constructed and learning by doing together to determine courses of action for change in an area (Albrechts & Balducci, 2013; Healey, 2010; Innes & Booher, 1999). These changes happening at the urban scale are in part self-driven by flows of resources, communication, energy, services and people through what Healey

(2007) describes as a complex web of dynamic and interlinked networks. Applying complexity theory to understand how these interlinked urban networks function is not new. However, only relatively recently have academics begun to examine the social networks involved in spatial planning processes from a complex systems perspective (Portugali et al., 2012; de Roo et al., 2012). Dempwolf and Lyles highlighted this topic by writing:

Empirical knowledge of how actors in planning processes are embedded within networks and how the structure of those networks serves to enable or inhibit individual and joint action to address wicked problems and social dilemmas is underdeveloped (Dempwolf & Lyles, 2012, p.4).

The wickedness the authors refer to stems from complex causal networks that make the center of problems difficult to locate and from their embedment in constantly changing contexts (Rittel & Webber, 1973). Thus, the other contributor to this 'double complexity' of planning object and process (te Brömmelstroet, 2017b, p.77) is the distribution of knowledge about planning problems across a growing field of actors, each possessing a unique set of knowledge about the spatial system. As a result planning problems are becoming increasingly multi-dimensional 'in which everything seems to be interconnected' resulting in the increased involvement of many different issues (Geertman, 2013, pp. 50-51).

Luhmann (1990) characterizes complexity in social systems based on three dimensions: material, social and temporal. I apply these dimensions to spatial planning to help convey the confounding nature of the planning process. Material complexity is the distinction of system components such as planning issues as one thing and their rejection as another. System components are material manifestations of options and they represent the realm of possibilities under consideration by actors. Social complexity is generated as perspectives pertaining to system components are accumulated and compared with one's own perspective. This second dimension of complexity is a by-product of communicative interactions. As planning actors communicate their different views and perceptions of the spatial system and its components, they create a system that is more complex. Finally, temporal complexity reflects differences in how actors prioritize process steps and component relationships to achieve a common goal. This third dimension emphasizes the human factor contributing to the uncertainty found in all planning processes regardless of project size or relative complexity. It also indicates the presence of dynamics that link planning issues to project objectives, indicators for evaluating scenarios and other system components in a constantly adapting planning process.

These three dimensions of complexity in planning can inhibit efforts to define the problem space and determine effective strategies for dealing with an uncertain future. Planning problems have become so convoluted that some claim planning in western countries seems to have lost its strategic, future orientation (Couclelis, 2005; Batty, 2003). What would be required for planning to fulfill its strategic mission is for planning issues to be linked to actions and for incremental feedback to be provided concerning the impact of interventions on the spatial system (de Roo & Rauws, 2012). Planning approaches that are based solely on communicative interactions may lack the required structure to forge these links. De Roo and Rauws (ibid) suggest that the most appropriate form of spatial planning for dealing with complexity would be *scenario planning*, since it falls halfway on the spectrum between the order and certainty of technical-rationality and the highly complex state of communicative rationality.

A distinction needs to be made between planning scenarios that deal with issues within the boundaries of a spatial system and scenarios that are concerned with outside influences of the environment to which the system belongs. The latter have been couched as context scenarios when dealt with in earlier planning support studies (see Pelzer, 2015). This thesis, however, takes issue with the former, or scenarios over which planning actors have agency, not just knowledge. These 'second-order scenarios' are scenarios that depict 'alternative courses of action *within* the purview of the planning system' (Couclelis, 2005, p.1363 - emphasis in original). Exploring and experimenting with second-order scenarios may provide the type of feedback that planning actors require for planning their interventions on the spatial system. Moreover, collaborative efforts in scenario development can create opportunities to combine scientific knowledge with other forms of knowledge (see Albrechts & Balducci, 2013) for improved communication and shared learning. The remainder of this section breaks down the strategic stages of scenario-based spatial planning approaches that are the focus of this research.

Stages of strategy making

The importance of the strategic stages of planning cannot be overstated. These stages are composed of strategic, non-routine tasks that guide routine planning and determine strategies for action (Batty, 1995). Since strategic tasks are responsible for defining the problem space and constructing performance measures, they are likely more essential than their subsequent solution-seeking tasks (Rittel & Webber, 1973). In his dissertation, te Brömmelstroet (2010b) drew upon the complexity sciences when he defined strategy making as 'a virtual construction site where planning actors actively link different types of knowledge to make sense of the complexity of (urban) problems and develop possible long-term actions for improvement' (p.13).

Figure 1.2 provides a dynamic view of strategy making including cyclical patterns of divergence and convergence and iterative feedback for learning about the spatial system and the potential impact of interventions on the system. Strategy making can be depicted in cycles of intelligence, design and choice. According to Simon’s (1977) decision-making theory, intelligence tasks include the creation of a site inventory and the formulation of goals and objectives. Design tasks include the development of alternative plans to achieve the goals and objectives. Choice tasks include the evaluation and selection of alternative plans. In keeping with the central notion of this dissertation, which is the tackling of wicked problems encountered in scenario-based planning, the preferred terminology for these three strategic stages is problem formulation, scenario development and scenario evaluation and selection.

Considering the skepticism of planning and complexity scholars towards models that depict planning as a linear, non-dynamic process (Yamu, 2014), this process model depicts strategy making as a nonlinear, dynamic process in which stages overlap. One requirement for planning systems to remain dynamic is the ability to formulate discrete interactions out of otherwise ‘undifferentiated chaos’ through choice making (Luhmann, 1995, p. xvii). Divergence and convergence are two fundamental dynamics of communication in collaborative processes (cf. Pelzer, 2015). The two dynamics respectively account for the generation of ideas and for coming to consensus by making choices

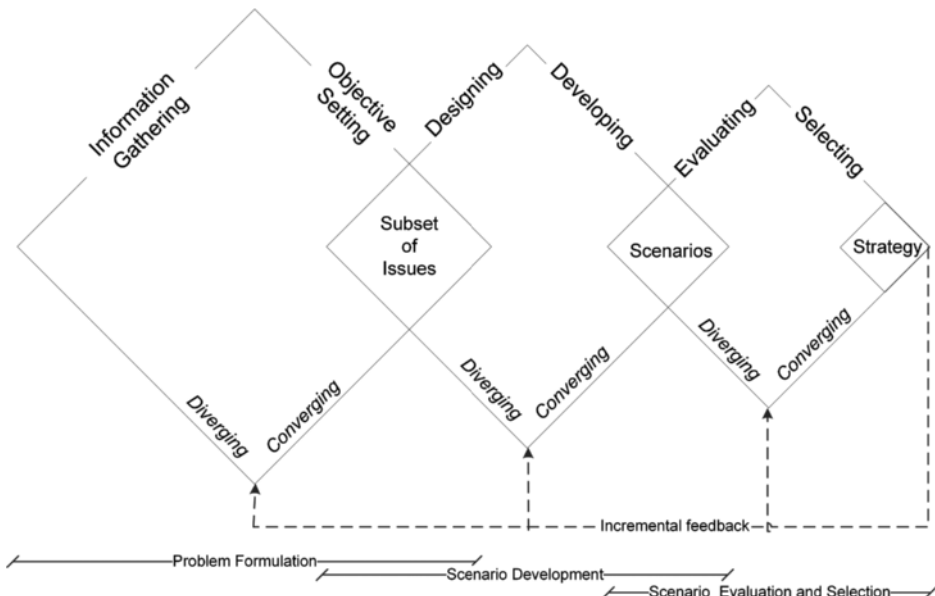


Fig. 1.2 Dynamic view of the strategy-making stages of planning

(Dennis & Wixom, 2002). They have been described in planning theory as the opening up and closing down of knowledge claims, or claims of understanding causal relationships (Rydin, 2007).

Divergence is associated with the types of idea generation involved in gathering information about the planning problem, designing scenario components in terms of what Wegener (2001) refers to as bi-space (i.e. space and its attributes) and determining indicators for evaluating scenarios. Divergent thinking is applied during problem formulation to determine the system boundaries and during scenario development to brainstorm about how to design and evaluate the performance of models (Vennix et al., 1992). The tasks of combining, deciding and implementing typically succeed idea generation (Lamm & Trommsdorff, 1973). These tasks are associated with convergence. Convergence deals primarily with the choice making involved in setting objectives based on a subset of key planning issues, developing scenarios and determining appropriate models for exploring issues and selecting a strategy.

Authors have noted that cycles of divergence and convergence are repeated across these strategy-making stages (te Brömmelstroet & Schrijnen, 2010). Through these cycles, planning issues are identified, explored and ultimately selected, thereby, generating dynamic pathways of issue adaptation that bridge the various strategy-making tasks. Finding a balance between idea generating and selecting dynamics is fundamental to informed strategy making. The delays and financial costs associated with failed attempts at reaching agreements on strategies are staggering (te Brömmelstroet, 2017b). Considering the potential implications of failed strategy making, there seems to be a legitimate need for dedicated strategy making support. Yet, recent years have not seen a significant increase in the uptake of dedicated support in the form of PSS during these strategic stages. The following section explores why.

1.3 Planning support systems and their underlying models

Three decades ago Britton Harris (1989) outlined a move beyond the limited capacity of GIS to support the professional tasks of planners when he introduced the concept of PSS. Since then numerous PSS have been developed often as the one-off outputs of scientific studies. Early projects include STRAD (Cartwright, 1992), the strategic advisor for dealing with wicked, unstructured problems, UrbanSim (Waddell et al., 2003) to model land use and transport interactions and What if? (Klosterman, 1999) to support scenario-based collaborative planning. These and other PSS have been documented in several edited books (see Geertman et al., 2017; Geertman et al., 2015; Brail, 2008; Geertman & Stillwell, 2003a; Brail & Klosterman, 2001).

PSS tend to outperform other GIS-based tools in terms of the provision of knowledge, communication of knowledge and support in the analysis of knowledge (Vonk & Geertman, 2008). Despite their knowledge-handling capabilities, these technologies by and large have not entered the realm of non-routine, strategic planning tasks. Strategic tasks rely heavily on dynamic processes of communication and knowledge exchange for learning about a spatial system. Supporting these process-related aspects is important when confronted by divergent knowledge and priorities that compel actors to frame issues differently (Matos Castaño, 2016). Instead, PSS tend to focus on the substantive aspects of a planning issue – e.g. easing traffic congestion, prioritizing land uses (Pelzer et al., 2014). Dealing with well-defined, routine problems is more straight forward since these tasks rely on 'expert knowledge [that] is relatively unambiguous but subject to error because of the extensiveness of the "facts" involved' (Batty, 1995, p. 6).

Consequently, PSS that have successfully made the transition to practice typically support routine planning tasks (Couclelis, 2005). According to a study by Vonk et al. (2007b), out of 58 analyzed PSS, 55 systems supported problem exploration and the analysis of trends while only one system supported problem formulation tasks. The functionality of the PSS that were evaluated focused considerably more on analyzing and modelling information than on supporting communication and information gathering, two process-related aspects of problem formulation. Such analyses of PSS use have become associated with the task-technology-user fit model (Vonk, 2006; Goodhue & Thompson, 1995). This model provides insight into the influence of method and tool components on both the process and outcome of group work (Geertman, 2013).

Present-day research examining the relationships between planning task, planning support and users is centered on understanding the *usefulness* of these tools. PSS usefulness is determined in part by the fit between the support function of the system and the planning task, or its utility, and in part by the perceived usability of the utility function (Pelzer, 2017). Several studies provide discussions of usefulness, particularly concerning the potential communication and learning benefits of PSS use (see Shrestha, 2018; Pelzer et al., 2016; Pelzer et al., 2014; Goodspeed, 2013a). Communication and learning are two process-related aspects that I have attempted to link in the previous section to the dynamics of divergence and convergence. Communication and learning have been measured at both the group and individual level. Both levels of analysis are important since planning as a communicative activity is grounded both in the collective common sense of the group acting together and in the knowledge and consciousness that autonomous individuals gain through self-reflection (Alexander, 1988 as cited in Klosterman, 1997). While the term usefulness hints at a bias toward the potential benefits of PSS use, Pelzer (2015) identified two negative influences of these tools on group

processes. He explains that PSS can obstruct communication processes and can steer rather than facilitate the topic of these discussions.

Consequently, there are a number of factors that inhibit PSS from adequately supporting communication and learning processes. PSS are perceived to be 'overly detailed and precise, mathematically complex, rigid, slow, unintelligible and not transparent enough to be compatible with the unpredictable and dynamic nature of strategy-making processes' (te Brömmelstroet, 2017b, p. 78). These factors contribute to a mismatch between the supply of PSS and the demand for planning support, particularly in coping with increasingly complex planning tasks (Geertman, 2017). It has been stated in the past that GIS-based planning support 'can, at best, only provide useful information with respect to the somewhat narrower aspects of typical planning problems' (Harris & Batty, 1993, p. 190). PSS with high explanatory power and sophisticated modelling capabilities play an important but somewhat limited role in the provision of knowledge that is useful for complex planning practices. Considering the non-routine nature of strategy making, it can therefore be deduced that many of its strategic tasks fall outside the supportive capabilities of many PSS.

The studies summarized above point to an omission in the current debate concerning the *contextualization* of PSS. Several recent empirical studies into PSS applications conclude that the usefulness of PSS is largely context dependent (Russo et al., 2018; Pelzer et al., 2016; te Brömmelstroet, 2013; Biermann, 2011). The notion of contextualization takes into account that no two planning processes are alike and therefore no two PSS applications should be the same. Relevant context-specific factors that determine the potential influence of planning support include user requirements and capabilities, characteristics that distinguish a given planning process and policy context and the content of planning issues that are included in the elaboration of the planning problem (Geertman, 2006; Walker, 2002).

Contributions from the aforementioned literature can be summarized in three main objectives for PSS contextualization. The first objective pertains to the adaptation of relevant knowledge about planning issues that can be used as input for PSS. According to Biermann (2011) two 'soft' sides of the PSS technology package that come to the forefront are the diversity of planners' issues and needs and the wicked planning problems that are difficult to describe using the formal language of computer processing. Research that explores these two soft sides of development is underrepresented in the current body of PSS literature. The second objective deals with the development of support methods, both formal and informal, that can be used in triggering the adaptation of planning issues (i.e. demand-driven PSS development). Already for some

years now there has been the sentiment among scholars that for planning to recover its future-oriented mission, 'PSS should incorporate a variety of suitably chosen models and [informal] techniques' (Couclelis, 2005, p. 1368). In a similar sentiment, Geertman (2008) states that PSS should be attuned to the knowledge, skill level and technical know-how of users and should incorporate interdisciplinary means for handling issues, for example, by connecting the social to the spatial.

The third objective relates to the determination of appropriate underlying models for exploring a specific planning problem. Research over the past four decades has shown that there is little to be gained from the use of comprehensive, sophisticated models when dealing with wicked planning problems (te Brömmelstroet et al., 2014; Lee, 1994, 1973). Modellers should resist the urge to extend their models to incorporate advancements in information and communications technology (ICT) and new data sources and instead build simpler exploratory models for identifying the salient characteristics and informing debate about these problems (Batty, 2013). Particularly in the realm of strategy making, simplicity, transparency and flexibility have become buzzwords for the development of PSS and its underlying models (te Brömmelstroet, 2012). Approaches for determining useful models and informal techniques for supporting the process-related aspects of strategy making, however, are limited.

Fulfilling these three research objectives may require a 'structured dialogue between planning actors and PSS developers' (te Brömmelstroet & Schrijnen, 2010, p. 18). The remainder of this section explores the notion of a structured dialogue first by discussing the underlying models of PSS and then by introducing existing approaches that aim at structuring dialogue around the act of model building.

1.3.1 The underlying models of PSS

Couclelis (2005) positions the use of models for spatial planning within four interrelated realms of dynamic change (see Figure 1.3). At the center is the spatial system whose internal dynamics are susceptible to the influence of external forces from both its environment – the world beyond its boundaries – and the planning system. The planning system is made up of actors who decide on actions intended to affect change in the spatial system. Models – conceptually speaking – capture the salient features of dynamics occurring in the spatial system to inform the actions taken by the planning system. A spatial model is a simplified representation of a spatial system or part of it used for 'description, explanation, forecasting or planning' (Wegener, 2001, p. 3). However, the uncertainties present in the three other realms – the spatial system, the planning system and the environment – cast a shadow of doubt over the reliability of the model (Couclelis, 2005).

As a consequence of this uncertainty, models have a limited range of support capabilities, particularly in supporting the future-oriented mission of planning. Models are not capable of making long-term forecasts in the context of nonlinear complex systems, but they can be invaluable when used to explore alternative planning scenarios (Wilson, 2018). Still, several persistent technological and human factors related to the underlying models of PSS block their application in this strategic work. Lee (1973) was early to point out the wrongheadedness of models owing to the tendency of their structures to mask relationships between variables and to constrain what can and cannot be modelled. This issue of transparency is at the center of the PSS adoption conversation. Transparency is considered an essential prerequisite for planning support use, as it relates to both the acceptance of reliable data used as inputs and the outputs of modelling that are meaningful (Geertman & Stillwell, 2004).

A significant part of this lack of transparency relates to how PSS and their models are developed. Scholars describe a fundamental miscommunication whereby PSS experts and model developers lack knowledge about the application domain while potential PSS users are not familiar with the technology (Russo et al., 2018; Vonk & Geertman, 2008). On the one hand, if developers are the main system modellers, the underlying models they develop typically reflect the strict technical rationality of the PSS development process (te Brömmelstroet & Schrijnen, 2010; Vonk & Geertman, 2008; Vonk,

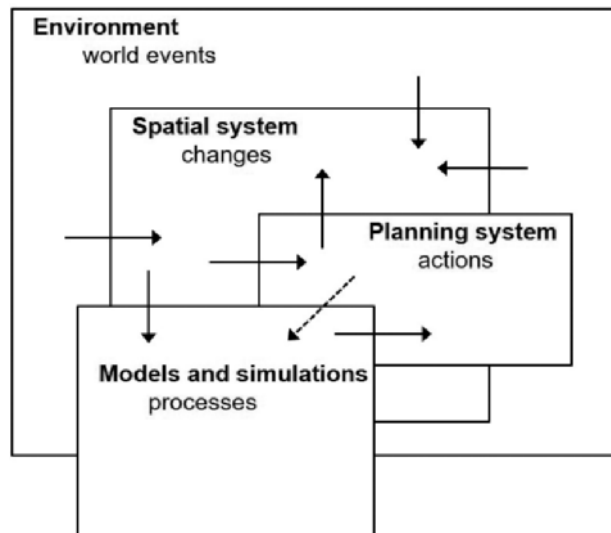


Fig. 1.3 Four interrelated domains of change with a superimposed arrow indicating the potential contribution of planning actors to model building (adapted from Couclelis 2005)

2006) rather than the communicative rationality of the planning process (Pelzer et al., 2014; Healey, 2010; Booher & Innes, 2002). On the other hand, the problems planning actors encounter in the political realm do not translate easily to the scientific techniques of models and simulations. This is because wicked planning problems are not easily quantified and there is no scientific basis for their solutions (Armstrong and Hobson, 1973 in Duke, 2011). Consequently, fundamental choices such as which model to use are often left to the 'experience, interests and expertise of the research team rather than the characteristics of the problem or system to be modelled' (Prell et al., 2007, p. 1). Thus, I have superimposed an arrow in Couclelis' figure indicating the potential contribution of actors within a planning system and their context-specific knowledge in the development of simpler, more transparent models that these actors, in return, may consider useful for informing their debate.

1.3.2 Intertwining strategy making and model building

One suggestion to open channels of communication between planning actors and planning support experts is to engage in an integrated process of mutual adjustment between planning support and planning practice (Geertman, 2006). Socio-technical PSS development is an example of such an approach. According to this approach, the optimality of a system is context dependent and is the outcome of a social process based on sharing views and knowledge (Vonk & Ligtenberg, 2010). PSS developers, experts and end-users are key contributors to socio-technical PSS development approaches according to van Delden et al. (2011). The system developers are designers of the PSS architecture. Planning support experts, often scientists, balance conceptual choices of how to represent main processes in models with pragmatic considerations of available data, knowledge, the problem definition and resource constraints. Planning actors, who are the intended end-users of these systems, set the context and define the planning problem. As owners of planning problems, planning actors can help to define the problem space by expressing and mapping their knowledge and preferences of planning issues (Janssen et al., 2006; Arias et al., 2000). Some key planning actors have been identified as planning professionals, GIS specialists, executives, professional stakeholders and citizens (Vonk et al., 2007b). However, most studies that have applied a socio-technical approach limit the scope of actor participation to executives (i.e. project leaders), domain experts, GIS specialists and other planning professionals (see Shrestha, 2018; Biermann, 2011; Vonk & Ligtenberg, 2010; te Brömmelstroet & Schrijnen, 2010).

Mediated Planning Support (MPS) builds on these socio-technical principles in its introduction of model building as a means of engaging domain experts in a structured dialogued (te Brömmelstroet & Schrijnen, 2010). MPS pays particular attention to the underlying models of PSS. It applies collaborative modelling techniques such as group

model building (GMB) and mediated modelling. These modelling techniques serve to elicit descriptions of complex systems from experts as a means of building understanding and commitment (see also Voinov & Bousquet, 2010). Next to socio-technical PSS development approaches, co-design principles have been applied to determine PSS requirements, validate components and test prototypes with end users (C. Pettit et al., 2014). Here, co-design is applied as a means of rapid system development and testing where requirements are incomplete and constantly changing. Co-design practices seek out understandings of users and contexts of use that are deemed to be critical, particularly at the front end of design (Stappers, 2006). The fuzzy nature of the front-end of a co-design process leaves it open to change. This openness makes it a good fit to applications in the realm of spatial strategy making as a flexible approach for dealing with wicked problems without a clear end goal.

1.4 The problem statement and research questions

To improve the uptake of PSS, numerous conceptual studies on PSS adoption point to the need for better contextualization. Considering the increasing complexity of scenario-based spatial planning, PSS contextualization in this thesis takes issue with the growing demand for support of divergent and convergent dynamics across multiple strategy-making tasks. These dynamics are responsible for the adaptation of planning issues into content for scenarios, objectives underlying these scenarios and indicators for evaluating scenarios based on the results of modelling and simulation. This thesis also attempts to develop new modelling concepts that approach cities as complex and adaptive spatial systems 'instead of just adding more variables to existing models' (Vonk & Geertman, 2008, p. 162). From a methodological viewpoint, PSS contextualization can benefit from a pragmatic research approach that engages both the conceptual and practical experimental schools of PSS research and that tests abstract concepts in both control-rich and context-rich settings (te Brömmelstroet, 2017b). Practical experimental studies are used to test methodological techniques and procedures based on abstract ideas (concepts) that attach meaning to content (Geertman, 2013). So far, there are not many practical studies into how a PSS contextualization process could or should take shape.

The forthcoming chapters of this dissertation have both a conceptual and practical aim. The conceptual aim is to shed light on the dynamics of strategy making that are supported or inhibited by the use of planning support. The practical aim is to develop and test methods that facilitate the participation of different actors in the contextualization of planning support. These two aims are formulated into a central research question:

How can planning support be designed to fit the context-specific requirements of spatial strategy making?

This question is broken down into four sub-questions that give direction to the studies included in this dissertation. These are:

RQ1: What are the dynamics that require support during strategy making and how does tool use influence these dynamics? (Chapter 2)

RQ2: How do different conditions of use influence PSS performance? (Chapter 3)

RQ3: What are the potentially useful elements of gamified planning support for strategy making in group settings? (Chapter 4)

RQ4: How can game co-design contribute to the elicitation of knowledge that is needed to contextualize models used by PSS? (Chapter 5)

The final section of this introduction outlines the research methodology as it is applied in the subsequent thesis chapters.

1.5 Research methodology and thesis guide

To engage in pragmatic PSS research, I chose to adopt the practice of co-design as described in Sanders and Stappers (2014). In his own dissertation, te Brömmelstroet (2010b) describes the role of design in the pragmatic research approach stating that the products of design-oriented research are 'prescriptions that are *tested* in practice and *grounded* in scientific knowledge' (p. 14 - emphasis in original). Design-oriented research provides a means with which to study the iterative shaping of an object through a process defined by its context without the necessity of a clearly-defined problem (Schön & Rein, 1994). The design process, therefore, provides an adaptable and open-ended means for researching the dynamic, strategic stages of spatial planning.

Figure 1.4 depicts three approaches to co-design – probes, toolkits and prototyping – in relation to the phases of the design process. The functions of probes and toolkits overlap. They both to varying degrees evoke inspiring responses from participants and steer processes of participation, reflection, facilitation and bridging ideas and scenarios for the future (Sanders & Stappers, 2014). Prototyping brings together insight gained from the other approaches for testing and refinement into a more mature product.

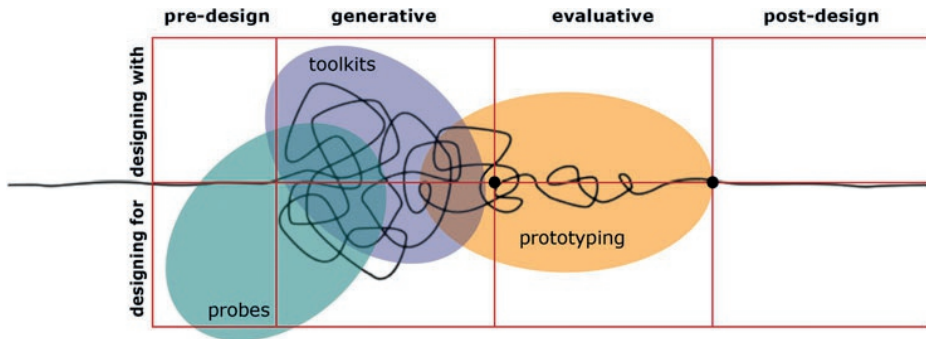


Fig. 1.4 *The three approaches of the co-design framework (Sanders and Stappers 2014)*

The application of the co-design methodology varies throughout the dissertation and is therefore described separately in the summary for each chapter. Efforts to answer the research questions introduced in Section 1.4 will be conducted in two parts. The first part aims at generating principles for the design of contextualized planning support interventions while the second part applies these principles in the design of game-based support for creating a structured dialogue during strategy making and for linking the outputs of strategy making to model building.

Chapter 2: Mapping the Use of Planning Support in a Strategy-Making Session

The work described in Chapter 2 extends applications of the complexity sciences to study the potential influence of different planning support methods on strategy making. This toolkit testing approach permits the exploration of relationships between planning issues and potential links to planning support in relation to divergent and convergent dynamics. The main contribution of the paper is a more dynamic means of analyzing the influence of planning support on strategy making than that of current analyses that are primarily oriented towards support for a specific planning task and user requirements. Findings relevant to the PSS bottlenecks highlight the need for simpler, more flexible and transparent planning support, an argument also made by te Brömmelstroet (2012).

Chapter 3: Tables, Tablets and Flexibility: Evaluating planning support performance under different conditions of use

Following the study of the potential influence of different types of planning support on communication dynamics, Chapter 3 probes strategy making to examine the influence of different use conditions on the performance of the Urban Strategy PSS. Varying levels of facilitation flexibility and different types of visualization hardware are used to create the use conditions for testing three hypotheses about PSS performance and

usability. A controlled setting with students is constructed to detect relative differences in scores based on the performance variables of idea generation (divergence), ideational quality (as a measure of convergence), process quality, and usability. Findings indicate that for contextualizing such tools to the complex reality of strategy making, there is a need for greater support of individual work and for structured ways of applying more adaptive PSS.

The second half of the thesis deals with the design and testing of two PSS prototypes based on the principles of simplicity, flexibility and transparency in addition to the structuring of divergent and convergent dynamics. Prototyping can structure the dialogue between planning actors and modelers by both making user requirements concrete and communicating what the PSS can(not) do (te Brömmelstroet, 2012). Thus, prototyping may be essential for a successful intertwining of strategy making and model building. Building on feedback from planners themselves, te Brömmelstroet (2010a) states that PSS should be based on transparent assumptions and function as laboratories for collective experimentation and learning through play. Thus, two game-based support methods are introduced as means of engagement through playful experimentation. They support two channels of communication and learning relevant to both strategy making and model building – the channel among planning actors within a planning system and the channel between planning actors and planning support experts. These two prototyping studies (Chapters 4 and 5) are summarized below.

Chapter 4: Gamified Strategy Making: Is it useful?

Despite the rapid growth of games and gamified experiences dedicated to the field of planning too little attention has been paid to the demand for these support tools in actual practice (Ampatzidou et al., 2018). Chapter 4 describes a study on the usefulness of a gamified planning support method. A tangible game was designed for the study since high-tech simulation games for planning are at risk of losing their ‘power to improve communication between competing stakeholders’ (R. Duke, 2011, p. 13). Gamification is thought to introduce motivational affordances to non-game processes that are capable of inducing the psychological outcomes that can lead to desired changes in behavior (Hamari et al., 2014). This chapter builds an argument for the gamification of strategy-making processes and then dissects the game elements of the planning support method for closer examination. The game elements are described using 10 design principles for motivational affordance and subsequently analyzed in terms of their impact on divergent and convergent dynamics. In the case of this study, issue divergence, issue convergence and parameter divergence are the sought-after behavioral outcomes that should emanate from effective multi-level communication

and learning about the spatial system under investigation. Following the pragmatic research approach, use of the gamified method in a controlled setting is evaluated to ensure the internal validity of results and in two case studies for external validation in context-rich settings.

Chapter 5: Critiquing Parameterized Assumptions in the Third Space: A game co-design method to elicit context-specific knowledge

While Chapter 4 focuses on supporting strategy making, Chapter 5 examines the other side of the coin, which is actor engagement in model building. More specifically, the chapter explores game co-design as a means of eliciting knowledge from actors about a specific spatial context for model-building purposes. While numerous methods for eliciting knowledge from experts about complex systems exist, there is a paucity of methods dedicated to the elicitation of knowledge about complex *spatial* systems from system experts for model-building purposes. The study derives a set of requirements for a game co-design method based on prior knowledge elicitation methods originating from disciplines such as system dynamics modelling. Divergence and formalization are identified as two dimensions of knowledge elicitation that are significant both for the scenario development stage of strategy making and for model building. These two dimensions were used to examine the usefulness of a game co-design method that elicits area-specific knowledge from planning actors about the strategic redevelopment of a business and science park in the Netherlands.

The implications of these four studies are bound together in Chapter 6 through a discussion of key findings, reflections on the conceptual and methodological advancements of this dissertation and recommendations for future research. Table 1.1 provides an overview of the research questions explored in each chapter along with a summary of planning support methods and co-design approaches applied in each of the empirical studies.

	Central Research Question: How can planning support be designed to fit the context-specific requirements of spatial strategy making?			
Chapter	2	3	4	5
Research Question	What are the dynamics that require support during strategy making and how does tool use influence these dynamics?	How do different conditions of use influence PSS performance?	Does the gamification of strategy making provide a useful means for supporting divergence and convergence in group settings?	How can game co-design contribute to the elicitation of knowledge that is needed to contextualize models used by PSS?
Empirical Study	Session with case study	Controlled experiment with 133 students	Prototype testing in controlled experiment with 60 students and sessions with 2 case studies	Prototype testing in three sessions with a case study
Co-design Approach	Toolkit	Probe	Prototyping	Prototyping
Planning Support Method	Preliminary modelling Sketching Flashcards Facilitation Dialogue	Urban Strategy PSS	Gamified strategy making	Game co-design
Article Title	Mapping the Use of Planning Support in a Strategy-Making Session	Tables, Tablets and Flexibility: Evaluating planning support performance under different conditions of use	Gamified Strategy Making: Is it useful?	Critiquing Parameterized Assumptions in the Third Space: A game co-design method to elicit context-specific knowledge
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Table 1.1 Research Overview



Chapter 2

Mapping the Use of Planning Support in a Strategy-Making Session

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Abstract: This chapter introduces an alternative means of evaluating the performance of planning support systems. These systems that were originally developed to support the professional tasks of planners have been assessed primarily based on their task-technology-user fit. During the tasks of early planning phases, planning actors attempt to adapt planning issues out of their 'wicked' state and into clear directions for action by means of communication. The search for better support of adaptations that result from these complex, multi-actor communications requires a more dynamic means of evaluating planning support. To gain a deeper understanding of planning support use during actor communications, we conducted a strategy-making session using preliminary modelling, sketching, facilitation and traditional support tools. We visualized the session as a network of communicative interactions and identified planning support involvement during key issue adaptations. Findings show that preliminary modelling and sketching were often used when identifying planning issues and adapting them into attributes for scenario development and that unsupported dialogue was used to communicate in depth about project objectives. We conclude that introducing planning support as needed in formats that are both visual and easy-to-understand may add value to strategy making in workshop settings.

2.1 Introduction

The introduction of the complexity sciences to the study of cities has generated new insights into highly networked urban environments where everything seems connected to everything else (Healey, 2007; Castells, 1989). Only recently has the planning of these environments been examined rigorously from a complexity perspective (Portugali, 2012b). Research on complexity in planning has been compiled in publications under the header of complexity theories of cities (CTC) in edited books and in a 2016 theme issue of *Environment and Planning B* (Sengupta et al., 2016; de Roo et al., 2012; Portugali et al., 2012; de Roo & Silva, 2010). Contributions within these publications describe the open, multi-actor, nonlinear processes of the communicative rationality model that currently dominates European planning, and argue for an openness to the diversity of knowledge that new actors bring to spatial planning (de Roo & Rauws, 2012). Others caution that too much structuring of these communicative planning processes may produce too simple results (Sijmons, 2012).

Planning support tools that were traditionally designed to address reasonably clear problems have not made a successful transition to these complex, multi-actor contexts (Albrechts & Balducci, 2013). This reality has opened the current discussion on the added value of planning support systems (PSS) in practice. PSS have been defined as 'geoinformation technology-based instruments that incorporate a suite of components (theories, data, information, knowledge, methods, tools...) that collectively support some specific parts of a unique professional planning task' (Geertman, 2008, p.217). PSS provide useful support during problem exploration and analysis tasks, but expert users consider them of limited added value to problem formulation tasks (Vonk, 2006). This may explain why most PSS have not found their way into the early phases of planning (te Brömmelstroet & Bertolini, 2008). Issues early on are still open and must be sorted out, making early planning phases dynamic and unpredictable (te Brömmelstroet, 2017a, 2010a).

The added value question has prompted PSS scholars to investigate the task-technology-user fit (Pelzer et al., 2015a; Geertman, 2013; Vonk et al., 2007b; Goodhue & Thompson, 1995) to understand the necessary conditions of use of PSS in complex, collaborative contexts. Several recent studies of PSS use have been conducted in workshop settings. These studies emphasize a growing need for environments that nurture communication and shared learning rather than the continued contribution of more analytical information to practice (Champlin et al., 2018b; te Brömmelstroet, 2017a; Pelzer, 2017; Pelzer et al., 2015b; Pelzer et al., 2015a; Goodspeed, 2013a). Such environments should support the exchange of knowledge about planning issues in

a manner that gives form to problems at stake (Geertman, 2006). Communication is central to sorting out the different types of knowledge needed to define and locate problems within a complex causal network (Rittel & Webber, 1973). Tool use must be balanced in a way that supports group communication without disrupting it (Pelzer et al., 2015b) allowing actors to move planning issues effectively out of the problem mess – a process we refer to in this paper as *issue adaptation*.

Determining the ‘fit’ of support tools may require a more dynamic means of evaluating planning support performance than what the task-technology-user fit provides. Geertman (2013) proposed a new planning support science (PSScience) research agenda for exploring how to organize planning support instruments (e.g. modelling and visualization tools) in relation to the planning actors (and their knowledge), issues and tasks in place- and time-specific contexts that constitute complex systems. This agenda links planning support research to the growing field of CTC research, and in doing so, it provides a framework for the study described in this paper. We attempt to move ‘beyond metaphor’ in the application of complexity thinking (Sengupta et al., 2016, p.970) to examine the fit between planning support tools and planning issues in a strategy-making session.

We pose the following research question: Which planning support tools are in use when adaptations of planning issues occur? This question explores how actors organize the use of various planning support options at their disposal and for what purpose. Concepts from social systems and complex adaptive systems (CAS) theories are employed here to identify the paths of issue adaptation within a communication network. We also consider how to align planning support development with the context-specific knowledge of planning actors. It is thought that exposing developers to this knowledge during the development process improves the substantive quality of the support (te Brömmelstroet & Schrijnen, 2010).

This paper continues in the next section with an introduction to systems theory which underpins this study followed by a discussion of planning support tools that may be well-suited to support planning at an early stage. After introducing the case study, we describe the strategy-making session and method for analyzing the data that was collected during the session. We then report and discuss the empirical findings. Finally, we conclude the paper with a discussion and reflections on both the potential and limitations of the analysis method as it relates to the advancement of professionally supported collaborative planning sessions.

2.2 Systems theory

In their seminal paper, Rittel and Webber (1973) attributed 'wicked' problems to networks of interconnected systems that make problem centers less apparent. For them, interconnectedness was the source of ill-defined planning problems that cannot be solved, but at best only re-solved. Planning actors attempt to resolve their problems by linking issues to actions and their consequences in a future-oriented 'what if...' examination of possible interventions in a spatial system (de Roo & Rauws, 2012). This process can also be couched in terms of the strategy-making tasks of problem formulation and scenario development (te Brömmelstroet & Bertolini, 2008; Couclelis, 2005). During strategy making, issues must evolve out of their wicked state and become clear directions for action. According to van de Riet (2003), this involves linking the current situation to possible futures and defining evaluation criteria and constraints for making a selection. Through extensive communicative interactions (Luhmann, 1990), planning actors send and receive information as they set a framework for choice making. While planning literature offers ample explanations of *why* actors in a planning system must make choices, social systems and CAS theories shed light on *how* these choices are made.

Choice making determines the well-being of a system and its ability to adapt. A planning system must 'learn' through its communication interactions and adapt its discourse. To trigger these adaptations, planning actors require efficient means of communicating their many planning issues without being left with too few from which to select. Issue selection is, therefore, a balancing act since 'systems that are too simple are static and those that are too active are chaotic' (Miller & Page, 2007, p.129). One mechanism a system uses to strike this delicate balance is *contingency* (Luhmann, 1995). Contingency preserves the complexity of a system by making choices that momentarily reduce complexity. It recognizes the possibility of an alternate path, had other choices been made (Holland, 1995). To determine these paths, different types of knowledge (see Albrechts & Balducci, 2013) are required along with effective means for choice making. Dennis and Wixom (2002) describe how actors reach agreement on the best alternative(s), first by generating a wide variety of options (divergence) and then selecting from these options (convergence). Divergence can be encouraged in a way that reveals actor issues and preferences, or what Harris (1989) calls 'hidden or undeveloped criteria of choice' (p.88). Convergence can then be facilitated to reach agreement on key objectives. When these dynamics of divergence and convergence are executed effectively, contingency can give quality to pure quantity (Luhmann, 1990).

When faced with an elaborate set of choices, actors may adopt mechanisms that structure the choice making process (Miller & Page, 2007). Planning support tools can serve this purpose. These tools demonstrate agency, or the ability to 'manipulate, at least partially, their outputs so as to influence the actions of others' (Miller & Page, 2007, p.95). Couclelis (2005) relates this to the way actors use models to feed information into decisions that influence a spatial system. Planning support tools may, however, have undesirable disruptive impacts on system adaptation. Means of planning support may be unsuited to the task (Webster, 2010) or their outputs may produce too much order, which is at odds with the unpredictable and uncertain nature of planning (Sijmons, 2012).

By now, we know well that planning processes do not neatly follow a 'sequence of well-defined steps' (Bishop, 1998, p.189). Planning support must be designed in a way that provides structure while permitting nonlinearity. There is some indication that nonlinear adaptation can be triggered at discrete moments. According to CAS literature, systems exhibit lever points, i.e. 'points where a simple intervention causes a lasting, directed effect' (Holland, 2006, p.6). Still, scholars know little about how to utilize lever points. Samoilenko (2008) explains, one would require a methodology to search for the lever points, the capability to affect them and upfront knowledge about the impacts the lever points may have. These issues are significant and require research that extends beyond the scope of this paper. But we can already begin to scratch the surface through experimentation and observation that are guided by existing theory.

In his earlier work on lever points, Holland (1995) explained that all CAS have two adaptation properties in common that are well-known in economics, the multiplier effect and the recycling effect. The *multiplier effect* occurs when a resource passes from node to node catalyzing a chain of adaptations and is potentially transformed in the process. Mazhelis et al. (2006) explains, 'the cumulative effect of an initial change (interaction) is increased (multiplied) as the change is propagating through the network' (p.7). Applied to strategy making, we can imagine an issue being triggered to 'firework' into multiple measurable or location-specific attributes that can be used in scenario development.

The *recycling effect* uses the same raw input that, cycle after cycle, is captured and reused at each node of a path (Holland, 1995). As strategy making evolves from a discussion over wicked problems to clear directions for action in the spatial system, recycled planning issues can be traced back to (nearly) every communicative interaction in the adaptation path. The recycling effect may indicate the efficiency of the system in capturing and reusing issues during adaptation. Efficiency has been used as an indicator in PSS and decision support systems (DSS) studies to measure the influence

of information technology on group or organizational performance in decision making (see Yamu, 2014; Shim et al., 2002).

2.3 Early-stage planning support

We define planning support as ‘all the professional help in the form of dedicated information, knowledge and instruments that intentionally improve planning processes... and/or planning outcomes’ (Geertman, 2013, p.51). This definition originates from PSS literature, but it acknowledges that PSS are one of many planning support tools. It can generally be said that these systems are developed with a specific professional task in mind (Pelzer et al., 2015a; te Brömmelstroet, 2012; Geertman & Stillwell, 2004; Goodhue & Thompson, 1995) and therefore, are not well-suited for other tasks. In this section, we review tools that are known to support group work and, therefore, may support communication during strategy making in a more dynamic manner. By dynamic, we mean the reciprocal adjustments that users, tasks and supporting tools must make to be responsive to a specific context of time and place (Geertman, 2013). We explore the potential contribution of these tools to the strategy-making tasks of problem formulation, objective setting and scenario development.

2.3.1 Preliminary modelling

Dialogue between developer and intended user is the cornerstone of group modelling approaches (e.g. system dynamics modelling, mediated modelling) and is now becoming an integral part of PSS development (te Brömmelstroet & Schrijnen, 2010; Voinov & Bousquet, 2010). According to te Brömmelstroet and Schrijnen (2010), ‘the focus shifts away from the development of a technically more sophisticated support system, towards a process of PSS development that is intertwined with the planning process itself’ (p.3). Modelling provides a structured process for working out the most important issues of a problem (van den Belt, 2004). It can be used to determine what factors or variables to include or exclude from the system boundary by stimulating the divergent thinking that is necessary during problem formulation or model conceptualization (Vennix et al., 1992).

A preliminary model can be developed prior to the beginning of a workshop based on input from interviews (van den Belt, 2004). Since the model is in an early state, end users can recognize and critique assumptions relatively easily. Critiquing and redesigning flawed parts of the model can lead to group ownership and creativity (Vennix et al., 1992). Preliminary modelling entails more than working out relationships of abstract concepts. Ford and Sterman (1998) hypothesized that ‘pushing experts to

describe relationships at the simulation model level helps them to clarify and specify their knowledge more than they would if we worked at a more abstract level' (p.313).

2.3.2 Traditional tools

While a continued openness to new PSS technologies is desirable (te Brömmelstroet et al., 2014), there are limitations to their capacity to support planning in the strategic phases. At a time when computers were new to the collaborative planning arena, Shiffer (1992) observed that participants would often opt to use more passive media like flipcharts in meetings. Integrating such traditional tools with new technologies may create the social learning environment that enables productive interaction (Al-Kodmany, 2001). Sketching is a tool that invites participants into the design process by using visualization as a common language and in doing so, promotes dialogue and provides accurate design information for later applications (Al-Kodmany, 2001; King et al., 1989). Sketching on a map can be used to rapidly work out spatial relationships between elements without knowing their geographic positions (Hopkins, 1999). It is a visualization method whose strength lies less in the accuracy of information it conveys than in its capacity to stimulate communication.

2.3.3 Facilitation

Janssen et al. (2006) state that the more uncertainties involved in the task, the more dialogue should be facilitated. Facilitation involves dynamic interventions to manage relationships between actors, tasks and tools, to structure tasks and to contribute to achieving meeting outcomes (Hayne, 1999). Hirokawa and Gouran (1989) explain that facilitation should address both procedural and substantive problems. This is necessary since process and outcome are often blurred (Innes & Booher, 1999). *Procedural* facilitation deals with agenda setting, time keeping and ensuring that discussion remains relevant. *Substantive* facilitation manages the use of available information for making group choices. Noting that tool use often interrupts communication, Pelzer et al. (2015b) added *tool-related* facilitation to this list. They concluded that facilitation performs an important function in PSS workshops to encourage tool use while also providing sufficient space for group discussion.

Dialogue itself is considered a means of planning support. The Habermasian notion of reflexive dialogue refers to the collective interpretation of the world and agreement in a specific context using the richest available resources to test assumptions (Healey, 1999). If well-managed, dialogue can produce high-quality agreements, flexibility, learning and change (Connick & Innes, 2003), all of which are needed – though difficult to attain – in complex, multi-actor contexts. On this basis, we suggest that the aim of planning support, particularly during strategy making, is not to support a specific

planning task or user need, but rather to support dialogue in its handling of planning issues. We hypothesize that by untethering the components of the task-technology-user fit, we will see patterns of planning support use that do not fit neatly within a specific planning task or correspond to an individual user need.

2.4 Case description and methodology

The purpose of the empirical study was to examine the issues planning actors discuss in a strategy-making session when using different types of planning support. In this section, we describe the case study, the strategy-making session and the analysis method.

2.4.1 The Turfkade case

The 134-hectare Turfkade business terrain sits in Almelo, a city in the eastern part of the Netherlands, roughly 30 km from the German border. The terrain primarily consists of mid-sized industry and producers, some of which own their own buildings while others rent. The terrain, which dates back to the 1800s, received its last significant modernization in the 1970s. Currently, the combined impact of industrial sector decline and proliferation of younger commercial terrains in the region has pressured the local government to invest in revitalization. The Province of Overijssel initiated the Turfkade project by providing support and financing through *Herstructureringsmaatschappij Overijssel* (HMO), a company established to stimulate investment in the industrial terrains, business parks and inner cities of Overijssel.

To gain a better grasp of the planning problem, we visited the business terrain three times, interviewed the account manager, a city planner, the director of HMO, and a Province official who were involved in the project, reviewed project documents and conducted a project maturity assessment with the account manager. The results of the maturity assessment primarily indicated that: stakeholders were not involved in the revitalization project and were unaware of the potential impacts of the project. Furthermore, the planners were interested in utilizing planning support tools but so far, no support technologies or visualization techniques had been used. Based on the assessment results, we suggested to conduct a strategy-making session with the account manager and some representatives of the business owners. During the session, we would collaboratively develop a model that the account manager could use to communicate project plans and receive feedback from a larger group of business owners.

2.4.2 The strategy-making session

We use the PSScience research agenda (Geertman, 2013) as a framework for describing the Turfkade strategy-making session as a system that consists of planning actors, issues, tasks and their relations in a given context of time and place (see Table 2.1):

- The *planning actors* included the account manager, a business owner¹ (referred to as the Turfkade actors), a session facilitator (first author) and a chauffeur (second author) who facilitated interaction with the model. Following the action research method Baskerville (1999), the authors performed a role similar to organizational consultants. According to this method, researchers intervene in the problem setting and engage in participatory observation.
- We derived the three *planning tasks* from studies of strategy making (te Brömmelstroet & Bertolini, 2008; Couclelis, 2005), non-routine planning tasks (Batty, 1995) and policy making in multi-actor contexts (van de Riet, 2003): problem formulation, objective setting and scenario development.
- The *planning issues* were the products of the three strategy-making tasks. Throughout the strategy-making tasks, issues originating from the planning problem adapted into project objectives, attributes of the planning issues, scenarios and indicators for assessing the scenarios.
- The *planning support instruments* included tools known to support multi-actor communication (see Section 2.3): preliminary modelling, sketching, flashcards and procedural, substantive and tool-related facilitation.
- We conceptualized the *factual role of planning support* as planning support involvement in the successful adaptation of a planning issue during one or more communication interactions.
- The context of planning support was the Turfkade strategy-making session
- Prior to the session, the second author programmed a preliminary model of the Turfkade terrain on a Google Maps base layer using JavaScript, which the first author then used to create a buildings layer. This layer consisted of building quality ratings that the account manager sketched on a paper map of the project area. The building quality ratings ranged from one (old or poor condition) to five

1 A second business owner was scheduled to participate but cancelled on the day of the session.

(new or good condition). The preliminary model included an area deterioration indicator that was generated using the building quality ratings and a building proximity measurement. The proximity measurement factored the quality ratings of neighboring buildings into the quality rating of a given building to indicate the perceived quality of the area.

Table 2.1 *Adapted version of the PSScience research agenda (Geertman, 2013, p. 53) to describe the components of the Turfkade session.*

	Substantive categories	Turfkade session
Elements	Actors involved	Account manager, business owner, facilitator, chauffeur
	Planning issues (in categories)	Planning problem, issues, objectives, attributes, indicators, scenarios
	Planning tasks	Problem formulation, objective setting, scenario development
	Planning support instruments	Preliminary modelling, sketching, flashcards, facilitation (including procedural, substantive, tool-related)
Relations	Factual role of planning support	Successful adaptation of planning issues

The strategy-making session was not scripted. Instead, the first and second authors planned a sequence of planning tasks: problem formulation (issue divergence), objective setting (issue convergence) and scenario development (attribute divergence). They also decided in advance when to introduce the different planning support tools. The second author opened the session by introducing the preliminary model. The Turfkade actors worked with the area deterioration indicator as an ice breaker for the problem formulation task. Next, flashcards were introduced for objective setting. The Turfkade actors were each asked to choose flashcards corresponding to their four most important issues (collected during the four interviews). If their main issues were not on the card, they could write in new issues on blank flashcards. The Turfkade actors were instructed to use these main issues as a basis for setting three objectives. Due to time restrictions, the Turfkade actors were asked to select the two most important objectives to work with for scenario development. Finally, they were instructed to sketch possible solutions that met the two objectives as descriptively and creatively as possible. The authors determined when to provide substantive, procedural and tool-related facilitation as needed.

2.4.3 Analysis of the session

To conduct the analysis, we developed a network that depicts the communicative interactions that occurred during the strategy-making session. These interactions are

organized into a network of nodes linked together by edges. The nodes represent issues of the Turfkade project and their adaptation into objectives, attributes, indicators and scenarios, each originating from the project problem: 'degradation of the terrain'. In addition to linking the issues and their derivatives, the edges provide directional information (what did an issue become?) and identifying information (what type of planning support was involved?) about the adaptation of an issue. Directional information is important to record because the way people communicate does not follow the linear progression of steps (Engeström, 2011). We define adaptation as the transformation of an issue into something characteristically different than its previous state. When issues can be classified in a new category or are clarified using more specific or descriptive detail, they qualify as issue adaptations.

We captured the communicative interactions among the planning actors using written records on session materials, audio-visual recordings and photography. We began the analysis with an open coding (Strauss & Corbin, 1990) of the session transcript, first by hand and then using ATLAS.ti 7 software. During open coding, we marked each instance in the transcript where an issue was communicated and color-coded them by issue category. Next, we transferred these instances in chronological order to an Excel spreadsheet and categorized them based on strategy-making task. Once each instance was registered, we interpreted the links between the instances. If the same issue was communicated multiple times without adapting, we identified it as a *recurrence* and labeled it with an asterisk. We then visualized this chronological list of issues and the communicative interactions (edges) that link them in network form using Microsoft Visio 10.

Next, we returned to the audio-visual recordings to cross-check the type of planning support that was being used during each adaptation and labeled the edges correspondingly. If no planning support tool was in use during the adaptation, we labeled the edge 'dialogue'. In the next section, we demonstrate the use of the network by describing four adaptation paths before introducing the entire network.

2.5 Findings

2.5.1 Path 1. Contingency

Figure 2.1 illustrates contingency in the network of communicative interactions. Divergent communicative interactions about the planning problem 'degradation' produced 31 issues.

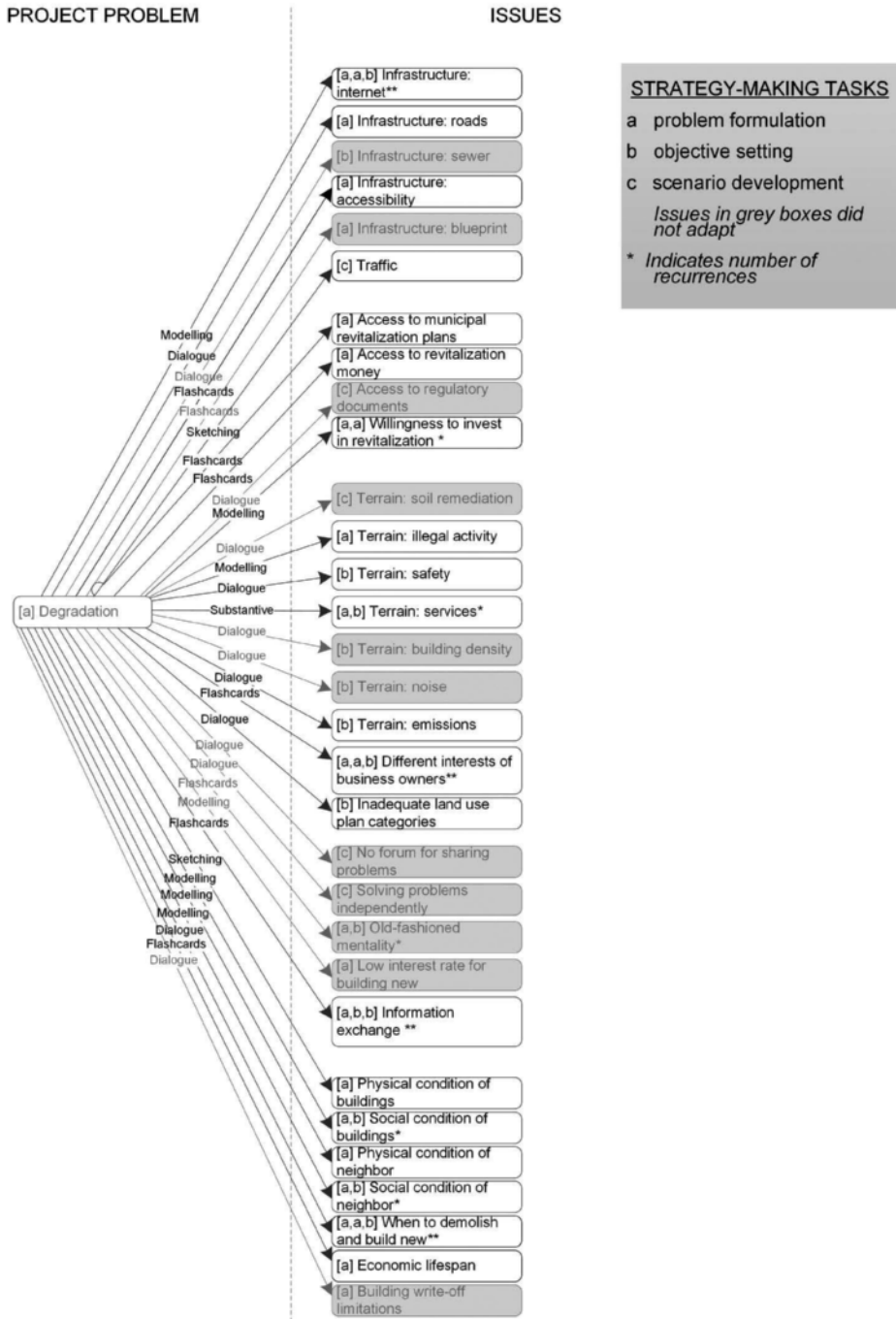


Fig. 2.1 Contingency path with issues that did not adapt marked in grey.

Convergent communicative interactions resulted in the selection of 20 issues for adaptation, while 11 issues (grey boxes) were not selected. Of the planning support options, preliminary modelling and flashcards were both associated with the most issue adaptations. Each of these options was used in the selection of six (6) issues followed by dialogue (5), sketching (2) and substantive facilitation (1). Procedural and tool-related facilitation were not observed in any of the adaptations. Dialogue (8) was most often associated with issues that were not selected, followed by flashcards (2) and preliminary modelling (1). This means we found the involvement of one of the planning support options in three-quarters (0,75) of the issue selections, while we associated dialogue with the majority (0,73) of the issues that were not selected. The contingency path also shows that of the five issues that appeared in the communication network during scenario development (c), only one of these issues ‘traffic’ underwent adaptation.

2.5.2 Path 2. Multiplier effect

The second path (Figure 2.2) illustrates the multiplier effect, where adaptations to the issues ‘infrastructure: internet’, ‘infrastructure: roads’ and ‘traffic’ occurred. During problem divergence, these issues were selected with the use of preliminary modelling, dialogue and sketching, respectively. Adapting these issues into attributes involved the use of sketching only, except for the issue ‘traffic’ during which procedural facilitation was also in use.

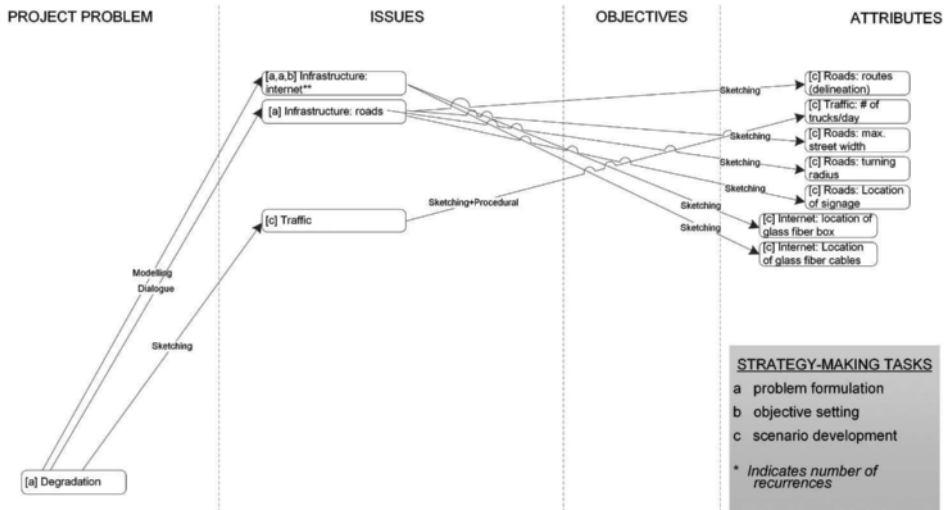


Fig. 2.2 Multiplier effect showing issues that adapted into several attributes using sketching and procedural facilitation.

While sketching, the Turfkade actors had difficulty identifying attributes for scenario development. Therefore, the facilitator and chauffeur explained the type of information they required:

Facilitator: We need to know what we should create in a virtual environment to help you discuss with the other stakeholders using these [the model].

Chauffeur: If we know what the needs are for each building...then we can say, good, but at this moment there is an owner who needs internet and because of that the area does not work well. We can calculate this. So, he moves out and someone else moves in to that ...with a need for traffic and the traffic is organized well there. Then you can look at how it works.

Business owner: Measurement of the delivery intensity, how easily can I access the main road? ...and that clients [of one business] can exit easily without being blocked by freight trucks that make deliveries twice a day randomly to the neighbor.

Subsequently, sketching was used while the Turfkade actors identified four attributes of the 'roads' issue ('road width', 'route delineation', 'turning radius of trucks' and 'location of signage') and one attribute of the 'traffic' issue ('number of trucks per day'). They sketched two attributes of the 'Internet' issue ('location of fiber optic cables' and 'location of a new fiber optics box').

2.5.3 Path 3: Recycling effect

In the third path (Figure 2.3), flashcards and dialogue were used when the issues 'when to demolish and build new' and 'economic lifespan of a building' were selected. Using only dialogue, both of these issues were recycled into the scenario assessment indicator 'building age greater than 25 years'. Subsequently, the facilitator and chauffeur supported the Turfkade actors substantively to create a scenario 'remove all buildings with expired economic lifespan'. The path that resulted in this scenario indicates a link between dialogue and recurrence. The Turfkade actors repeatedly communicated about the issue 'when to demolish a building' throughout the session, first during issue divergence:

Business owner: I would wipe a third of the buildings off the map...but they provide ambiance. When do you part ways with the old [buildings]?

Then during issue convergence using dialogue (recurrence 1):

Account manager: when do you say farewell to a building, when its economic lifespan is over?

And again, during objective setting using dialogue (recurrence 2):

Account manager: If you take it [old multi-business facility] out, you revitalize. You give it a new function. It could be that you get a piece of land back where you can do what you want if you arrange it. Then you are a step further.

Adapting into the indicator 'building age less than 25 years' using dialogue:

Account manager: There should be a rule, after 25 years, knock it down. Then you don't hold on to anything and you have plenty of space.

Subsequently, the indicator 'building age less than 25 years' adapted into a scenario using substantive facilitation:

Chauffeur: I have no problem if we develop a plan...where half of the terrain must go...And we conclude that we must demolish a portion and then that portion can continue on a smaller scale.

Account manager: That's what needs to happen here.

Path 4: Combined multiplier and recycling effects

Another path (Figure 2.4) demonstrates how a combination of the multiplier effect and the recycling effect integrates issues, an objective, attributes, an indicator and a scenario into a single path. First, preliminary modelling triggered a discussion about the issue 'willingness to invest in revitalization'. Subsequently, the Turfkade actors used dialogue to adapt this investment issue into the objective 'strategies for co-financing'.

During objective setting, the actors adapted the scenario 'designated areas for rented and single owner buildings' into the indicator 'revenue'. Then during scenario development, the abovementioned issue and indicator were adapted into a set of attributes using both sketching and procedural facilitation:

Account manager: What is an attribute here?

Chauffeur: That is the where and how much.

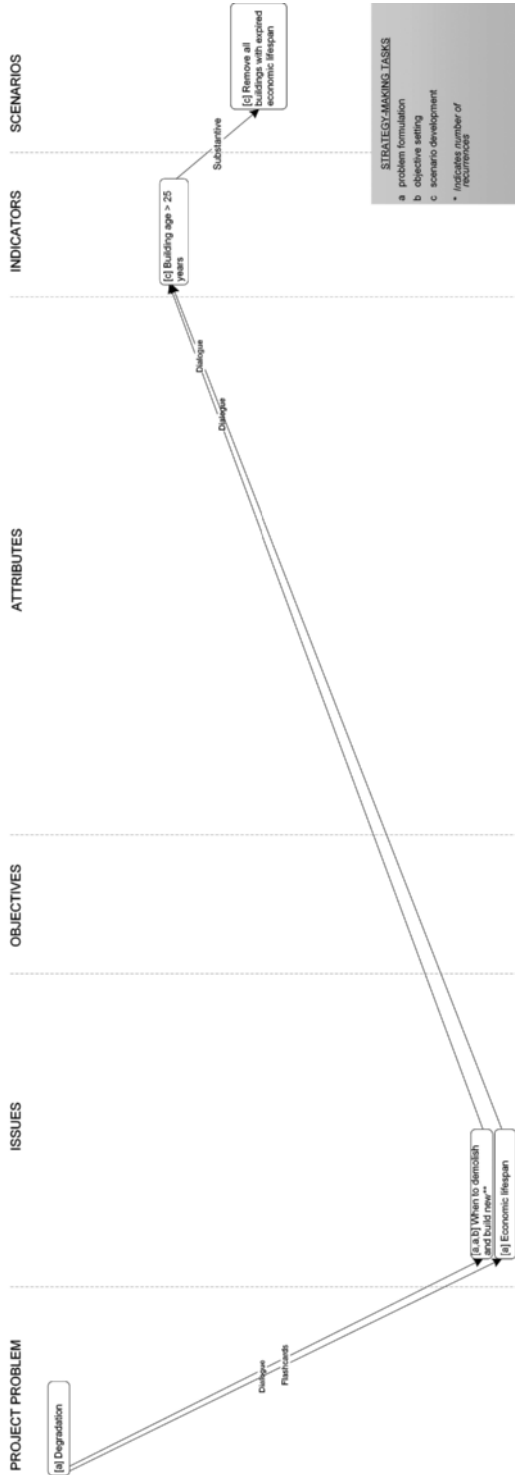


Fig. 2.3 Recycling effect showing the adaptation of issues from project problem to scenario.

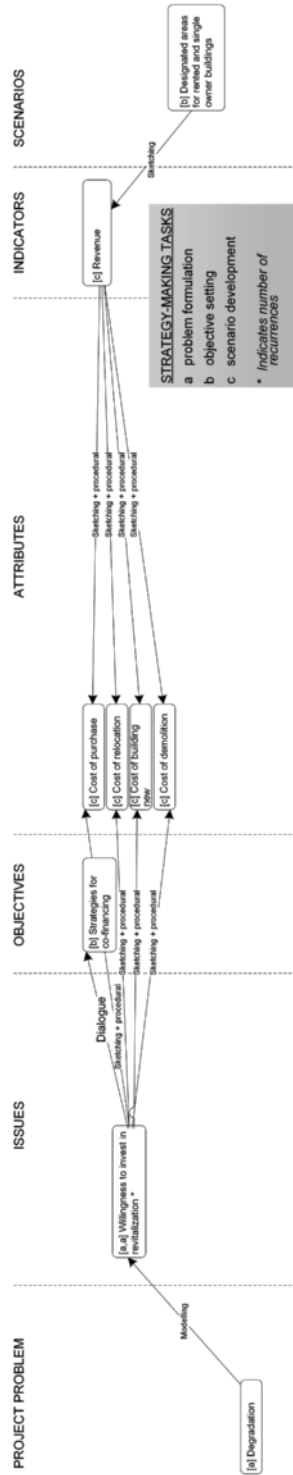


Fig. 2.4 Combined multiplier and recycling effects shown in a single path view.

Account manager: Yes, the attribute is money... '1' is cost to buy, '2' is cost to relocate... and '3' is cost to build new.

Business owner: In use. Demolish. [pointing to different buildings on the map]

Account manager: Cost to demolish.

The mapping of the communication network shows that these attributes were generated nonlinearly. The scenario was created during the objective setting task prior to generating attributes which occurred in scenario development. It is also worth mentioning that preliminary modelling and sketching (two support tools that are strong in communicating knowledge visually) were in use during the adaptation of the non-spatial issue 'willingness to invest in revitalization' into several non-spatial attributes pertaining to costs and the indicator 'revenue'.

2.5.4 Map of all adaptations during the session

Looking across the complete network of communicative interactions (Figure 2.5), three trends emerge. First, almost every recurrence in the communication network occurred in the contingency path and all but one of these recurrences involved the use of planning support. For example, during a discussion about the 'physical condition of a building' and 'physical condition of neighboring buildings', sketching and the preliminary modelling apparently triggered recurrences of two non-spatial issues 'social condition of building' and 'social condition of neighboring buildings'. This discussion led to a significant shift in focus for the entire session. An excerpt from this discussion illustrates the shift:

Account manager: A building can bring down the quality of its surroundings. And the physical [condition] is significant, but the social [condition] is also significant.

During objective setting one actor repeated the issue again stating:

Account manager: What kind of crowd does [building] attract and how much responsibility, but with the multi-business facility there is no accountability because everyone is a renter.

This discussion over the social and physical condition of buildings also demonstrated nonlinearity. Soon after their introduction into the conversation (while using preliminary modelling), the Turfkade actors expressed these issues as measurable attributes (e.g.

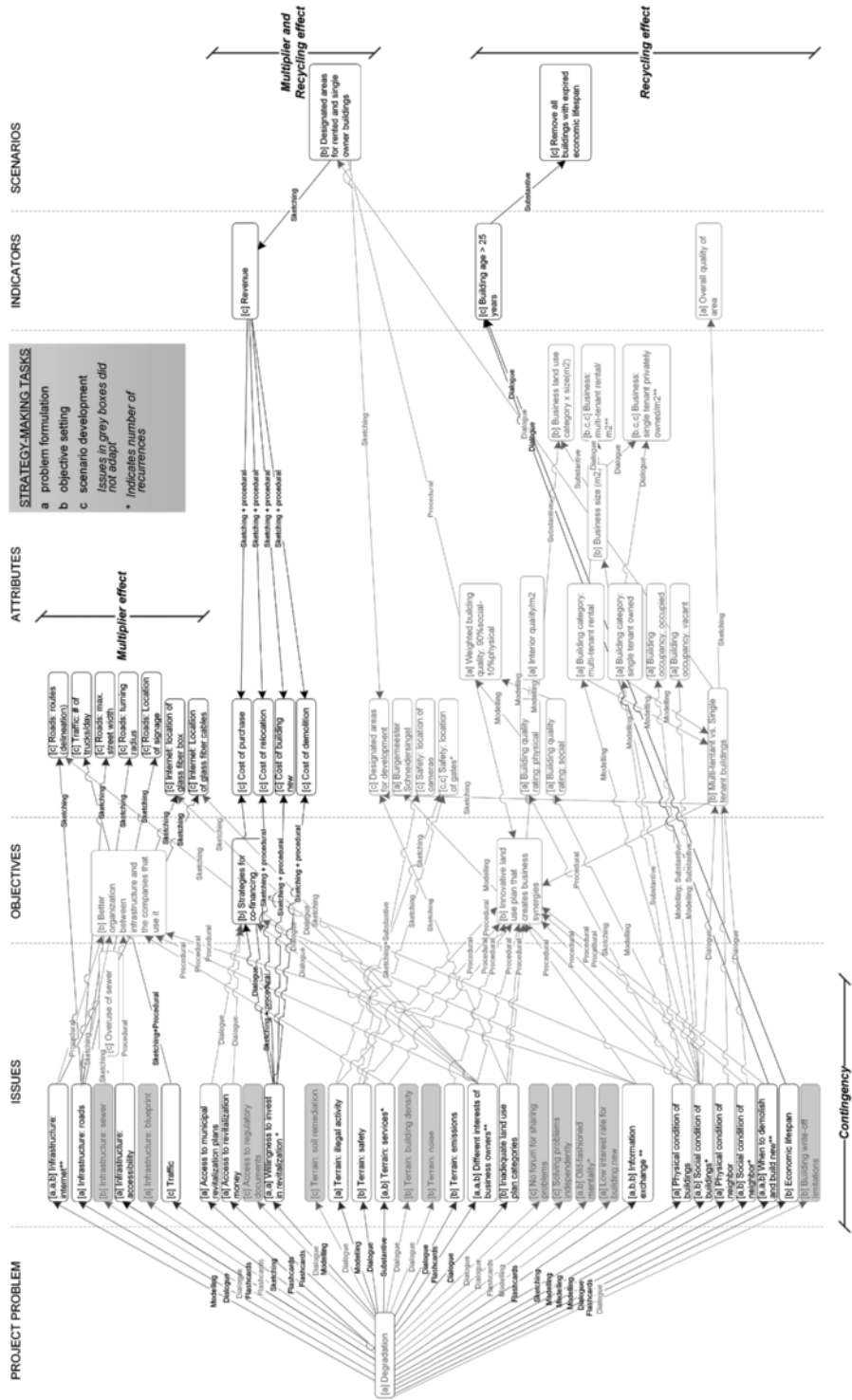


Fig. 2.5 Network of communicative interactions with the four paths highlighted Discussion.

'building category: multi-tenant rental', 'building occupancy: vacant'). During objective setting, the discussion reverted to abstracter terms, comparing one building type to another, i.e. attribute: 'multi-tenant vs. single-tenant buildings'. Subsequently, this attribute was linked to the objective 'innovative land use plan that creates business synergies', the indicator 'overall quality of the area' and the scenario 'designated areas for rented and single owner buildings'. Modelling, sketching, procedural facilitation and dialogue were all involved in the recycling of this attribute.

Second, a large number of issues were involved in objective setting and were linked to one or more of the three objectives. Other than the use of procedural facilitation to help structure the objective-setting task, the actors did not use any planning support tools. Instead, they relied on unsupported dialogue.

Third, we observed that when actors communicated about the issue 'multi-tenant versus single-tenant buildings' (while using preliminary modelling), they also created the scenario 'designated areas for rented- and single-owner buildings'. This occurred early in the workshop during the objective-setting task. Subsequently, the Turfkade actors sketched attributes and generated an indicator for assessing the scenario. This trend shows an efficient path of issue recycling that was triggered by the use of preliminary modelling.

2.6 Discussion

PSS performance so far has been evaluated largely based on the task-technology-user fit of these systems. Given the 'communicative turn' (Healey, 1996) in planning, reciprocal adjustments (Geertman, 2013) must be made between tasks, tools, users and their knowledge to support communication in complex, multi-actor settings. Complexity thinking contributes a new perspective that is focused on the dynamics of communication between actors and across multiple planning tasks. In this study, we have dissected multi-actor communications and examined them at the communicative interactions level to better understand the use of planning support in a strategy-making session. We explored the question: Which planning support tools are in use when adaptations of planning issues occur? We were able to identify several characteristic adaptation paths and the presence of planning support at key moments during these adaptations.

Findings from the contingency path show that issues communicated through unsupported dialogue in most cases were not selected for adaptation. This means the issues were communicated once, but as the session progressed, the actors did not refer to them again. It is possible that unsupported dialogue lacked the structure necessary to

focus communication on the most important issues surrounding the area degradation problem. Difficulty gaining clarity about planning issues is a common challenge in planning and it contributes to the well-known wicked problems that characterize the early phases of planning. A need for structure might also help to explain why most of the issues that did adapt were identified using planning support of various types. However, once key issues had been identified (issue divergence), the actors seemed to rely heavily on dialogue to gain agreement on their project objectives (issue convergence). This could be seen in the many recurrences of issues linked to the project objectives, indicating that these issues were discussed several times. Here, it seems that actors used dialogue to work out their different understandings and knowledge about a planning issue.

Findings from the multiplier effect path show that some issues were adapted early into model attributes. Although the actors mostly used preliminary modelling or sketching to generate these attributes, more traditional tools were also used to generate the issues from which the attributes emerged. It is conceivable that the use of visualization techniques, particularly the preliminary model, oriented communication towards issues that are more suitable for spatial modelling, perhaps to the detriment of critical non-spatial issues. Geertman (2006) explains we should be aware that some issues lend themselves better to quantitative analytical or modelling support than other issues. On the other hand, working with visual, map-based support methods may provide an effective means to identify important issues, both spatial and non-spatial, and to communicate about them concretely. A good example of this occurred while working with the preliminary model. The actors decided that the physical condition of buildings was not the only factor causing area degradation. Undesirable activities in and around some buildings were also a critical factor. While sketching, the actors diverged to identify multiple interrelated attributes and indicators. In some instances, procedural facilitation was necessary to formulate the indicators. It seemed that the Turfkade actors were not accustomed to communicating about their issues in quantifiable or measurable terms.

In the recycling effect path, we observed efficiency in the communication interactions. Through the combined use of dialogue, flashcards and substantive facilitation, the actors managed to develop a basic but complete scenario. This efficiency finding may indicate that a balance between support tool use and group communication (Pelzer et al., 2015b) was achieved. The combined multiplier and recycling effects path shows that issue adaptations can be even more efficient when both are triggered. The communicative interactions in this path adapted in a nonlinear, non-sequential way. The combination of structure and different visualization methods apparently enabled the actors to move both efficiently and nonlinearly through the strategic tasks of problem

formulation and scenario development. Looking at the entire strategy-making session in a single network view, it seems that issues that could be easily clarified and related to the spatial system were quickly adapted using visual, yet easy-to-understand support (i.e. preliminary modelling and sketching) while the less clear, more conceptual issues required unsupported dialogue, and at times facilitation, to adapt. These findings indicate the need for applications of planning support methods in multiple formats to support efficient communication during strategy making.

Together, these findings suggest that factors of structure, visualization and simplicity implemented on an as needed basis may be significant to consider when developing planning support. Since actors may be easily overwhelmed by sophisticated models, softer introductions to the technology like working with preliminary models may prove beneficial. We know from literature that these softer visual methods support divergent thinking, which is needed both for problem formulation and for the production of accurate design information (Al-Kodmany, 2001; King et al., 1989). Furthermore, the active participation of the facilitator and chauffeur in the strategy-making session provided these project 'outsiders' contextual information that may be useful for the further development of models and other planning support.

While the design of this study does not permit us to draw conclusions about causality between planning support tool use and communication, the findings do offer an example of how planning support performance can be viewed from a dynamic, issue-oriented perspective. From this perspective, planning support can be evaluated based on its capacity to stimulate adaptations at the communicative interactions level – potentially contributing to progress in a collaborative planning context.

2.7 Reflections

In this study we were interested mainly in the mechanics of how issues adapt during dialogue and also when planning support is used. Further research that engages planning and policy-making theory may provide explanatory power to the observations we have reported. The method we developed to investigate planning support use at the communicative interactions level could be reproduced in sessions with more participants. For large multi-actor group settings, the manual mapping methodology presented in this paper may become too tedious. Online software packages such as Gephi (<https://gephi.org/>) and NetworkX (<http://networkx.github.io/>) generate sophisticated network analyses and visualization that may better support the interpretation and communication of large data sets. It would also be interesting to use such software to compare networks of communicative interactions across multiple strategy-making sessions or

projects. Such a comparison could help to build theory about causal relationships between planning support and issue adaptations. Nonetheless, it is not too soon to begin experimenting with the principles of structure, visualization and simplicity and incorporating them into games, methods and techniques to provide flexible, customized support to actors during the early phases of planning projects.



Chapter 3

Tables, Tablets and Flexibility:
Evaluating planning support system
performance under different
conditions of use

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Abstract: There is a widely shared view that planning actors require planning support systems (PSS) that can be easily adapted to changing project demands packaged in easy-to-understand formats. Recent studies confirm this and show that PSS are increasingly user-friendly. Still, little is known about under what conditions they add value in practice. This paper tests three hypotheses about PSS performance and usability in an experimental study. 133 students were exposed to different conditions of PSS facilitation flexibility and visualization hardware (tablets versus mactable). They performed identical strategy-making tasks consisting of divergence and convergence. In addition to measuring the quantity and quality of ideas, we assessed perceived process quality and usability of the PSS. Tablet groups performed better on idea generation and evaluated their solution to the planning problem more positively. In contrast, mactable groups performed better on ideational quality and evaluated their experiences in terms of collaboration, more positively. Groups under indicator flexibility performed best in idea generation, while groups under no flexibility received the highest score for ideational quality. Process quality scores were highest under no flexibility followed by indicator only flexibility. Findings suggest tablet use may be more effective for idea generation, an outcome of divergence, while mactables better support group communication, a key aspect of convergence. The study confirms the need for tools and methods that fit both individual and group work. Findings also indicate that identifying structured ways of applying adaptive PSS to the complex world of planning practice may be key to contextualizing such tools.

3.1 Introduction¹

The question of supporting planning and policy making with dedicated information is an old and important one (e.g. Gudmundsson, 2011; Geertman, 2006; Innes, 1998; Weiss, 1977; Harris, 1965). However, the question is as poignant as ever. The challenges planners face are vast and complex. Yet, contrary to traditional, modernist beliefs about planning, these challenges can likely not be addressed by simply conducting more research and providing more scientific information (Hajer et al., 2010; Rydin, 2007). Research about the relationship between science and policy has revealed that the application of scientific insights in policy making is far from straightforward (e.g. Amara et al., 2004; Weiss, 1977). In order for information to be fruitfully applied it has to connect to the interactive, participatory and fuzzy nature of planning (cf. Klosterman, 1997). Consensus about what knowledge is used is at least as important as its scientific validity (van de Riet, 2003).

Dedicated tools are increasingly available to support planners in their tasks, captured under the header of Planning Support Systems (PSS). These can be defined as: ‘... geo-information technology-based instruments that incorporate a suite of components that collectively support some specific parts of a *unique professional planning task*’ (Geertman, 2008, p. 217 - emphasis in original). To do so, they actively feed explicit/codified information (often provided by computer models) into planning processes. PSS, especially those that are designed to support the more strategic planning phases, are increasingly designed as visually attractive and interactive platforms that aim to structure the mutual exchange of knowledge among a diverse group of actors.

However, although many waves of excitement about such instruments have been observed, they play a modest role in planning practice, at best (Vonk et al., 2007a; Klosterman, 1997). A persistent mismatch between the information models and architectures of PSS (Vonk and Ligtenberg, 2010) and the information needs of strategy-making processes seems to stifle this long-anticipated progress. Planners keep seeing PSS as overly detailed and precise, mathematically complex, rigid, slow, unintelligible and not transparent enough to be compatible with the unpredictable and dynamic nature of strategy-making processes (Vonk et al., 2005). Vonk et al. (2007a), for instance, show how Dutch provinces have a rather low uptake of geo-information based systems, whereas Goodspeed (2013b) emphasizes that there are vast differences in the extent to which American metropolitan planning organizations have support tools embedded in their

1 This introduction is partly adapted from Pelzer, P. (2015) *Usefulness of Planning Support Systems: Conceptual Perspectives and Practitioners' Experiences*. In *Planning*, Groningen. Reprinted with permission of the author.

organization. Next to the *frequency* of usage, little is also known about the *quality* of usage and their added value for planning practices.

Recent scholarship has begun to study this omission by paying dedicated attention to the performance of a PSS in planning (Pelzer, 2017; te Brömmelstroet, 2017a; Goodspeed, 2016a; te Brömmelstroet, 2013). This includes for instance the extent to which tools influence the learning that takes place (Goodspeed, 2016a). One important measure is the usability of a PSS, for instance operationalized as the transparency or understanding of the underlying model (Pelzer, 2017).

In this paper we are building on this conceptual work to understand the performance effects of two recent trends in PSS applications in the Netherlands. First, PSS are increasingly used not as desktop applications but as part of a dynamic workshop or process in which a range of stakeholders engage. Both te Brömmelstroet and Schrijnen (2010) and Vonk and Ligtenberg (2010) suggest that the process of developing the underlying model should be both *flexible* and *facilitated*, allowing for input of these stakeholders, for instance in selecting indicators and customizing workspaces. Following Pelzer et al. (2015b), such flexible facilitation strategies can have profound effects on PSS performance. Second, planning includes a range of tasks that influence the role of the PSS. This is also casted as the task-technology fit (Goodhue & Thompson, 1995). New visualization technologies that come to the PSS domain include maptables and tablets. They aim to make knowledge more interactive and they can be used in a dynamic workshop setting. Since most PSS studies were done before the advent of such hardware, we know little about how these innovative techniques change PSS performance.

Existing hypotheses about PSS performance are typically the result of testing 'one-off' technologies or academic prototypes used within a specific planning context of a single-case study (Marsden, 2015; C. J. Pettit et al., 2015; Geertman et al., 2013; Demetriou et al., 2012; Biermann, 2011; Geertman & Stillwell, 2009; Brail, 2008; Geertman & Stillwell, 2003b; Klosterman, 2001). Although we acknowledge the merit of this, we argue that the value of such studies increases when they are combined with control-rich studies in which the performance of PSS is systematically measured (te Brömmelstroet, 2013; te Brömmelstroet, 2009). Levy (2008) similarly states that hypothesis-generating case studies (i.e. typical PSS case studies), 'examine one or more cases for the purpose of developing more general theoretical propositions, which can then be tested through other methods, including large-N methods' (p.5). Here, we aim to test the two above-mentioned PSS trends in an experimental study.

Section 3.2 introduces the key terms and concepts that informed the design of the study. In Section 3.3 the study is introduced. The results are presented in Section 3.4. The paper closes with a discussion of the findings followed by conclusions and reflections.

3.2 Operationalization of key terms

According to several authors the incompatibility of rigid, technology-oriented PSS with the flexible and unpredictable nature of planning tasks and needs is rooted in social aspects that cannot be overcome by just improving the computational capabilities of these tools (e.g. te Brömmelstroet, 2012). Strategic urban problems do not have an optimal solution and are increasingly political and contested. Improving the strategic capacity and ability of planning actors requires a process of shared 'enlightenment' and the creation of 'negotiated knowledge' (Gudmundsson, 2011; Healey, 2007; Amara et al., 2004). Consequently, performance measures of PSS have shifted from a strict focus on their technical functionality to their performance with respect to specific planning tasks. PSS performance comprises two interrelated concepts, utility and usability (for further discussion see Pelzer, 2017). According to (Nielsen, 1993), 'utility is the question of whether the functionality of the system in principle can do what is needed, and usability is the question of how well users can use that [utility] functionality' (p.25). Increased attention to usability has resulted in the increased use of PSS applications on tablets and the development of specialized collaborative planning hardware, for example the mactable.

In addition to these technological advancements, it is necessary to approach the use of PSS holistically, by both looking at the instrumental characteristics and the process in which the application should be embedded. The effort to embed these technologies in planning practice is part of a socio-technical discussion surrounding the contextualization of PSS (e.g. te Brömmelstroet and Schrijnen, 2010; Vonk and Ligtenberg, 2010). This discussion shows that assessing PSS performance solely on the fit between the technical functionality of a system and the planning task is inadequate. The PSS contextualization debate is broadening the performance discussion to include the *conditions of use*. To the authors' knowledge, the causal relationship between PSS performance and the conditions of PSS use has yet to be explored in an experimental setting. In this section we introduce the process and outcome measures that we use to assess PSS performance during strategy making. We then formulate two hypotheses about how different conditions of use will impact PSS performance and one hypothesis about the usability of the PSS and the session in general.

3.2.1 Dependent variables: PSS performance of strategy-making tasks

In collaborative planning settings, since outcome and process are tightly intertwined (e.g. Innes and Booher, 1999), the application of PSS could (or should) add value to both. Following earlier scholarship (Pelzer, 2017; te Brömmelstroet, 2013), PSS performance can be measured along two outcome dimensions (variety- and quality of ideas) and at two process levels (individual and group).

During strategy making, actors engage in tasks that encourage shared learning and knowledge exchange for the purpose of identifying and structuring a planning problem. The aim is to reach consensus about the planning problem to steer decision making (Carsjens, 2009; Friend & Hickling, 2005). It is crucial that individual issues and interests have been fully explored and differences have been resolved creatively (Innes and Booher, 1999). Following the Group Support Systems (GSS) literature, this can also be couched in terms of 'divergence' (opening up to different ideas or knowledge claims) and 'convergence' (closing down on different ideas or knowledge claims). Dennis and Wixom (2002), for example, explain that actors are encouraged to diverge to generate a variety of ideas and then to reach consensus by converging on the best alternative(s). The assumption is that the quality of ideas selected during convergence is influenced by the generation of a large, diverse set of ideas from which to select.

In planning, the rational, linear and expert-driven approach to producing 'better' decisions has been replaced by a process-driven approach (de Roo & Rauws, 2012; Healey, 2003; Salet & Faludi, 2000). It is generally accepted that improving divergence and convergence can benefit outcomes (Dennis & Wixom, 2002; Phillips & Phillips, 1993). The strategic change that accompanies such tasks often occurs in spurts and is evoked by available resources (Minzberg, 1978). In collaborative planning contexts, these spurts often take place in group settings. Workshops not only provide a group setting for actors to engage in strategy making, but they also serve to test tools and to obtain indications of the potential benefits of tool use (Janssen et al., 2006). This is why numerous studies have explored the influence of planning and decision support technologies in socio-technical workshop settings that involve collaboration between PSS developers and users (see Pelzer et al., 2016; Goodspeed, 2013a; te Brömmelstroet & Schrijnen, 2010; Vonk & Ligtenberg, 2010; Carsjens, 2009; te Brömmelstroet & Bertolini, 2008). The added value of these technologies for group work is well documented, yet little is known about their influence on individual work. Evidence shows that divergent thinking should be performed by 'nominal' groups of non-interacting individuals rather than in an open forum of discussion and idea exchange (Vennix et al., 1992; Lamm & Trommsdorff, 1973). Thus, performance of workshops should be analyzed both at the group level and individual level (cf. Pelzer et al., 2014).

Dennis and Wixom (2002) suggest measuring GSS performance based on factors such as the number of ideas generated, decision quality and participant satisfaction. While counting the number of generated non-redundant ideas is straightforward, measuring decision quality is more difficult. This is because convergence on a decision requires participants to reach consensus on a course of action (Dennis and Wixom, 2002). If consensus is absent, external quality assessment based on ratings can be used (Lamm & Trommsdorff, 1973). In their metastudy on measuring ideational quality, Dean et al. (2006) suggest to use a multidimensional framework to capture the different aspects of possible decision quality such as innovativeness, implementability, completeness and effectiveness (see p. 663). When assessing process quality, particularly in the context of PSS use, explanatory insights can be gained from exploring participant perceptions of the strategy-making process at the group and individual level (see e.g. Rouwette et al., 2009).

3.2.2 Independent variables: Facilitation flexibility and visualization hardware

For optimal performance in planning, PSS would ideally be flexible and user-friendly systems that help the user (1) to select an appropriate method from a toolbox of analysis and forecasting tools, (2) to link these tools to relevant data and (3) to run these models in different graphical and interactive formats (Klosterman, 2001). In addition to these specifications, two significant factors influence PSS performance. These are the degree of flexibility permitted by PSS facilitation (the conditions of use) and the type of hardware on which interaction with the tool is organized.

Facilitation flexibility

Hypothesis 1. Less facilitation flexibility leads to more generated ideas, higher scores on idea quality and higher process satisfaction scores both at the group level (communication, shared language and consensus) and at the individual level (insight) (based on Pelzer et al., 2015b).

In PSS literature, the term 'flexibility' refers both to the extent to which the information model or tool can be influenced by the user (Geertman et al., 2013) or to limitations placed by facilitation on when a PSS is used and what data or visualization method will be used (Pelzer et al., 2015b). The process of model building is to a large extent about making choices (Meadows & Robinson, 2002; Vennix & Gubbels, 1992) and in most PSS many of these choices are made long before the PSS is applied in practice (Vonk & Ligtenberg, 2010; Petch & Reeve, 1999). Newer, more flexible information models solicit user involvement to build queries, select from options and to work with individual characteristics (for examples, see Geertman et al., 2013). In this case, 'flexibility means

that PSS should leave room for assumptions and outcomes to be adjusted in such a way that they can address a (specified) range of planning issues. This can create more room for a real and realistic mutual learning process between PSS developers and planners' (te Brömmelstroet, 2012, p. 103).

In this study, we are primarily interested in the effects of facilitation on PSS performance. Since most stakeholders do not have the technical knowledge to use PSS (Vonk, 2006), interaction with a PSS should be facilitated. In a workshop setting, facilitation mainly involves encouraging PSS use while preventing the PSS from dominating group discussion (Pelzer et al., 2015b). The facilitator can determine the conditions of PSS use (facilitation flexibility), for instance, deciding *when* to engage with the PSS and what indicators to use in a workshop. Khalifa et al. (2002) similarly examined the effects of content and process facilitation restrictiveness on GSS performance. Though facilitation is acknowledged as an integral part of a successful PSS workshop, little empirical research has been conducted into the effects of restrictions on facilitation flexibility. Restrictions on flexibility in this study included both process and indicator (content) flexibility. See Section 3.3.2.

Visualization hardware

Hypothesis 2. Mappable use leads to higher process satisfaction at both the group level and the individual level compared to tablet use (Pelzer et al., 2014).

Whereas initial PSS applications included single-user desktop computers and projectors, there is now a whole gamut of visualization techniques available. These techniques have been developed based on principles of usability and collaboration. Recent additions to these are tablets and maptables. *Tablet* mobile devices provide user-friendly touch interfaces and display applications, often for single-user activities. After Apple brought tablets to the consumer market with the 2010 launch of the iPad, tablets found their way into the domain of planning to help professionals engage with spatial information. A recent survey of 133 planners across California found that respondents most often used email, search engines and GIS/mapping on their mobile devices, i.e. smartphones and tablets (Riggs & Gordon, 2015). Empirical evidence is yet lacking concerning the performance of PSS applications on tablets, for example, for idea generation, individual and group learning or gaining insight about the problem. *Maptables*, on the other hand, were explicitly developed to support collaborative planning situations (for an early application, see Hopkins et al., 2004). Maptables are map-based touch tables 'particularly tailored to support collaborative planning processes' (Pelzer et al., 2014, p.18). Extensive users indicate that maptables facilitate dialogue and shared learning and also benefit learning at the individual level (Pelzer et al., 2014).

3.2.3 Usability

Hypothesis 3. Perceived PSS usability is positively correlated with process satisfaction (see te Brömmelstroet, 2017a).

Participant perceptions of usability are relevant when assessing PSS workshop performance. Usability measures how well users can use the [utility] functionality of a system (Nielsen, 1993). The quality of the interaction between the user and a product is in part determined by the context of use (van der Bijl-Brouwer, 2012). The emphasis on context means that the user experience of a product is in part influenced by the circumstances surrounding its use. In the socio-technical application of PSS, as described by Vonk and Ligtenberg (2010), usability serves as a measure of both process and tool. Therefore, it stands to reason that there is a correlation between usability of the PSS under different conditions of visualization hardware and facilitation flexibility and process satisfaction. A recent study into the links between usability and perceived quality of process supports that these are positively correlated (te Brömmelstroet, 2017a).

3.3 Research design

In this study we randomly assigned groups of planning students to perform a typical strategy making exercise that involved the tasks of divergence and convergence. All groups performed these tasks using an identical setup and received full support of state-of-the-art PSS software, a facilitator and a chauffeur (see Section 3.3.1). Following the three hypotheses, we –again randomly– applied different use conditions that were expected to influence the performance of the PSS: three levels of process and indicator flexibility and two types of visualisation hardware (see Section 3.3.2). We tested to see if these different conditions had systematic effects on the performance of the groups during divergence and convergence tasks (see Section 3.3.3).

The study is populated with 133 Urban Planning Bachelor students of the University of Amsterdam (68) and Utrecht University (65). These numbers gave us the repetition needed to control for many contextual variables and to find systematic differences. We are aware that the research design is not ‘representative’ (for a discussion, see Araujo et al., 2007) of the real-world. Although the students are future planning participants, they do not yet have a (good/bad) history with PSS, power relations or real stakes.

3.3.1 The procedure

Preparation

The research team consisted of two of the authors accompanied by a chauffeur (operating the PSS) and a facilitator (facilitating the group process), the latter two from the

Dutch knowledge institute TNO. In both universities, the experiment was part of a regular course in an undergraduate program in urban planning. The students were briefed in a plenary session. They were informed that they were going to take part in a design competition to develop solutions for a typical urban planning problem: an existing road is causing a number of negative externalities that hamper the development potential of an urban infill location in Utrecht. The PSS was introduced by showing an online video². The students were told that their performance was going to be measured based on the number of ideas they could generate and on the best solution (judged by external experts).

The PSS

Urban Strategy, a state-of-the-art software package that was recently developed by TNO, was used as PSS. It offers a wide range of computer models that cover urban dynamics ranging from traffic to air quality and ground water levels. These models are linked in an architecture that allows the PSS chauffeur to access and run the models from a distant location over a Wi-Fi connection. Each model is simplified to the extent that it can do a complete model run within a minute to test the effect of an intervention. The output is presented in tables, graphs, 2D and 3D maps. The instrument aims to support complex urban strategy-making sessions in practice. The following indicators were the most important during the workshop;

- *Noise (40DB)*: the extent to which traffic and industry causes noise nuisances. This was depicted in a categorized 'contour map', showing how different areas experience different amounts of noise measured in decibels (DB).
- *Air quality (PM10)*: the extent to which traffic and industry effects the air quality. This was depicted in a categorized 'contour map', showing how different areas experience different amounts of air pollution as measured in particulate matter (PM).

In some sessions these indicators were discussed step by step (low facilitation flexibility), in other sessions the participants could choose themselves how to use these indicators (high facilitation flexibility). In this experiment the TNO facilitator, also considered part of the PSS, took responsibility for the interaction among the participants and between them and Urban Strategy. The facilitator followed a strict script for this interaction, which was developed by the researchers. This script was altered per treatment (see Section 3.3.2 for details). The TNO chauffeur communicated with the models.

2 <https://www.youtube.com/watch?v=5QRcnZTKasQ>

The session

Each group was invited to attend the session room in a specific timeslot of 40 minutes. The PSS facilitator welcomed them. Then he repeated the abovementioned challenge of the design competition. Participants were told to develop as many solutions for this as possible, and to select the three solutions that seem most effective, innovative and realistic. After this, the facilitator mainly supervised the group process and was keeping them on time.

3.3.2 The facilitation flexibility and visualization hardware conditions**Three degrees of flexibility**

In GSS literature, Khalifa et al. (2002) examined the effects of content and process facilitation restrictiveness on GSS performance. Similarly, we are interested in how restrictions on facilitation flexibility influence PSS performance. In the sessions, we simulated three different levels of process and indicator (content) facilitation flexibility:

- **None:** the participants were informed that Urban Strategy could perform many analyses, but that they were going to work with the PM10 contour map and the 40Db noise contour map. Also, the process structure of the session was given to them (10 minutes for brainstorming, 10 minutes for calculation, 10 minutes to extend/refine the ideas).
- **Indicator:** the participants were informed that Urban Strategy could perform many analyses. They were presented with more detail on maps showing different indicators such as noise quality, air quality and traffic flows and asked to self-select two to work with. The same process structure of the session was again given.
- **Indicator and process:** the participants were informed that Urban Strategy could perform many analyses. They were presented with more detail on maps showing different indicators such as noise quality, air quality and traffic flows and asked to self-select two to work with. They were also asked to design their own process structure for the session (especially when they wanted to interact with the PSS).

Visualisation hardware

One quarter of the groups were supplied with tablets to conduct the exercise; the other groups worked with a mactable (see Table 3.1). The software was exactly the same for both groups, and in both groups the chauffeur assisted them to conduct impact analyses with Urban Strategy. In the tablet groups the students typically provided answers to a specific question independently, whereas in the mactable groups these specific questions were answered in groups (as visualized on the mactable).

Table 3.1 *The number of students per treatment (amounts in brackets indicate number of groups)*

Visualization Hardware	Degree of Flexibility			Total
	None	Indicator	Indicator and Process	
Tablet	11 (2)	11 (2)	13 (2)	
Mappable	35 (6)	36 (6)	27 (5)	
Totals	46 (8)	47 (8)	40 (7)	133 (23)

3.3.3 Performance variables

In this study we measured three variables of performance during the divergence and convergence tasks. They are operationalized based on a study on the performance of brainstorming groups (Rietzschel et al., 2006) and a paper on performance during Group Support Systems use (Dennis and Wixom, 2002): productivity or number of ideas generated, ideational quality and the satisfaction of the participants (quality of process). We then measured the usability of the PSS and the session in general.

Idea generation

During divergence, each group listed as many ideas as they could come up with on a blank form that was provided to record the group ideas. The ideas were counted, where redundant ideas were discarded (see Lamm & Trommsdorff, 1973).

Ideational quality

The quality of an idea is operationalized as a combination of effectiveness, implementability, innovativeness and completeness (Dean et al., 2006). During the convergence task, the students were asked to select their three best ideas. These three ideas were rated by two field experts with extensive experience in the domain on these four qualities using a five-point Likert scale. The raters were blind to both the treatment conditions and our hypotheses.

Quality of the process

We evaluated perceived process quality at the group and individual level based on 20 statements (see Appendix 1) using a seven-point Likert scale. Following studies on the quality of group processes (mainly Rouwette et al., 2009) and PSS performance (mainly te Brömmelstroet, 2013), these statements reflected the process quality dimensions: general reaction, insight, communication, shared language, consensus and efficiency gains.

Usability of PSS

Finally, we measured perceived PSS usability with 14 statements (based on Pelzer, 2017; te Brömmelstroet, 2017a, Pelzer et al., 2015b see Appendix 2) using a seven-point

Likert scale. These statements related to aspects of tool and tool facilitation such as transparency, output clarity, credibility, focus, level of detail, process organization and chaperoning. Process organization and chaperoning of the tool are also related to the process quality variables since they measure the usability of the PSS workshop setup and process support.

3.3.4 Analytical approach

We applied a two-way ANOVA using SPSS Statistics to compare mean differences of the different conditions of use on PSS performance. This procedure also detects effects from interactions between independent variables on the dependent variable. The mean output values are provided in the Section 3.4. To analyze the divergence task, we compared the mean number of generated ideas by groups according to their treatment. During the convergence task, the four ideational quality factors were analyzed by comparing the mean score of the top three ideas generated by each group. We analyzed the ideational quality scores given by one external rater and used scores given by a second rater to control for interrater validity. We also analyzed student responses to each of the perceived quality of process and usability statements. We report the statements that scored significantly different for quality of process and usability in the paper and provide comprehensive lists of mean values in Appendix 3. Additionally, we looked for interactions between the flexibility and hardware conditions on each of the dependent variables. And finally, we conducted a bivariate correlation test to assess whether there were correlations between the measures of perceived PSS usability and quality of the process. We provide a comprehensive list of the correlation values in Appendix 4.

3.4 Results

3.4.1 Divergence

The analysis of the divergence task showed little effect of PSS flexibility and visualization hardware conditions on the number of ideas generated. Though differences among the flexibility conditions are negligible, the findings indicate some impact of the visualization hardware conditions. Groups that used tablets generated on average more ideas than those that used the mappable (see Table 3.2). None of these effects was statistically significant, in part because of the limited number of groups in each condition.

3.4.2 Convergence

The analysis of the convergence task showed scores on the four qualities of generated ideas that were around, and mostly slightly below the average score on the five-point Likert Scale. For the criteria Implementability, Innovativeness and Completeness, as flexibility decreased, quality scores increased, although only slightly (see Table 3.3).

Table 3.2 Idea generation scores

	Degree of Flexibility				Visualization Hardware					
	None		Indicator		Process & Indicator		Tablet		Mappable	
	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N
Number of ideas per group	17,88	8	19,13	8	17,57	7	18,82	17	16,50	6

Table 3.3 Ideational quality scores

	Degree of Flexibility				Visualization Hardware					
	None		Indicator		Process & Indicator		Tablet		Mappable	
	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N
Effectiveness	3,25	24	2,79	24	3,19	21	3,12	51	2,94	18
Implementability	2,67	24	2,58	24	2,52	21	2,59	51	2,61	18
Innovativeness	3,04	24	2,71	24	2,52	21	2,82	51	2,61	18
Completeness	2,71	24	2,29	24	2,10	21	2,29	51	2,61	18

Table 3.4 Quality of process scores

	Degree of Flexibility				Visualization Hardware					
	None		Indicator		Process & Indicator		Tablet		Mappable	
	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N
<i>Individual</i>										
Real solutions ^a	5,43	46	5,26	47	4,63	40	5,24	98	4,80	35
Correct assumptions ^c	5,43	46	5,23	47	4,85	40	5,22	98	5,09	35
<i>Group</i>										
My vision clear ^a	5,42	45	5,25	44	4,92	38	5,19	95	5,28	32
Problem of others ^b	5,31	42	5,16	44	5,18	39	5,09	93	5,59	32
Platform ^b	5,47	45	5,23	47	5,35	40	5,24	97	5,66	35

^a Significant at the 0.05 level (2-tailed) for flexibility

^b Significant at the 0.05 level (2-tailed) for hardware

^c Significant interaction effect at the 0.05 level (2-tailed)

Scores for visualization hardware use were split, whereby tablets performed better on Effectiveness and Innovativeness and maptables performed better on Implementability and Completeness. None of these effects was statistically significant also in part because of the limited number of groups in each condition.

3.4.3 Quality of process

The students were generally positive about the PSS-supported strategy-making workshop. Almost all process quality statements for the 133 participants show a positive score, significantly higher than 4³. Four statements show statistically significant differences within flexibility conditions or within the hardware conditions and one statement shows interaction between the hardware and flexibility conditions. Findings indicate that the conditions had varying influence at the two levels of analysis. No flexibility was perceived more positively, evidenced at the individual level by the statement 'the result offers a *[real solution]* to the problem' and evidenced at the group level by the statement 'the other participants understand my view of the problem *[my vision clear]*'. Although other differences were not statistically significant, they did point in the same direction. At the group level, mappable use outperformed tablet use on the statements 'I now understand how the other participants view the problem *[problems of others]*' and 'during the session a *[platform]* emerged that supported the sharing of ideas' (see Table 3.4). The statement 'the result of the session is based on *[correct assumptions]* about the urban system' shows an interaction effect between the flexibility and hardware conditions (interaction values not displayed in table), whereby tablet use under the no flexibility condition resulted in the highest score (M = 5,69) .

Findings indicate an inverse relationship, whereby decreased facilitation flexibility corresponded to an increase in average scores given by the students on three of the five statistically significant statements (see Figure 3.1). This inverse relationship was consistent across 14 of the 20 statements. Highest agreement was given to the group-level statement 'I was able to *[share my ideas]* and opinion' under the no flexibility condition, while lowest agreement was given to the group-level statement 'during the session we developed a *[shared professional language]*' under the indicator and process flexibility condition (see Appendix 3).

3 The only statement that did not score above 4 was considered to have a potentially negative sentiment, meaning a low score implies high perceived quality of process.

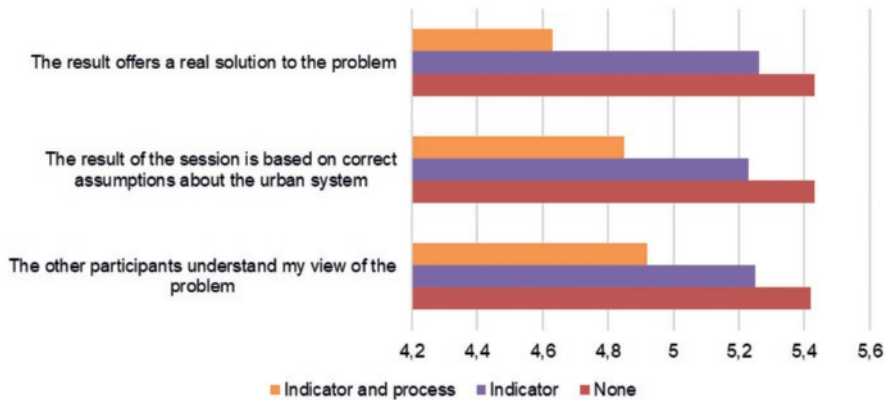


Fig. 3.1 Differences in quality of process scores based on facilitation flexibility

3.4.4 Usability

Almost all of the 14 usability statements for the 133 participants, show a positive score, significantly higher than 4⁴. One statement, ‘the [level of detail] of the maps was sufficient’ shows statistically significant differences between the visualization hardware conditions (see Table 3.5). Here, the mappable outperformed tablet use while differences among the three facilitation flexibility conditions were not significant.

A bivariate correlation test of usability and quality of process generated numerous significant correlations between the two datasets (see Appendix 4). Roughly three-quarters (72,9%) of individual-level quality of process responses (strongly) correlated to usability responses compared to 57,9% of group-level quality of process responses. In most instances, the 5 statistically significant quality of process statements (strongly) correlated with the usability statements (see Table 3.6). ‘The [level of detail] of the maps was sufficient’, which was the only significant usability statement, and 8 other usability statements (strongly) correlated with all five of the significant quality of process statements. ‘Engagement with the tool was well supported [tool support]’, on the other hand, only correlated with the statements ‘the result of the session is based on [correct assumptions] about the urban system’, ‘the other participants understand my view of the problem [my vision clear]’ and ‘during the session a [platform] emerged that supported the sharing of ideas’.

4 The only statement that did not score above 4 was considered to have a potentially negative sentiment, meaning a low score implies high perceived usability.

Table 3.5 Usability scores

	Degree of Flexibility				Visualization Hardware					
	None		Indicator		Process & Indicator		Tablet		Maptable	
	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N
Level of detail ^b	5,57	46	5,64	47	5,70	40	5,52	98	5,94	35

^b Significant at the 0.05 level (2-tailed) for hardware

Table 3.6 Correlations between quality of process and usability (N between 119 and 133)

	Trans- parency	Commu- nicative value	Clarity of output	Process organiza- tion	Tool support	Credi- bility	Compre- hensive- ness	Consen- sus	Imagina- tive	Focus	Level of detail	Easy to understand	Disam- bigua- tion	Creativ- ity
<i>Individual</i>														
Real solution	0,161	0,327**	0,342**	0,210*	0,160	0,402**	0,332**	0,254**	0,242**	0,356**	0,192*	0,188*	0,187*	-0,194*
Correct assumptions	0,186*	0,395**	0,325**	0,305**	0,270**	0,497**	0,360**	0,193*	0,254**	0,410**	0,201*	0,155	0,239**	-0,123
<i>Group</i>														
My vision clear	0,163	0,309**	0,214*	0,382**	0,196*	0,309**	0,330**	0,174	0,261**	0,295**	0,262**	0,161	0,252**	-0,085
Problem of others	0,215*	0,337**	0,248**	0,328**	0,177	0,196*	0,320**	0,198*	0,338**	0,299**	0,189*	0,233**	0,313**	-0,096
Platform	0,114	0,479**	0,345**	0,449**	0,296**	0,318**	0,293**	0,146	0,232**	0,277**	0,234**	0,108	0,180*	-0,025

**Correlation is significant at the 0.01 level (2-tailed)

*Correlation is significant at the 0.05 level (2-tailed)

3.5 Discussion of findings

Building on theoretical expectations and empirical results from case studies of PSS use, this study formulated three hypotheses about the expected effect of facilitation flexibility and visualization hardware on two important tasks of strategy making: divergence and convergence. We designed a procedure where groups of students were asked to diverge to generate as many planning solutions as possible and then to converge to make a selection of planning solutions, supported by a state-of-the-art PSS. We randomly changed the conditions of PSS use enabling us to test the effect of these differences on the quality of divergence and convergence and on perceptions of process quality and usability of both tool and process.

Hypothesis 1. Less facilitation flexibility leads to more generated ideas, higher scores on idea quality and higher process satisfaction scores both at the group level (communication, shared language and consensus) and at the individual level (insight) (based on Pelzer et al., 2015b).

Contrary to expectations, the measured effects of facilitation flexibility on idea generation and idea quality were not statistically significant. The different conditions of facilitation flexibility did, however, significantly influence perceived quality of process. Here, we found numerous instances where increased quality of process was linked to limited facilitation flexibility. In most instances the no flexibility condition outscored the other flexibility conditions. Three of the four ideational qualities showed a similar trend. No flexibility consistently outscored the other facilitation flexibility conditions across the different measures of PSS performance of this study, from process quality at both the group and individual levels to the outcomes both in terms of number of ideas generated (quantitative) and ideational quality (qualitative). A caveat to take into account here is that we did not apply the full variation of facilitation treatments that might include no facilitation at all or deliberate interventions triggered by the flow of the process (cf. Pelzer et al., 2015b).

Hypothesis 2. Mappable use leads to higher process satisfaction at both the group level and the individual level compared to tablet use (Pelzer et al., 2014).

The visualization hardware results show that while quality of the process at the group level was higher for mappable use, tablet scores were higher at the individual level. This only partly confirms the expected better performance of maptables. Maptables performed better on statements that evaluated understanding, e.g. 'I now understand how the other participants view the problem [*problems of others*]' and 'during the session

a [platform] emerged that supported the sharing of ideas'. However, there was some indication that participants may not trust their outputs, as was seen in the higher scores given by tablet users on the individual-level statement 'I [trust that the outcome] is good'. Although the differences were not statistically significant, tablet use outscored mappable use on related statements such as 'the result offers a [real solution] to the problem' and 'the session produced [usable results]'.

Interestingly, more ideas were generated by the tablet groups and ideational quality scores were mixed between the two hardware types. Together, these findings are compelling. They point to a potential causal relationship between the outcomes of divergence and convergence. The higher ideational quality scores by tablet groups for Effectiveness and Innovativeness may be explained by the ability of the tablet groups to generate more ideas from which to select while tablet use may also have contributed to more 'radical' individual thought. Comparatively, the mappable may have supported a stronger atmosphere for shared learning resulting in more Complete and Implementable ideas. While these findings substantiate the performance of mappables at the group level for communication and shared learning, they also indicate a need for further investigation into alternatives that support divergence tasks and individual needs during strategy making. The findings also suggests that the hardware on which PSS software is applied may influence user perceptions of process quality and process outcomes.

Hypothesis 3. Perceived PSS usability is positively correlated with process satisfaction (see te Brömmelstroet, 2017a).

Finally, we found many (strong) correlations between participant perceptions of quality of process and usability. These correlations were more dominant at the individual level than at the group level, indicating that perceptions of tool and process usability may be more positively linked to individual-level process quality factors such as gaining insight 'my [insight into the problem] has increased' and trusting outcomes 'I [trust that the outcome] is good' than to communication at the group level.

The findings, furthermore, underscore claims by Pelzer et al. (2015b) of the need to strike a delicate balance between PSS use and group discussion. This means interaction with the PSS either to learn about the technology or to set up and to explore the data should not dominate shared learning and communication about the problem at hand. Structuring conditions of PSS use by limiting indicator options and steering both process and interaction with the tool is important. Doing so seemed to allow participants to

focus on communication and shared learning of their ideas rather than learning to use the tool or managing group work.

The confirmation of this hypothesis could be interpreted as a sign that the emphasis in the literature on improving the usability of PSS to overcome implementation barriers was valid (e.g. Vonk et al., 2005). However, while higher usability correlates with higher process satisfaction, this relationship should not be interpreted too linearly. One of the reasons of the relatively high usability scores is arguably the fact that the instrument and the process are carefully tailored to each other. The PSS is not an 'external' tool that is brought in, but part of the planning process and the tasks therein. While this synthesis is positive, it also means that the causality becomes more complex, i.e. assessments of usability become in a way similar to assessments of process quality. Future research could further unpack this blurring of lines as instrumental interpretations of PSS give way to the view that PSS belong to an integrated support process.

3.6 Conclusions and reflections

The findings do not provide conclusive evidence that different conditions of PSS use have significant effects on strategy making. This study produced few significant values perhaps because of the small sample size of results analysed at the group level and because of the overwhelmingly positive responses of the students that showed little variation in the quality of process and usability scores. The less positive scores the external rater gave for the quality of the ideas indicate that running a similar experiment with planning experts might yield more variation in the results; however, it would be difficult to gather a statistically significant number of participants for such a study. A higher N in the current study would have allowed us to conduct a more sophisticated quantitative analysis, like a regression model, which could shed more light on the relative weight of the different variables.

Moreover, there are evident problems with the representativeness of these types of experiments with planning students (te Brömmelstroet, 2015). When compared to planning experts, these students lack field-specific knowledge and experience. This likely explains the rather poor scores given by the external rater on ideational quality across all of the solutions produced by the students. However, we considered the lack of experience and, thus, lack of bias or (positive/negative) feelings about planning practice to further validate the findings. Working with these 'blank slates' in a controlled setting allows us to look at relative differences in scores, instead of absolute scores, making internal and external validity of the findings less problematic. Additionally, we were able to carry out our analysis under the assumption that the exercise was properly designed

and executed. The overwhelmingly positive responses of the students to the process quality and usability statements indicate that they understood the tasks at hand, that sufficient time was provided to complete the tasks and that they had sufficient support in using the visualization hardware. Therefore, we assume that the exercise setup itself, which was not a part of the study, effected results either minimally or consistently across the conditions of use.

The PSS under scrutiny in this paper, Urban Strategy, is a sophisticated and innovative instrument that allows real time impact analysis of proposed changes in the urban environment (i.e. answering What if?-questions). Since our chief interest lies in the PSS performance, we have decided not to discuss the technical capabilities of Urban Strategy in detail, but focus on participant experience instead. It would, however, also be valuable if a more technical paper on Urban Strategy would appear in the literature, since these kinds of papers about PSS like LEAM, What if? And SLEUTH have inspired developers and researchers to develop technology to support planning.

The analysis in this study was primarily concerned with the main effects of two condition of use variables on strategy making. Our analysis only revealed one interaction between the conditions. This lack of interaction is in part because we measured divergence and convergence at the group level, resulting in a low N. Future research that involves multiple factors impacting the planning process should, however, be aware of a potential interaction effect during analysis. The many strong correlations between quality of process and usability reflect findings from a recent study that looked at correlations between user-friendliness and usefulness (te Brömmelstroet, 2017a). Combined, these studies highlight the need to better understand user perceptions of PSS. At the same time, we acknowledge that the correlations we found can be explained in part by the overlap of frameworks for the terms, which we borrowed from previous studies. The ambiguity of terms that describe user perceptions of PSS including usefulness, usability, user-friendliness, performance and added value seems to be a pitfall of the young debate surrounding socio-technical PSS development.

This study of PSS performance adds to a growing body of studies that addresses PSS from a socio-technical perspective using rigorous social science methods (e.g. Pelzer et al., 2015b; Goodspeed, 2013a; Vonk & Ligtenberg, 2010; te Brömmelstroet & Schrijnen, 2010). This strand focuses on the way in which a PSS is contextualized in a particular socio-technical setting. The contribution of this paper to this emerging strand is that it has (a) defined and categorized the relevant dependent and independent variables, (b) illustrated how an experiment could be set up and analyzed, and (c) provided – preliminary – insight on how the variables effect each other. In future research, we should not

wait for final evidence to advance, but rather we need to keep better track of innovations that are used. Our findings indicate that process facilitation that provides both individualized support for idea generation and collaborative support for evaluating ideas could be beneficial. Such support interventions would, further, take both individual and group learning and communication needs into account when introducing visualization hardware. Monitoring the effects of these interventions on the quality of planning in a more structured way can lead to proofs of concept. This requires PSS academics and developers to become more explicit about what they aim to improve, in which context and how this can be measured.

While continuously changing technology and context-dependency prevent cookbook solutions – even if hypotheses are confirmed – being explicit and reflective about the relevant dimensions of a PSS application is critical for researchers, developers and practitioners. While we acknowledge the demand for more flexible information models, our findings indicate that the use of such models benefits from less process and content flexibility, through careful facilitation. Facilitation has arguably always played an important role when PSS are applied in group settings, but is only recently popping up as a dimension that deserves conceptual and empirical attention (e.g. this paper; Pelzer et al., 2015b). Moreover, since the PSS field is never static, new relevant aspects will inevitably pop up. Such emergent aspects need to be spotted by reflective practitioners and researchers and subsequently be scrutinized in rigorous empirical studies.



Chapter 4

Gamified Spatial Strategy Making: Is it useful?

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Abstract: This chapter describes a pilot study conducted in both control-rich and context-rich settings to test the usefulness of a gamified strategy-making method. During the strategic stages of spatial planning, actors require structured and engaging means of brainstorming and opening up to the ideas of others and collectively making choices based on numerous issues that seem connected to everything. We introduced game elements in strategy-making sessions and used mixed methods to evaluate whether these elements provided a useful means for actors to conduct problem formulation and scenario development exercises. Quantitative results indicate that the introduction of game elements may help actors to brainstorm and select their main issues but additional support is needed to help actors parameterize these issues. The controlled experiment we conducted with students ensured the internal validity of these results. Qualitative evaluation of participant feedback indicated that while the gamified method provided structure, it also added complexity to the two exercises. External validation of these findings within the context-rich settings of two cases indicated that the method is more useful when applied by professionals facing real-world planning problems. We also provide suggestions for the development of game-based group model building methods that facilitate structured dialogue between planning support experts and users.

4.1 Introduction

Spatial planning has been described as a 'hopelessly complex human endeavor' that could benefit from help provided by the broadest spectrum of academic fields (Couclelis, 2005, p.1355). Part of this complexity originates from the distributed and controversial nature of knowledge about planning problems (Fischer, 2000). Planners nowadays spend much of their time collecting the knowledge of different planning actors and facilitating processes where this knowledge is shared, debated and transformed for scientific analysis. The complexity of these social processes is augmented by the complexity intrinsic to cities, which Portugali (2012a) describes as open, self-organizing spatial systems. Because of this 'double complexity', planners must ensure that interaction between actors is structured and based on relevant knowledge about the spatial system (te Brömmelstroet, 2017b, p.77).

The role of (geo)information and knowledge within the strategic tasks of planning is less evident than within more straight-forward operational tasks (Geertman, 2006). Few existing technology-based tools, therefore, are capable of supporting the work of planning actors to identify what Batty (2013) describes as the salient features of a spatial system. Consequently, key features may be absent when performing these forward-looking, normative tasks to determine desirable future states of the system (te Brömmelstroet & Bertolini, 2008; Couclelis, 2005). Planning support systems (PSS) are a class of tools that have been developed to provide support during such tasks. PSS have been described as loose assemblages of components (e.g. information, knowledge, methods and tools) that integrate geographic information systems (GIS) with a variety of models, some computer-based, and are considered uniquely useful for planners (Geertman et al., 2015; Geertman, 2008; Batty, 2003). Examples of numerous one-off PSS have been collected in several edited books (see Geertman et al., 2017; Geertman et al., 2015; Brail, 2008; Geertman & Stillwell, 2003b; Brail & Klosterman, 2001). Despite their intended use, the impact of PSS on the strategic work of planners has been marginal.

Current research into the PSS implementation gap is being conducted on two fronts. First, the use of PSS is being evaluated in empirical studies to understand various aspects of their perceived performance (e.g. Russo et al., 2018; Pelzer et al., 2014; Goodspeed, 2013a; Vonk, 2006). A recent trend in researching these systems focusses on the *usefulness* of PSS in supporting multi-level group processes (Shrestha, 2018; Champlin et al., 2018b; Pelzer, 2017; te Brömmelstroet, 2017a). Second, to create more useful PSS, academics have attempted to move beyond traditional technical-rational development approaches (see Vonk & Ligtenberg, 2010). These earlier approaches have

produced PSS that are perceived by users to be too rigid, unintelligible, lacking communicative value and based on opaque assumptions (te Brömmelstroet, 2010b; Vonk et al., 2005). To overcome these bottlenecks preventing adoption, advancements in PSS are needed that trail the planning processes they support. Noting their potential structuring role, te Brömmelstroet (2010b) stated that PSS should serve as an 'infrastructure that systematically introduces relevant (spatial) systematized knowledge to a specific process' (p.13). Such processes can be broken down for purposes of analysis into dynamics of divergence and convergence. Together, divergence and convergence create a dynamic cycle of opening up to ideas and closing them down that link the different stages of strategy making (Pelzer, 2017; Rydin, 2007). Academics have used a similar dynamic process model to study the influence of tool use in group strategy-making sessions (see Champlin et al., 2018a; Champlin et al., 2018b). Still, PSS developed for the distinct purpose of structuring divergence and convergence across multiple strategy-making tasks are lacking.

As PSS scholars continue to grapple with the development of more useful PSS, the game industry is booming. Games have attracted millions of players since the 1990s and game techniques have infiltrated planning education and practice (Devisch, 2008). Recent planning and PSS literature reflect this uptake of games (e.g. Ampatzidou et al., 2018; Flacke & De Boer, 2017; Raghothama & Meijer, 2015; Poplin, 2014; Devisch, 2008). Games in planning simulate different complex socio-political and technical-physical dynamics to support the collective formulation of problems and establishment of system boundaries (Raghothama & Meijer, 2015). Games also provide new tools to playfully negotiate and explore the effects of actions within a given set of social and design parameters (Tan, 2016). The application of PSS in the form of games to complex strategy-making contexts may motivate discourse needed to sort through what Rittel and Webber (1973) refer to as 'wicked' planning problems and to parameterize relevant system components used in the exploration of possible future states of a spatial system., i.e. problem formulation and scenario development, respectively,

To move PSS research forward, te Brömmelstroet (2017b) suggests combining practical studies of PSS usefulness with conceptual studies of PSS development in 'reciprocal loops'. In this study, we apply a reciprocal loop research approach by developing a one-off gamified strategy-making method and testing its usefulness under different use conditions. Our aim is to gain insight into the following research question: Does the gamification of strategy making provide a useful means for supporting divergence and convergence in group settings? We have chosen to conduct this pilot study both in a control-rich experiment to validate differences in the measured usefulness variables

(internal validation) and in two cases to validate findings from the controlled study in context-rich settings (external validation).

This paper continues with a discussion of research that led to the design of our gamified strategy-making method and the variables under investigation. In Section 4.3, we introduce the gamified method before outlining the research design. After presenting and discussing our findings, we conclude the paper with reflections on the gamified method and suggestions for future research on game applications for group model building.

4.2 Gamifying spatial strategy making

In planning theory, spatial strategy making is described as 'transformative governance work' that concerns the shaping of dynamics for the evolution of urban regions (Healey, 2009, p.440). This transformative work involves what Couclelis (2005) describes as three pursuits that fulfill the future-oriented, normative function of planning. The first deals with the broader world within which this spatial system is embedded, or 'first-order scenarios'. The second and third deal with the system being planned to determine 'the range of desirable future states of the system, along with the paths leading to such futures', or 'second-order scenarios' (Couclelis, 2005, p. 1363). Since we are interested in eliciting descriptions of the spatial system from the actors involved in making decisions that influence this system, we limit our focus in this paper to second-order scenarios.

During spatial strategy making, actors engage in complex communicative interactions through which they learn about components of a spatial system and their relationships (see te Brömmelstroet, 2017b). Divergence introduces complexity and uncertainties into these interactions that must be momentarily reduced or managed by making choices, also known as convergence. If left unchecked groups have a tendency to include all issues and to analyze their details. In doing so, they skip the crucial step of selecting the most important issues and synthesizing the broad lines (van den Belt, 2004). Premature convergence, on the other hand, may bypass communication interactions that are essential to learning, resulting in group think and suboptimal plans (Ford & Sterman, 1998).

In addition, a considerable portion of strategy making deals with sorting out interpretations and values (Couclelis, 2005). PSS use for multi-actor strategy making has been criticized for creating implicitly value-neutral and objective conditions where the realism of contextual factors and power in the use of knowledge is missing (te Brömmelstroet, 2017b). Adding realism to these group dynamics is difficult given the restrictions of the information frameworks of most PSS. These frameworks are not easily adjusted to context or area specifics. Context-specific factors such as user characteristics, the char-

acteristics of their knowledge, information and the planning issues themselves limit the potential supportive role of PSS (Geertman, 2006). For this reason tools introduced in the early stages of planning should strike what Pelzer et al. (2015b) refer to as a 'delicate and context-dependent balance' between tool use and group communication (p.355).

In recent years, the use of games has been gaining attention in spatial planning and PSS research. Games function as systems of 'interacting elements that work together on the bases of rules' (Harteveld, 2010, p. 32). Because they simulate dynamic real-world phenomena, games provide safe spaces for experimentation where people can apply their knowledge and skills to a strategic debate (R. D. Duke & Geurts, 2004). When designed as frame games, these games allow players to place their content into a framing set of rules and procedures that structure the transferring of information and knowledge (Ballon & Silver, 2004). Frame games permit quick and easy experimentation by allowing actors to create and manipulate content (Greenblat and Duke 1979 in R. Duke, 2011). In doing so, planning actors can use the game to build conceptual models of a spatial system.

The introduction of games into existing processes can motivate desired actions and behaviors through the utilization of game elements that facilitate goal-oriented, rule-bound play. Gamification, as it has been called, refers to the 'use of elements of game design in non-game contexts' (Deterding et al., 2011, p. 9). According to Hamari et al. (2014), gamification implements motivational affordances to induce psychological outcomes that can lead to behavioral change. In the remainder of this section, we identify 10 principles of motivational affordances (independent variables) and introduce the desired psychological and behavioral outcomes (dependent variables) being assessed in this study.

4.2.1 Gamification design principles

In accordance with gamification theory, introducing motivational affordances into strategy making should induce psychological outcomes such as learning and communication that lead to the successful performance of strategy-making tasks. In a literature review of gamification studies, Hamari et al. (2014) applied 10 principles that motivate desired behavior (see Zhang, 2008). Table 4.1 provides a summary of these 10 principles, which are also applied in this study to describe the gamified aspects of our strategy-making method. According to Zhang autonomy in the regulation of own behaviour (P1) facilitates gains such as engagement, performance and high-quality learning, while self-identity (P2) relates to developing personal potential. Emotional satisfaction can be obtained by effectively combining goals/challenges (P3) and feedback (P4) with respect to goal attainment. Interpersonal interaction (P5) allows humans to pursue an

innate desire to form social bonds (P6). Needs for leadership and followership should be accommodated through channels of influence (P7 and P8). And finally, emotions should be induced both by initial exposure (P9) and intensive interaction (P10) with a method or technology.

Table 4.1 *Design principles for motivational affordance (Adapted from Table 1 in Zhang 2008, p.146)*

Principle 1. Support autonomy	P1
Principle 2. Promote creation and representation of self-identity	P2
Principle 3. Design for optimal challenge	P3
Principle 4. Provide timely and positive feedback	P4
Principle 5. Facilitate human-human interaction	P5
Principle 6. Represent human social bond	P6
Principle 7. Facilitate one's desire to influence others	P7
Principle 8. Facilitate one's desire to be influenced by others	P8
Principle 9. Induce intended emotions via initial exposure	P9
Principle 10. Induce intended emotions via intensive interaction	P10

4.2.2 Usefulness variables

In the context of PSS, usefulness is the outcome of the *utility*, meaning the fit between the support function of the PSS and the planning task at hand, and *usability*, meaning the ability of users to apply the utility functionality (Pelzer, 2017). Pelzer et al. (2015a) explain that usefulness refers to the added value of a PSS in terms of whether its application leads to an improvement in situations compared to where PSS is not applied. We assess usefulness in terms of the psychological and behavioural outcomes induced by the gamified strategy-making method.

4.2.3 Psychological outcomes

Spatial strategy making belongs to communicative planning practice, which is grounded in two facets of rationality. One is the 'collective common sense' and the collaborative efforts of groups to decide and act together and the other is the self-reflective consciousness of the individual acting autonomously (Alexander 1988 in Klosterman, 1997, p. 49). PSS use in group settings can be measured at both group and individual levels through *ex post* assessments of usefulness based on user feedback on variables such as communication and learning about the spatial system (for examples, see Shrestha, 2018; te Brömmelstroet, 2017a; Pelzer et al., 2014; Goodspeed, 2013a).

Games and gamified activities are generally designed for an individual experience, which is reflected in the reporting of game use. According to Hamari et al. (2014),

the psychological outcomes of gamified activities most commonly reported in studies were individual motivation, emotions and attitude. Similar factors have been used in PSS literature to describe personal attributes that influence multilevel group processes (te Brömmelstroet, 2013). A multilevel assessment of PSS usefulness was conducted in a recent study using mixed methods evaluation (see Champlin et al., 2018b). Group-level variables included in the study were novelty of ideas, communication, consensus regarding the problem and goals and relevance of the outcome (derived from te Brömmelstroet, 2013). Individual-level variables included process satisfaction, insight into the planning object and insight into the different views or frames of actors (derived from Matos Castaño, 2016; Pelzer et al., 2014; te Brömmelstroet, 2013).

4.2.4 Behavioral outcomes

This study is concerned with two main tasks of strategy making – problem formulation and scenario development. Divergent thinking is often necessary in this early stage ‘where an individual or a group is attempting to determine what factors or variables to include or exclude from a system’s boundary’ (Vennix et al., 1992, p. 29). Vennix continues by stating that since group work tends to inhibit divergence, the quantity and diversity of ideas may be greater when individual contributions are aggregated. A recent study concluded that more attention in the form of dedicated tools that support individual work is needed during divergence (Champlin et al., 2018b). In contrast, during convergence, such as when building consensus about project objectives, actors tend to set aside support tools and rely, instead, on facilitated dialogue (Champlin et al., 2018a). One reason for this may be that while computerized tools are known to enhance and even transform planning processes, ‘they often lack the ability of traditional tools to draw people into meaningful interaction’ (Al-Kodmany, 2001, p. 2).

4.3 The gamified strategy-making method

In this section we introduce our gamified strategy-making method. This method consists of two facilitated strategy-making exercises that are conducted in a single group session. After describing the two exercises, we introduce the gamified aspects of the method based on the ten design principles mentioned above.

4.3.1 The two strategy-making exercises

Exercise 1: Problem formulation

The problem formulation exercise involves exploring issues related to planning problems (issue divergence) and determining a set of objectives based on group consensus about the most important issues (issue convergence). Problem formulation is conducted in a series of steps similar to the four steps of the nominal group technique (Delp et al.,

1977), which are: 1) silent idea generation, 2) round-robin listing of individual ideas, 3) clarification and evaluation of ideas through discussion and 4) prioritizing ideas with the group decision being mathematically derived through rank ordering or rating. First, silent idea generation allows the participants time to think before they generate and prioritize their issues without being influenced by others. Second, the round-robin listing allows participants to briefly describe their issues and why they are important. The third and fourth steps permit structured dialogue about the issues before calculating the cumulative group scores of issues. Afterwards, as a group, the participants use these scores to formulate a set of project objectives and then identify issues that should be included within the boundaries of future scenario alternatives that reflect these objectives.

Exercise 2: Scenario development

When developing scenarios, strategies should be thoroughly considered through processes of sketch planning and 'not primarily in the final stages of plan making' (Harris, 2001, p. 62). Sketch planning can be used to indicate spatial relationships in current or future states (Hopkins, 1999). It provides groups a visual means of communication when identifying the salient features of a spatial system. These features are communicated in terms of parameterized space and its attributes, or bi-space (Wegener, 2001).

Due to the limited time available in the sessions, we limited the scope of the exercise to parameter divergence. Once actors have agreed on key project objectives, they then reflect as a group on the issues related to these objectives and determine how the issues should be described in bi-space. Sketch planning supports this task and can be conducted using touch-sensitive hardware such as maptables with GIS interfaces or using paper maps. According to Goodspeed (2016b), computer-aided sketch planning provides rapid feedback and geospatial information while more flexible paper-based alternatives permit unstructured marking and annotations. Since not all parameters can be expressed spatially, actors should be provided multiple means of communicating their knowledge about issues. Multiple descriptions in verbal, visual and written formats permits 'testing and improvement through triangulation' (Ford & Sterman, 1998, p. 317).

4.3.2 The game elements

Weblinx is a game that supports actors in tackling wicked planning problems. Since important processes of reflection can be hindered by the integration of highly immersive digital environments (Harteveld et al., 2010), we chose to develop a tangible game for the purpose of maximizing human-human interaction. Tangible games have 'the power to improve communication between competing stakeholders' (R. Duke, 2011, p. 13), which can lead to double-loop learning (Argyris, 1977). The game includes interactive

game elements designed for engagement and dialogue structuring. The frame of the game provides a structured, interactive means of performing issue divergence and convergence that can be easily adjusted to different sets of planning issues, thereby, maximizing the potential for structured but flexible inter-actor dialogue. Weblinx consists of 6 game elements: the game board, zones, levels and token restrictions, a scorecard, cumulative scores, objectives and elastic strings. We describe each of these elements below based on the motivational affordances (see Section 4.2.1) that they contribute to the strategy-making process.

Game board (P9). The Weblinx game board (Figure 4.1) features a hexagonal web divided into 6 zones that provides a frame for prioritizing planning issues. Upon first glance, the meeting of the six zones at the center of the board should evoke a sense for the collaborative play mode (Peppler et al., 2013) that encourages participants to work towards a common goal.

Zones, levels and token restrictions (P1 and P2). Participants work with identical stacks of tokens, each labelled with a different planning issue¹. When tokens are added to the web-shaped frame, the complexity of the planning problem becomes visual and explicit. In the first step of play, participants work individually in silence to position the planning issues they consider important within their stakeholder zone. The participants organize each issue into one of the five zone levels. Restrictions on the number of tokens that can be placed on the three highest levels force participants to prioritize the importance of their issues.

Score card (P5, P6). The interactive tasks of identifying duplicates of planning issues on the board, calculating their cumulative value and writing them on the score card encourages dialogue among the participants while working as a team towards a shared goal. The score card also allows the participants to record both the issues related to the project objectives and parameters of these issues.

Cumulative scores (P3, P4, P7, P8). Calculating cumulative scores of the planning issues on the score card provides immediate feedback. The scores indicate the issues that were prioritized highest by the group. Participants can use this quantitative assessment of the planning issues to persuade other participants of the importance of an issue that may otherwise have been disregarded due to group dynamics such as unequal power distribution. Though not required, the participants can use the cumulative scores to

1 Participants are provided a set of pre-determined issues to avoid the potential confusion of participants using different words to describe the same issue and to prevent the use of phrases to describe an issue. The method permits participants to add new issues to the issue set.

guide their discussion of project objectives. Formulating objectives gives the participants a clear goal for collaboration and for using the method.

Elastic strings (P5, P6, P10). The elastic linking strings are a playful game element intended to encourage participant interaction and to promote intensive engagement with the method. After formulating objectives, the participants are asked to engage in double-loop learning by reflecting on the web of issues and physically linking planning issues that are relevant for the development of scenarios.

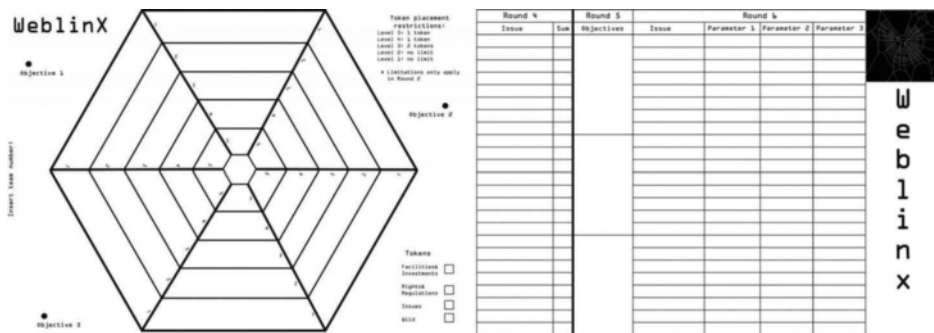


Fig. 4.1 Left. The Weblinx game board featuring stakeholder zones, token levels and token placement restrictions. Right. The score card for recording issue scores, objectives and parameters.

4.4 Research design

We use a quasi-experimental set up (Campbell & Stanley, 1963) to test our method in three contexts, which include a controlled setting with students and two planning projects with professionals. Testing in control-rich settings for 'internal validity' can show the effects of the method on dependent variables while testing in a context-rich setting for 'external validity' can contribute deeper insight into the effect of the method under real conditions (te Brömmelstroet, 2017b, p. 80).

4.4.1 The sessions

A pilot testing of the method was conducted in a controlled-study format with students from a Dutch university (Session 1). Thereafter, we conducted two sessions with planning professionals from redevelopment projects in the Netherlands (Sessions 2 and 3). The students adopted the issues of a randomly assigned stakeholder, while the professionals applied their own knowledge of real planning issues. Below, we provide descriptions and setups for the three sessions. An overview of the main characteristics of each session is provided in Table 4.2.

Control-rich testing with students

Session 1 was conducted in a third-year civil engineering Bachelor course with 60 students. Students were randomly divided into groups of six. Half of the groups used the gamified strategy-making method (method groups) and the other half was instructed to use only dialogue to perform the same strategy-making tasks (control groups). We introduced the students to a fictional case: the redevelopment of the NDSM Wharf, a decommissioned shipyard on the northern bank of the IJ River in Amsterdam. We provided factual information from online resources and allowed the students 15 minutes to prepare for their role by studying the case background materials and to create the planning issues of their character. Instructional handouts were provided for the control groups and the method groups. Two session facilitators were available to answer questions pertaining to the exercise and about how to play Weblinx, i.e. procedural and tool-related facilitation (Pelzer et al., 2015b).

Context-rich testing with professional planning actors

Session 2 was conducted with professionals from the Plein Westermaat project. The terrain was built ten years prior and is a popular retail terrain in the region. The retail units are fully occupied by Dutch and global companies including IKEA, Praxis, Prenatal and McDonalds. Over the years, the condition of the shared public spaces including parking zones had deteriorated significantly. The four professionals – the facility manager, two asset managers and a business manager – meet on a quarterly basis to discuss the budget for routine repairs and maintenance. However, past efforts to agree on an investment plan for the overall upgrading of public space in the 8-hectare retail terrain were unsuccessful. Intensive procedural, substantive and tool-related facilitation was provided (Pelzer et al., 2015b).

Session 3 was conducted with professional stakeholders from the Innovation Campus Kennispark project. At the time of our involvement in the project, the City planning department was developing a strategic vision for the spatial development of the Kennispark, which incorporated a neighboring university campus. The city planners asked us to repeat an earlier strategy development session with key stakeholders using the gamified strategy-making method for the dual purpose of identifying the focal point of their strategy and providing a better basis for thinking in scenarios.

Participants in each session followed the same procedural steps, as described in Section 4.3.1. The method groups in Session 1 and the professionals in Sessions 2 and 3 used the gamified method. Sketch planning was conducted on paper maps in Sessions 1 and 2, whereby, the professionals in Session 3 sketched one a mappable using Phoenix software. Each student in the control groups was instructed to create five planning issues.

Table 4.2 Overview of the main characteristics of the three empirical studies

	Session 1	Session 2	Session 3
Study type	Controlled experiment	Case study	Case study
Date	15-9-2014	17-9-2014	5-9-2017
Case	NDSM 2020 Wharf Strategic Vision Development	Plein Westermaat Public Space Upgrading	Kennispark Spatial Strategy Development
Duration (minutes)	75 (excluding 30-minute case study introduction and background research)	120	150
Session support	Facilitator (first author) Volunteer facilitator <i>Procedural and tool-related</i>	Facilitator (first author) <i>Procedural, substantive and tool-related</i>	Facilitator (first author) Mappable chauffeur <i>Procedural, substantive and tool-related</i>
Sketching tool	Paper maps	Paper map	Mappable with Phoenix software
Participants	Civil engineering undergraduates	CoVer Board	Spatial Development Group
Nr. participants	60	4	6
Nr. method groups	5	1	1
Nr. control groups	5	0	0
Roleplaying	yes	no	no
Planning actors	Province official City alderman/woman Project leader Transport planner Business owner Investor	Facility manager Dutch asset manager German asset manager Business manager	Project leader Urban designer City architect University architect Building owner Graduate student

The control groups were provided a partial score card for recording their objectives, selected planning issues and parameters and a paper map for sketching the parameters.

4.4.2 Data collection and analysis

We used a mixed method analysis approach to assess the dependent variables: psychological outcomes and behavioral outcomes. At the conclusion of Session 1, students responded to a psychological outcome questionnaire that we used to assess the perceived usefulness of the session. We operationalized usefulness variables (mainly from Pelzer et al., 2014; te Brömmelstroet, 2013) to fit the specific utility and usability aspects of the gamified strategy-making method under investigation in this study. The students responded to utility statements using a five-point Likert scale ranging from 1 'strongly disagree' to 5 'strongly agree'. The students also ranked 5 aspects of session usability they felt needed the most (5) to the least (1) improvement. We used an independent t-test to compare the mean scores of responses from the method groups to those of the control groups. We also looked for statistically significant differences in the responses from the method and control groups.

Data recorded on the game boards, scorecards and site maps provided quantitative data about the behavioral outcomes of the sessions, i.e. number of planning issues (issue divergence), number of selected issues (issue convergence) and number of parameters (parameter divergence) – written or sketched. We explored the behavioral outcome data in each of the three sessions following four steps. First, we counted the number of issues recorded on the Weblinx game boards compared to the number of issues that each control group was instructed to generate. Second, we counted the number of selected issues each group recorded on their scorecards. Third, we counted the number of parameters recorded by each group on the scorecards (written) and on the site maps (sketched). Fourth, we calculated the percentage of written versus sketched parameters generated by each group.

We triangulated (Creswell & Miller, 2000) these results with qualitative insights from the group reports and feedback from the business professionals by telephone (Session 2) and during discussions (Session 3). The students worked in teams consisting of a method group and a control group to write 5 reports. The narratives in the student reports provided comparative insights that added explanatory value to both the students' responses to the psychological outcome statements and findings from the quantitative behavioral outcomes analysis. We report our findings in Section 4.5.

4.5 Results

4.5.1 Behavioral outcomes

During the issue divergence and convergence steps, the student method groups and professionals achieved a larger average reduction of issues than the control groups, with 63% and 53% respectively. Figure 4.2 shows that the two groups most effective in issue divergence and convergence were Method Group 4 (86% reduction) and the Westermaat professionals (82% reduction). On average, the method groups selected 10.2 issues out of 38 individual issues; whereas, the control groups selected 14 issues out of the assumed 30 individual issues, or 5 generated issues per group member. However, the control groups outperformed the method groups on parameter divergence. Here, the control groups identified an average of 24 sketched parameters and 11,2 written parameters, whereby the method groups and professionals identified an average of 19,4 sketched parameters and only 7,1 written parameters.

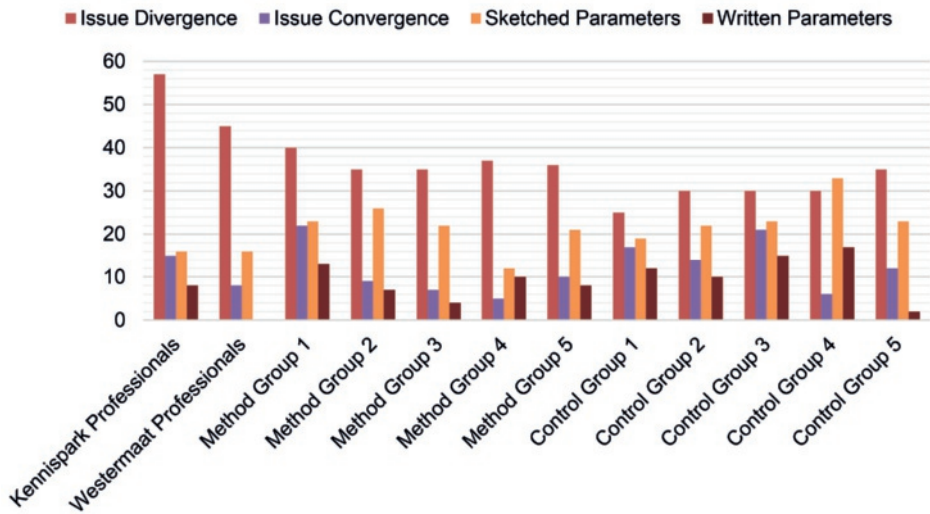


Fig. 4.2 Number of issues generated (issue divergence), selected (issue convergence) and number of parameters that were sketched and written (parameter divergence) per group

4.5.2 Psychological outcomes

Table 4.3 reports the perceived usefulness of the strategy-making session gathered from the psychological outcomes questionnaire. Overall, the results show a mostly positive attitude from both group types. Only one statement 'the exercise helped my group to [generate new issues] together' received an average score below 3.00, which was given by participants who used the gamified method. Results indicate two responses with statistically significant differences between the control and method groups. These

statements were ‘the exercise helped my group to [generate new issues] together’ and ‘the project [objectives reflect the main issues] of the group’. In both instances, the control groups were more positive about the method. However, trends in the data show that method group participants were more positive about individual issue divergence (‘the session helped me identify the issues of my stakeholder [identify my issues]’), issue convergence (‘the session helped my group to negotiate and [select issues]’) and issue parameterization (‘the session helped my group to specify [measurable parameters] for the project objectives’).

Table 4.3 Usefulness results categorized according to utility and usability

	Method		Control	
	Mean	N	Mean	N
<i>Utility (individual)</i>				
Identify my issues	3,60	30	3,23	30
Insight issues of others	3,57	30	3,60	30
Group feeling	3,07	30	3,17	30
<i>Utility (group)</i>				
New issue generation*	2,90	30	3,70	30
Issue selection	3,53	30	3,33	30
Objective setting	3,43	30	3,43	30
Objectives reflect main issues*	3,43	30	3,90	30
Issue parameterization	3,27	30	3,10	30
<i>Usability</i>				
More time*	3,00	30	2,20	30
Better visualization-problem formulation*	2,93	30	3,60	30
Better visualization-sketch planning*	2,87	30	3,77	30
More information	2,87	30	2,83	30
Clearer instructions	3,47	30	2,87	30

*Significant at the 0.05 level (2-tailed)

A review of the team reports provided insight into these statistical findings. All five of the teams expressed that the gamified method provided a more structured process for issue convergence. Team 3 explained:

Because of the low number of issues, it was still possible for the [control] group to have an overview of common issues (...). We think that in a case with many more issues, like 10 from every person, the [method] group had the benefit of still being able to read the most important issues, only because of the ease of just reading the [issues] closest to the center.

Team 2 explained that the issue convergence process of the control group was very random and that since the importance of each issue was not evaluated, less important issues were likely chosen. Adding to this randomness, the control groups of Team 2 and Team 3 both changed the sequence of the planning steps. They created project objectives before listing and selecting issues. According to Team 2:

This created the objectives more randomly without any arguments to the why and how. In real life this would lead to a lot of commotion (...) the [method] group has a good argumentation to why the objectives are chosen (...). To conclude, the process of the [control] group was led by instinct rather [than] logic.

In general, the student teams expressed difficulty writing and sketching parameters. Team 2 explained that their method group systematically defined parameters based on the objectives, while their control group was 'just guessing'. Team 4 expressed a similar view. Team 5 stated that the more precise issues of the method group led to fewer sketched and written parameters, and that the more global issues of the control group led to more parameters. Both Teams 1 and 3 expressed difficulty conducting the parameter divergence step.

Comparatively, feedback from the Westermaat professionals was mostly positive. The gamified method helped them to conduct strategy making in a methodical fashion and they were able to reach consensus. They generally felt that the gamified method helped them to effectively communicate and prioritize their issues and to set clear objectives. Businessman 1 stated:

[The gamified method] helped me to be forced to think about what is really important (...) to really pick the subjects that are of importance and to give a little bit of structure or hierarchy or importance to those items.

Businessman 2 expressed the usefulness of the gamified method in eliciting and communicating individual issues, stating:

I think we had these issues and we knew it but I think it's good to see what the other issues are. And that we have the same issues.

However, in a manner similar to the students, the Westermaat professionals expressed mixed views of the parameter divergence step. Businessman 1 explained that while issues like 'accessibility' are clear, it is difficult to measure subjective issues like

'improvement of the area'. According to Businessman 2, however, the sketching exercise triggered an important discussion about finances. He stated:

Yeah, I think the most important things were written down [on the paper maps] (...) And when we checked the financial parts of it, I think it's very difficult to do everything, but I think it's very good that we write down with each other the most important things (...). I think we can discuss about that in the next workshop.

Planners from the Kennispark case stated that the session provided a better basis than previous attempts to identify the focal point of their strategy and to think in scenarios. At the same time, they provided critical feedback about sketch planning and suggested that we continue to develop an underlying model capable of providing information about what the professionals are viewing in the PSS (see Figure 4.3). They stated that such a model would help them to have a more strategic discussion rather than get caught up in working out their different perceptions of routine issues. An excerpt from their dialogue explains:

Planner 1: What happens is, you see something [in a map or image] and we immediately react to what is there instead of what unites us.



Fig. 4.3 Kennispark professionals mark locations on a map of the Kennispark during the scenario development exercise.

Planner 2: Content-related discussions about details.

Planner 1: And that's not the point. Exactly.

Planner 2: Yes. And that is also the strategy that we want to define. What is important are the underlying motivations and you should be able to keep an eye on these in such a model.

Furthermore, usability results show statistically significant differences between the method and control groups in the rankings of 3 of the 5 statements. The control groups indicated a need for better visualization support both during the problem formulation and scenario development exercises of the session.

In their report, the Team 2 students wrote:

The [control group] identified the different issues, but didn't make it visual. With the visualization of the [issues], the [method group] had a clear view of where the types of issues came from (...). The method used by the [method group] created a better view of the value of the issues.

Comparatively, the method groups indicated a need for more time to complete the tasks. Also, although the scores were not statistically significant, participants of the method groups indicated a stronger need for '[clearer instructions] for each round of the session'. Additionally, we found remarks in the group reports that learning how to use the game elements took time away from conversations about planning issues. Furthermore, both the professionals and some student method groups found the step of linking the objectives to the selected issues (Step 4) to be confusing, thereby, adding little value to the exercise.

In their report, Team 1 students provide an example of why the method groups needed more time, stating:

At first the [game] was very complicated when the [strings] were introduced. We didn't have enough time to connect the issues to the objective.

In the sessions with professionals, where we had considerably more time to conduct the tasks and to provide substantive facilitation in addition to procedural and tool-related facilitation, usability feedback was more positive than that from the students.

4.6 Discussion of results

This section includes a discussion on the usefulness of the gamified strategy-making method based on the 10 principles of gamification that motivate desired behavior.

Principles 1 and 2: Support autonomy and promote creation and representation of self-identity.

Results from the three sessions show that the gamified strategy-making method was useful when applied to the problem formulation exercise, which can be observed in the behavioral outcome results. The zones, levels and token restrictions of the game permitted participants to generate ideas in a structured manner and also to engage in constructive dialogue about their individual issues. These game elements introduced silent, individual idea generation, process restrictions and visual representations of mental models that contributed to a structured dialogue (see te Brömmelstroet, 2010b) and enlarged intelligence about planning issues from multiple sources (Healey, 2010).

Comparatively, the collaborative orientation of the sketching tools applied in the scenario development exercise did not seem to support autonomy and the representation of self-identify to the extent the Weblinx game did. Though these tools had visual appeal, they lacked much of the dialogue structuring and facilitation of independent work that was deemed useful by users of the method during the problem formulation exercise. The Kennispark professionals were able to mark some of their issues on the mappable, but only with significant tool-related facilitation from the chauffeur. Since no attributes were assigned to these location markings, the professionals spent most of the time trying to understand the different framing of issues that the markings represented. Consequently, the actors were not able to communicate all of their planning issues using the language of bi-space. In comparison, working with a paper map, the Westermaat professionals sketched and described parameters textually for nearly all of their planning issues.

Differences between the two cases can be explained in part by the sketching tool they used and in part by differences in the context of tool use. Sketching on a paper map involved essentially no interruption in group dialogue to facilitate tool use and it provided the flexibility actors needed to sketch, mark through and label attributes of the space rapidly. In addition, the context-specific characteristics of the knowledge and instruments used in the sessions likely dictated the usefulness of support tool. Geertman (2006) explained that the support role of (geo)information is less evident in dealing with strategic problems compared to operational ones. Considering this, we

could have better supported the Kennispark case in its exploration of strategic issues with paper maps and the Westermaat case in its exploration of routine, operational issues with a maptable.

Principles 3, 4, 7 and 8. Design for optimal challenge, provide timely and positive feedback, facilitate one's desire to influence others and to be influenced by others.

Collectively, these motivational principles of gamification hint at important aspects of building consensus. Working towards consensus is just as much about learning, experimentation and change as it is about reaching agreements (Innes & Booher, 1999). The goal of agreeing on project objectives in a single session provided actors a tangible target to focus group communication. During objective setting, the feedback provided by working with cumulative group scores for issues permitted actors to influence and be influenced by others using the collective logic of the group to select issues.

Principles 5 and 6. Facilitate human-human interaction and represent human social bond.

The result that aligned least with our expectations was probably that of the elastic string use. The purpose for creating this game element was to increase tactile engagement with the game for a more playful and collaborative experience of identifying relationships between the issues. We thought that by linking the issues on the game board, actors could visually archive the issues they selected within the context of all the issues that were generated. We also thought that actors could use the linked issues as a roadmap in determining key issues and their relationships that should be sketched. Instead, usability feedback indicates that both the students and the professionals thought that the strings made the gamified method overly complex. Through experimentation we saw that the score card provided sufficient human-human interaction for this exercise and that the issue linking with the elastic string in use was superfluous. This example illustrates that decisions about the game design should be deliberate, meaning that each element in the game should have a utility that is clear both to the game developer and to the user.

Principles 9 and 10. Induce intended emotions via initial exposure and via intensive interaction.

Gamification taps into the emotions, attitudes and motivation of individuals to elicit a desired behaviour. The purpose for gamifying strategy making should be to engage actors, making them more open to the elicitation of their knowledge and committed to intensive interaction. We found that participants in all method settings were eager to use

the game board. This eagerness was often reflected in their body language as actors leaned into conversations and over the game board. The game board itself provided a structured means of visually depicting complex mental models of the spatial system, while the linking strings added an element of play that promoted intensive engagement with the method. However, more structured means of eliciting knowledge about the spatial system in terms of bi-space are needed before this knowledge can be used for scientific analysis.

In summary, the findings in this study suggest that gamification holds real potential for eliciting the communication and learning outcomes that can propel strategy making in group settings forward. Facilitators of these group processes should be aware, however, of the potential complexity that tool use adds to these communicative processes. Careful matching of support tool components to process dynamics may prevent adding a third dimension to the double complexity of planning process and object that planning actors already face. Comparative results from the controlled study indicated that learning to use the gamified method took time away from other important planning-related work, putting the groups that used the method at a disadvantage compared to groups that relied only on dialogue to complete the strategy-making exercises. That said, the professionals who used the method generally had fewer problems using the method, likely because the professionals already had a good understanding of their own issues, compared to the students who were roleplaying. Another reason the professionals may have encountered fewer difficulties was because the first author was available to facilitate the use of the gamified method more intensively and answer any of their questions, i.e. substantive and tool-related facilitation. Our findings substantiate claims by other PSS scholars that these methods should be easily understandable, smartly facilitated and customized to the specific characteristics of users, their planning issues and other contextual factors (Russo et al., 2018; Champlin et al., 2018a; Geertman, 2006).

4.7 Conclusions

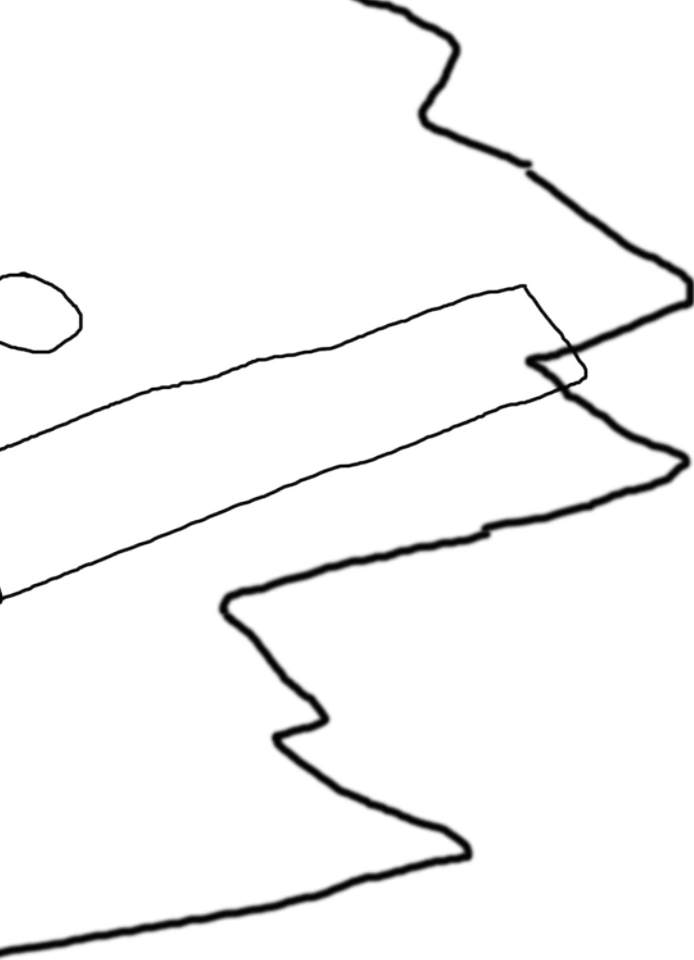
This paper started with the research question: Does the gamification of strategy-making provide a useful means for supporting divergence and convergence in group settings? Our reason for empirically exploring the potential usefulness of gamified strategy making was to experiment with a means to avoid several PSS bottlenecks that may be particularly problematic in group settings. These bottlenecks include being too rigid, unintelligible, opaque and not sufficiently accounting for context-specific factors, particularly inter-actor communication about planning issues. Dimensions where computer technologies excel may limit communication, thereby, hindering learning opportunities (Goodspeed, 2016b). Based on our findings, tangible frame games may

provide the requisite combination of structure and flexibility for planning actors to effectively diverge and converge about planning issues; however, if the game is not easily understood, these games can also interfere with human-human interaction. We, perhaps incorrectly, assumed that if divergence and convergence dynamics were sufficiently supported during problem formulation, then actors could work effectively together to parameterize their planning issues. On the contrary, we found that more support of autonomous work may be needed if actors are expected to communicate their issues in bi-space and to reveal the different frames and other divergent aspects of their knowledge about planning issues. Such work should be supported at the least by a facilitator who is responsible for process and for eliciting knowledge from the actors (see Richardson & Andersen, 1995)

Generally speaking, there is a lack of understanding about the effects of PSS use in different contexts. Experimentation in both real-world and roleplaying contexts could contribute to what Champlin et al. (2018b) claim is a need to combine hypothesis-generating field studies with control-rich studies for systematically testing these hypotheses. Testing the gamified strategy-making method in both control-rich and context-rich settings has given us some indication of where the game elements support the strategic tasks of planning and where they potentially add complexity and uncertainty. Designing the controlled experiment shows that, sometimes, setting up strategy-making conditions to be representative of practice can interfere with data collection. Since the control groups were instructed to conduct problem formulation using dialogue alone, they were not provided support materials for recording issues. A lack of recorded issues prevented us from drawing conclusions about the issue divergence results. Nonetheless, taken together with qualitative data of perceived usefulness, our calculations of issue reductions (convergence) suggest that gamified interventions can provide structured yet flexible support to dynamics of opening up and closing down planning issues. Additionally, te Brömmelstroet (2013) states that researchers of PSS performance should be explicit about the variables they measure so that a complete performance framework can be filled in through bottom-up contributions. That said, researchers should also be cautious of representing complex spatial systems and the social processes that seek to influence them too simplistically. While understanding causal relationships may be useful to identify general properties or rules of these systems and their relationships, they may not provide sufficient insight into the context of each project. New ways of representing and analyzing the salient features of systems in their highly networked state are needed.

These conclusions point towards new avenues for research into the use of games that support the development of strategies and analysis of potential spatial interventions

in the context of an uncertain future. These strategic tasks are fundamentally linked to later-stage decision making, which is often informed by scientifically-generated knowledge using (spatial) models and simulations of cities and their complex dynamics. Gamified means of structuring these early strategic tasks could fulfill requirements for what Harris and Batty (1993) describe as rapid PSS prototyping, independent of but loosely coupled to GIS. The integration of game building and model building in a process of co-creation may unveil new means of involving planning actors and their context-specific knowledge in the rapid prototyping of contextualized planning support.



Chapter 5

Critiquing Parameterized Assumptions
in the Third Space: A game co-design
method to elicit context-specific
knowledge

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Abstract: A frequent criticism of models and other knowledge-based tools for planning is the apparent mismatch between their information frameworks and the specific information needs of experts working in different planning contexts. Increasingly, actors involved in planning are contributing their context-specific knowledge about a spatial system during the development of these tools using co-design approaches. This study establishes a set of design requirements for a knowledge elicitation method that utilizes a game prototype as a third space where planning actors and planning support experts can meet halfway between the technology and user domains. After describing the method, findings from an initial use case are presented. These findings indicate that facilitating the work of actors in nominal groups to critique the parameterized assumptions of a game prototype was effective in eliciting different types of knowledge (divergence) about a spatial system in operationalized terms (formalization). We discuss the potential of game co-design both as a modelling as learning exercise for planning actors and as a means of eliciting their knowledge to better contextualize planning support to the complex dynamics of spatial strategy making.

5.1 Introduction

Models have made an indelible mark on the practice of spatial planning. This practice of linking knowledge to action in the public domain (Friedmann, 1993) utilizes models and other knowledge-based technologies to gain insight into causal relations within a given context through the production, transformation and transmission of knowledge (Gudmundsson, 2011). Spatial models represent various systems (e.g. housing markets, transportation, facility locations and land use) in bi-space, a term that refers both to space and its attributes (Wegener, 2001). These models help actors to understand (urban) spatial systems and what Healey (2007) refers to as their 'dynamic relational networks, transecting and interweaving with each other' (p.220). As the complexity of spatial systems increases, planners require tools with the capacity to support the visualization and analysis of these systems. The specific aim of developing planning support tools, particularly those that integrate (geo)information-based spatial models, has been to facilitate communication and learning among individuals as they address long-range problems and issues that are strategic and non-routine (Klosterman, 1997; Batty, 1995). Such tools, however, are noticeably absent during early planning stages when strategic tasks such as visioning, storytelling and scenario development are conducted (te Brömmelstroet & Bertolini, 2008).

To gain a broader adoption of these tools in practice, research indicates a need to situate spatial models to their intended contexts of use. This means that during the strategic stages of planning, planning support tools should be embedded in practices that deal with what Rittel and Webber (1973) term 'wicked' planning problems that have no scientific solution, only resolution. Biermann (2011) asserts that planning issues related to these problems could be 'the most relevant contextual factor' impacting the content-related quality of these tools (p.11). In communicative planning practices (Healey, 2007), knowledge about planning issues is distributed among many planning actors. Inter-actor communication about wicked problems could be informed by models that as Batty (2013) suggests incorporate simplified modelling rules and that are used in defining the salient features of systems. Numerous techniques for group model building (GMB) have been developed for the purpose of eliciting knowledge about complex systems from system experts (see Voinov & Bousquet, 2010; te Brömmelstroet & Schrijnen, 2010). However, most GMB techniques have shortcomings that relate to their ability to capture the divergent mental models of actors, particularly in group settings, and to operationalize their knowledge for formal modelling (Ford & Sterman, 1998).

Models in the form of games, especially roleplaying games, are particularly effective in representing the complexity of a system and in facilitating social learning (see Pahl-Wostl & Hare, 2004). These two capabilities have made games and gamified experiences popular techniques for planning in multi-actor contexts. Protocol for the design of games centers on two forms of what (R. Duke, 2011) refers to as intelligent communication: that among participants while playing the game and between the user and the game designer during game design (p.6). Next to spaces for intelligent inter-actor communication in strategy-making processes, there is a need for spaces that facilitate intelligent communication between these actors and planning support experts in model-building processes. Such a space has been introduced in co-design literature as the *third space*, which shares features of both the technology developer and user domains (Muller & Druin, 2002). More pragmatic, design-oriented research is needed to grasp the relationship between the mechanisms of such 'dialogue structuring' methods, context and outcomes (te Brömmelstroet & Schrijnen, 2010). So far, applications of game co-design to urban and spatial planning are preliminary but promising (see Ampatzidou & Gugerell, 2018). Exploration into game co-design as a socio-spatial GMB technique could contribute to the debate on how to contextualize the underlying spatial models of planning support tools.

Thus, this paper explores the introduction of a game prototype as a third space for the elicitation of context-specific knowledge about key planning issues in formats suitable for use in the development of a spatial model. Like spatial models, the game is built on an underlying set of parameterized assumptions about the spatial system in question, which actors are encouraged to critique and revise. The purpose of this design study is three-fold: (1) to establish a set of design requirements for a game-based method for knowledge elicitation, (2) to illustrate a game co-design method that complies with these requirements and (3) to determine whether the method provides an effective means to elicit the sought-after knowledge about a local context.

The structure of this paper is as follows: The next section operationalizes key terms concerning knowledge elicitation followed by the introduction of design requirements for the game co-design method. After describing the method, we report on the critiques of the parameterized assumptions and the game rules that the actors provided. The paper concludes with a discussion of the extent to which the game co-design method fulfilled its intended purpose of eliciting knowledge from system experts, in terms of both formalization and divergence, and provides recommendations for continued research in the realm of game-based GMB.

5.2 Operationalization of key terms

Knowledge elicitation for model building concerns the retrieval of knowledge from the mental models of system experts. Mental models contain knowledge about issues pertaining to the functioning of a system and the basis for individual action (Rouwette et al., 2009). Knowledge elicitation mainly deals with what Nonaka (1994) describes as the externalization of tacit knowledge in explicit, codified terms. Two dimensions of knowledge elicitation that are important for contextualizing model building to a strategy-making process are knowledge formalization and divergence.

5.2.1 Formalization

Spatial models vary in their degree of formalization. As knowledge about system components and their relationships becomes formalized, its depiction using quasi-natural language is operationalized into mathematical constructs (Wegener, 2001). Before developing mathematical equations, relationships between parameters of these components must be mapped and parameters must be quantified (Vennix et al., 1992). Andersen et al. (2007) described the formalization processes in GMB settings as a double-edged sword. On the one hand, if not properly facilitated, the structure of the formal model can stifle emergent communication. This statement points to a need for proper facilitation of model use that maximizes the opportunity to elicit knowledge from system experts. On the other hand, the formal structure can apply 'sensitivity checks and other cross-checks' (Andersen et al., 2007, p. 693). Crosschecking modeler estimates with knowledge from system experts can improve model credibility in the eyes of the intended users (Ford & Sterman, 1998).

5.2.2 Divergence

Interacting with the mental models of different actors belongs to divergent dynamics in group settings. Divergent thinking is essential when engaging groups and individuals in determining the boundaries of the system (Vennix et al., 1992). Divergence involves the generation of a wide variety of ideas based on individual contributions (Dennis & Wixom, 2002). When planning is in its strategic stages, divergence and shared learning about the system is more the focus than converging and decision making (te Brömmelstroet, 2017a). Divergence in multi-actor contexts can reveal differences in knowledge among actors.

Four aspects of divergence related to knowledge are: frames, domains, abstraction levels and uncertainty. First, planning actors use frames to filter and make sense of specific issues and their relationships (Matos Castaño, 2016; Dewulf et al., 2009). Frames about these issues may be expressed as perspectives pertaining to an issue

or preferences and priorities of one option over another. Second, the frame an actor uses to examine a problem can also reflect his or her domain of systematic-scientific expertise (Alexander, 2008). Third, actors apply their different domains of knowledge to different types of planning tasks. These tasks include non-routine tasks for preparing strategies over long periods or routine tasks for planning incremental change (Batty, 1995). Whether actors are dealing with routine or non-routine tasks may determine the level of abstraction (i.e. operational or strategic) from which they view planning issues (Geertman, 2006). Fourth, there are many uncertainties about the knowledge used in planning, and strategy making in particular. Identifying uncertainties concerning what is unknown, not understood, undisputed and hidden is an essential part of modelling and determining what model input may be genuinely helpful (Couclelis, 2005, 2003).

5.3 Requirements for a game-based method to elicit context-specific knowledge

Based on a literature review of knowledge elicitation methods from multiple disciplines and the key terms operationalized above, this section outlines seven design requirements for a game-based method that supports intelligent communication between planning actors and support experts, which are:

Requirement 1: Embedment of model building in the future-oriented tasks of spatial strategy making by means of a structured dialogue

As designers move closer to the intended users of their products, the front end of the design process is becoming increasingly open (Sanders & Stappers, 2008). This openness is reflected in planning support tool development approaches that are oriented towards the demand for support of dynamic early-stage planning tasks (see Vonk & Geertman, 2008; te Brömmelstroet & Bertolini, 2008). The general purpose of strategy-making tasks such as visioning, storytelling and scenario development is to influence the path of dynamics occurring in a spatial system towards a desired end (Couclelis 2005). Uncertainties about desirable alternative futures can introduce complexity and ambiguity into these tasks. Actor involvement in the design and development of planning support tools including their underlying models is seen as a means of creating a better fit between tool and process being supported (see Russo et al., 2018; C. Pettit et al., 2014; Vonk & Ligtenberg, 2010). Te Brömmelstroet et al (2014) have emphasized the importance of creating a 'structured dialogue' that involves actors in making important choices during model building. Mediated planning support (MPS) was developed as a method to structure the dialogue between domain experts and planning support experts by adjusting the generic features of an existing model (te Brömmelstroet &

Schrijnen, 2010). In doing so, the method has helped to imbed tool development in the complex reality of strategy-making tasks.

Requirement 2. Representation of both the expertise of planning professionals and the experiential knowledge of citizens

Of the many types of knowledge (see Pfeffer et al., 2013; van Ewijk & Baud, 2009), two types that are particularly relevant for developing spatial models are expert and experiential knowledge (Friedmann, 1993). Expert knowledge is a form of knowledge that is commonly applied in spatial planning (Pfeffer et al., 2011). Residents are often associated with experiential knowledge about a local area (Kyttä et al., 2011). Since residents are sources of knowledge about a spatial system, they too fall under the header of system experts. The inclusion of experiential knowledge in planning generates more robust arguments through the interplay of what strategy-makers say and the knowledge of those who have a stake in the area (Healey, 2007). Participatory methods are being linked to geographic information systems (GIS) for mapping and sharing spatially-explicit knowledge. SoftGIS methods, for example, excel in capturing localized experiential knowledge for statistical analysis and systematic GIS (see Kahila & Kyttä, 2009). Next to SoftGIS methods that produce knowledge about an area in big-data formats, methods are needed that provide such knowledge in high-quality formats.¹

Requirement 3. Parameterization of (non)spatial issues and the specification of relations using multiple description formats

Sterman (1994) claims that the only way to learn about complex systems is by eliciting knowledge about these systems and simulating their dynamics. It, therefore, follows that if learning about a spatial system is the aim, planning actors and their knowledge should be more involved in setting parameters and models (Pelzer, 2017) of these systems. GMB encompasses various techniques to elicit knowledge about system components and their relationships from system experts. In many cases, however, GMB approaches fall short of estimating the 'parameters, initial conditions, and behavior relationships that must be specified precisely in formal modeling' (Ford & Sterman, 1998, p.309). Eliciting knowledge about issues that have a spatial component is even more challenging. Spatially explicit formalization requires embedding spatial models in sophisticated system dynamics software that are difficult to use (Voinov & Bousquet,

1 The notion of determining appropriate moments in a planning process for the introduction of area-specific knowledge in big-data versus high-quality formats originates from a presentation given by the author together with Maarit Kahila-Tani on July 11, 2018 at the AESOP Congress in Gothenburg, Sweden.

2010). Alternatively, spatially explicit formalization could be facilitated through means of eliciting multiple descriptions of the spatial system. A triangulation of descriptions – e.g. verbal, textual and spatial – can improve information quality as actors seek consistency and descriptions are compared (Ford & Sterman, 1998).

Requirement 4. Idea generation or divergence through multiple, individual descriptions of the spatial system to reduce the risk of group-think and premature convergence

Knowledge elicitation methods such as GMB are popular means for identifying system components and their relationships. These methods are usually conducted in group settings. However, recent work on the use of planning support tools in group settings indicates the need for improved facilitation of individual work during idea generation (Champlin et al., 2018b). Since interacting groups tend to inhibit divergent thinking, nominal groups of one or two individuals are preferred for idea generation over group brainstorming (Vennix, 1999; Vennix et al., 1992). Nominal group work reduces the risk of group-think and premature convergence (Ford and Sterman 1998). Both are thought to impede group work while limiting the extent to which different frames and other aspects of divergence can be elicited from actors.

Requirement 5. Use of a model in a preliminary state so that actors are able to recognize and critique model assumptions

One means of structuring the dialogue between planning actors and support experts is through the exploration and critiquing of model assumptions before they are developed into mathematical constructs and entered into evidence-based knowledge technologies. Goodspeed (2016b) found that actors perceived their role in questioning assumptions and ensuring that planning support tools reflect their unique issues to be more important than their contribution to the technical aspects of model development. By removing the technical-functional aspects that actors often consider too sophisticated and intimidating (see discussion in Al-Kodmany, 2001) from model building, more focus can be given to planning issues and eliciting knowledge about them. Working with a preliminary model can help to structure model-building tasks by encouraging actors to redesign flawed parts of the model (Vennix et al., 1992). Using models with simplified rules and lowered explanatory power may also help actors to relate their inputs with model outputs (te Brömmelstroet, 2017b). A recent study on the use of different planning support methods found that actors working with a preliminary model could easily recognize assumptions and adopt the formal language used in the model when suggesting changes (Champlin et al., 2018a).

Building on these knowledge elicitation methods, we introduce two additional design requirements centered on the notion of models in the form of games. These requirements are:

Requirement 6. Use of a game environment as a third-space platform with hybridized features of both the user and technology domains

Sterman (1994) describes formal models as ‘virtual worlds’ where decision makers can refresh their skills, experiment and play for learning about complex systems (p.27). Serious games fit this description of a formal model. Games make planning more accessible (Ampatzidou et al., 2018), can simulate both socio-political and technical-physical networks of complex systems (Raghothama & Meijer, 2015) and offer a means to deal with problems where traditional scientific techniques are inadequate (Armstrong and Hobson 1973 as cited in R. Duke, 2011). Games that function as planning support tools can also incorporate game rules that reflect the rules that govern the city (Raghothama & Meijer, 2015). The relationships represented in game rules, can ‘make the player discover, experience emotionally, or experiment with new knowledge’ (Huynh-Kim-Bang et al., 2010, p.12). Ampatzidou and Gugerell (2018) have shown that involving future players as co-designers of games can lead to serious games for participatory planning that are both meaningful for players and embedded in the local planning context. The willingness future players demonstrated in their study to engage in game co-design points at the potential of games as third spaces for GMB. Core attributes of third spaces that are important for participatory practices include reciprocal learning, idea generation and challenging assumptions (Muller & Druin, 2002).

Requirement 7. Facilitation that structures communication interactions about problems and supports individual work

Facilitating the use of planning support tools involves structuring interactions among actors, tools and the tasks they support (Pelzer et al., 2015b). Facilitated processes are known to produce higher-quality outcomes and to enhance process satisfaction (Dennis & Wixom, 2002). Games and gamified applications may be adopted more broadly in planning processes when facilitators become more adept at administering such tools and determining appropriate situations for use (Ampatzidou et al., 2018). Champlin et al. (2018b) suggest that, given the demand for planning support with more adaptive information frameworks, facilitated interventions that limit the number of variables under consideration and support individual work may be important for planning quality.

5.4 Game co-design method and results

In this section we describe the main components of the game co-design method and report the results of an initial use case based on the dimensions of knowledge elicitation, namely issue formalization and the four aspects of divergence, i.e. frames, domains, abstraction levels and uncertainties.

5.4.1 The game co-design framework

The proposed game co-design method (Figure 5.1) integrates the abovementioned design requirements into a third space for planning actors to share their knowledge with support experts. Game content is developed based on a pre-selected subset of planning issues (for more about issue selection methods, see Champlin et al., 2018a). These issues are operationalized into parameterized assumptions and displayed as planning elements – i.e. actors, flows, facilities, investments and regulations – instead of GIS primitives (see Hopkins 1999) so that actors can identify the issues more easily. Multiple views of the parameterized assumptions are provided to permit a triangulation of knowledge. These views include an interactive map on a tablet device, a multiattribute table and tangible game elements. The views are used to elicit verbal, textual and spatial descriptions of the planning issues. Planning actors can select one or more of these views to critique the parameterized assumptions.

The method consists of two design stages: 1) *ex ante* game development and 2) critiquing parameterized assumptions of the game. In the first design stage, planning support experts develop a game prototype based on informed assumptions about a spatial system. The method itself is based on policy gaming, a process that ‘combines the rigor of systems analysis and simulation techniques with the creativity of scenario building and the communicative power of role-play and structured group techniques’ (Geurts et al., 2007, p.535). The second design stage is conducted in individual facilitated sessions with different groups of planning actors. The facilitators follow a script when eliciting descriptions of the system in its current and future states. The scripted questions and statements guide the actors through the application of their expert and experiential knowledge when critiquing the parameterized assumptions incorporated in the prototype.

5.4.2 Illustration: Co-designing the Kennistrekker game

In the spring of 2018, we began working with the a municipality in the Netherlands to facilitate communication with its stakeholders on the highly contested task of developing a housing (in Dutch: *huisvesting*) forecast. The housing forecast was part of a strategic redevelopment project of the Innovation Campus Kennispark, a 180-hectare

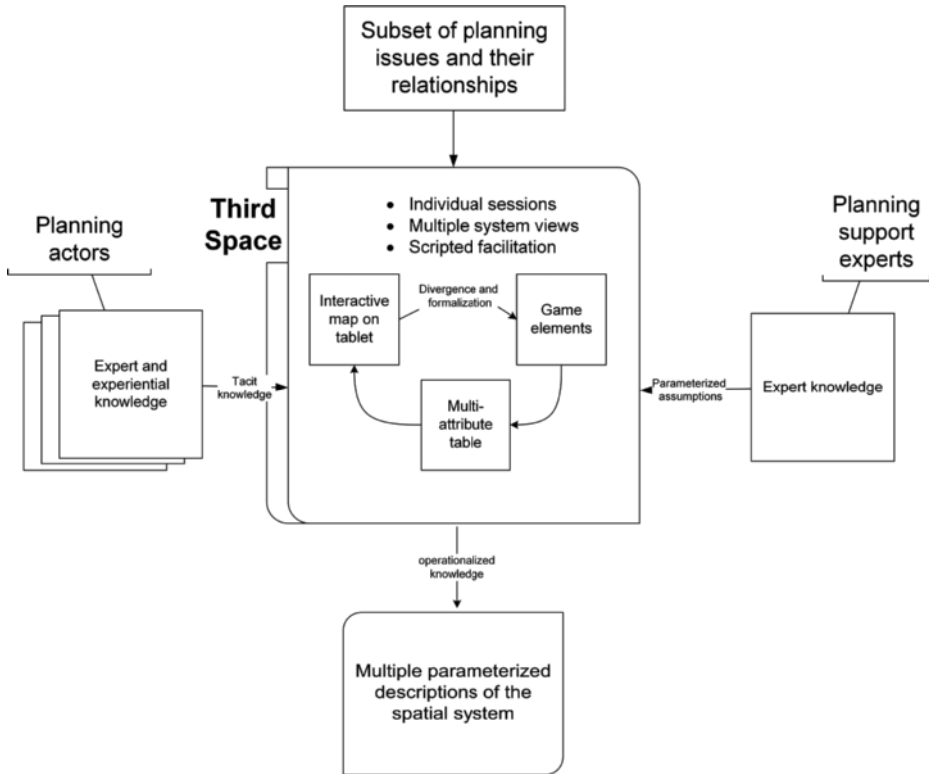


Fig. 5.1 The game co-design framework featuring the third space for knowledge elicitation

science park that includes a Dutch technical university and many high-tech and service companies. An agreement on the projected number, typology and location of new housing in the area was needed as a basis for determining necessary changes to the land use plan. Based on observations of several meetings, we concluded that three main factors were interfering with the development of the housing forecast: 1) different actor groups using different means of categorizing and assessing the housing demand, 2) insufficient crosschecking of expert planning knowledge with the experiential knowledge of potential future dwellers and 3) lack of a shared strategic vision for the redevelopment of the Kennispark.

To address these factors, we conducted three knowledge elicitation sessions following the abovementioned game co-design method, first with an urban planner and urban designer from the City (the planners), then with two university facility managers who were involved in determining student housing demand and finally with two members of the university student board (the students). These planning actors critiqued the underlying assumptions of the *Kennistrekker* prototype, a game which was designed to

simulate dynamic relationships between planning issues through the development of housing supply and demand scenarios. Relationships between the demand for housing by future inhabitants (the dwellers) and the supply of new facilities and infrastructure can be explored both spatially and non-spatially by playing the game. This exploration process is structured through the use of a subset of planning issues. These issues were selected during a strategy-making session with the Kennispark spatial development group, which the authors facilitated in September 2017. The subset included 10 issues: housing, restaurants, cafés, 24-7 dynamic area, green surroundings, accessibility, clusters, the Innovation Path, workspaces and barriers to university.

We derived most parameterized assumptions about the planning issues from notes taken during a housing meeting in January 2018. Since some issues were not discussed during the housing meeting, we did not have sufficient information to formalize all of the issues. To make the game playable, we used our own expert planning and modelling knowledge where information was lacking about planning issues to develop parameterized assumptions. We expected that many of our assumptions would be incorrect or incomplete and that the actors would critique and redesign what they considered flawed parts of the game.

Figure 5.2 shows the three views of the parameterized assumptions - game elements (comprised of game board, four dweller cards and thirteen action cards), an interactive map on a tablet and a multiattribute table – that were developed to help the actors describe the spatial system verbally, textually and spatially. The interactive map on the tablet was the view that was least used by the actors. Instead, the actors frequently referred to the map on the game board to communicate spatially about issues, both in terms of the current situation and future possibilities, and to sketch relationships between components. The planners, in particular, worked with the game board to communicate their critiques, which were mostly strategic and future-oriented. The facility managers worked primarily with the multiattribute table. Most of the knowledge elicited from them pertained to non-spatial housing and dweller attributes (e.g. number of units and budgets), indicating their domain-specific knowledge about the operational aspects of student housing. The multiattribute table provided a textual view of the planning issues in formalized language, which the actors would emulate when verbally and textually formulating their critiques.

An examination of the elicited critiques from a divergence viewpoint suggests that the actors primarily critiqued assumptions that were related to their own knowledge domains. Table 5.1 shows that the facility managers and students critiqued our demographic classification of dwellers and nearly every attribute related to housing demand.



Fig. 5.2 left. Game elements view including game board, action and dweller cards. top right. Interactive map on tablet view. bottom right. Multiattribute table view.

Both groups proposed alternative classifications based on what dwellers are willing to spend on monthly rent; however, their parameterization of these classes and rent thresholds varied. In general, the students expressed concern that the housing demand assumptions for students did not reflect their framing of the issue and suggested that students should be involved in setting the priorities of the undergraduate student character. The distribution of critiques across the matrix of facility supply assumptions (Table 5.2) provides a further indication that the actors limited their critiques to their own knowledge domains instead of commenting on each relationship between planning issues. The planners applied their expert knowledge, both strategic and operational, to critique the facility supply and land use assumptions. Of the 11 changes to assumptions about land uses, the planners adjusted 8, while the students only adjusted one. The two adjustments to the land uses made by the facility managers reflected the operational-level, domain-specific character of their knowledge about regulations, buildings and infrastructure on campus.

The game co-design method supported the elicitation of formalized knowledge about relationships between issues. The matrix shows that the actors not only critiqued our parameterized assumptions, they also helped to fill in gaps in the multiattribute table where we had not yet formulated assumptions about the relationship between issues. The view most commonly used by the actors to externalize their knowledge about these

Table 5.1. Multiattribute table of parameterized housing demand assumptions (A) and critiques provided by the City planners (P), facility managers (M) and students (S).

	Visiting Scholar		Graduate Student		Undergraduate Student
	Assumptions	Critiques	Assumptions	Critiques	Assumptions
# of units	150		700		350
Rent (eur)	700-850	(M) 700-1200	700-850	(M) ≤ 300-400 if on scholarship	≤ 700
Green space	≤ 200m		≤ 1000m		
Restaurant	5x ≤ 500m		5 ≤ 200m	(S) Least important	5x ≤ 500m
Café	1x ≤ 300m	(M) Remove this option	3 ≤ 200m		1x ≤ 500m
Bus stop	1x ≤ 300m	(P) Remove this option	1x ≤ 500m		1x ≤ 500m
Proximity to...	University			(S) Most important	
	Other	(M, P) Shopping center with supermarket; (M) Current option is too expensive		(M) Shopping center (M, P) Supermarket	Cluster 50 units ≤ 100m
Services					
Other issues	(M) Categorize EEA vs. non-EEA staff			(M) Categorize based on scholarship vs. salaried	

Undergraduate Student	International Student	General Issues for All Dwellers	
Critiques	Assumptions	Critiques	
	550		(M) 850 replacement units; 430 new low-budget
(M) ≤ 300-400 after subsidy (S) ≤ 500 average 300-400	≤ 300	(M) ≤ 300-400; Price is main priority (P) Vary 250-1000 (S) ≤ 300 netto	(M) Cluster undergraduate, Masters, scholarship and exchange students
(S) Most important factor			
(S) Remove this option			(M,S) Expand foodtruck daytime concept (M) Willing to travel to city for atmosphere (P) Combined 'horeca' concept
(S) Need more on campus			(P) Combined 'horeca' concept
(S) Already enough stops on campus	1x ≤ 300m	(S) Remove this option	
(S) High importance	≤ 300m	(M) ≤ 300m to classrooms (S) ≤ 3000m to classrooms; most important option	
(M) Shopping center (M, P, S) Supermarket (S) Sports facilities	Cluster 200 units ≤ 200m	(M) Shopping center (M, P) Supermarket (S) Supermarket with import products (S) Recreational facilities open weekends	<i>Different indicators for measuring accessibility:</i> (M) Proximity to bus/train station or by bike within 20-30minutes; (P) Measure using proximity radius; prioritize distance to parking for workers; (P) All facilities ≤ 5 minutes biking; dwellers walk/cycle nearby for daily use and use train on weekends; mix of 4-5 functions: Living, working, education, meeting spaces and Horeca (S) International dwellers move from A to B by foot within 300m; Dutch students from A to B by bike within 5 min. & pedestrian bridge
	Yes	(S) Not needed, too expensive	
		(P) Categorize EU vs. visa students; (S) Categorize by budget (scholarship vs. personally financed	(M) Guaranteed provision of housing for visa-required students/guests for 1st year (P) Availability of housing is most important criterium for students since planning is supply driven (S) Bicycle parking is important

Table 5.2 Matrix of facility supply and land use assumptions (A) and critiques provided by the City planners (P), facility managers (M) and students (S).

	Restaurants	Cafés	Bus stop	Parking garage	Workspaces
Land use restrictions	(A) Meeting spaces	(A) Meeting spaces	(A)Transport	(A)Parking (M) Green space (P) Workspaces, green space	(A) Workspaces (P) Green
Restaurants to...(1 cell)					(S) 50-300 m to place of study
Cafés to...(1 cell)		(S) More terrace space			(S) 50-300 m to place of study
Bus stop to...(1 cell)					
Parking garage to... (6 neighboring cells in triangle)				(M) Placement of garage must be away from UT entrance	(M) Removal of individual company parking (P) Distance 200-500m
Workspaces to...(12 cells)	(P) Close to	(P) Close to		(A) ≤ 25m away from (P) ≥ 500 workers in cluster 200-500m from garage	(A) Adjacent to
Housing (700-850 Eur) to..					
Housing (≤ 700 Eur) to...					
Housing (≤ 300 Eur) to...					(S) Noise buffer between
Green space to...					
Innovation path to... (10 cells; must connect to existing path)				(A) can also convert parking cells	(M) Extend from O&O complex to Coop store (P) 300x300m cluster with mix of 4-5 functions along path

Facility type and proximity to...

Housing (700-850 Eur)	Housing (≤ 700 Eur)	Housing (≤ 300 Eur)	Green space	Innovation path	Other
(A) Housing, green space (P) Workspaces, parking (S) Parking			(A) Green space (P) Workspaces, parking	(A) Meeting spaces, transport, parking (P) Workspaces, education	(M) Workspaces can also be used for education and research (bouwkavels)
(A) 300 units ≤ 500m (P) Change to no. of students, dwellers & workers per unit/area and appropriate mix (S) Change to 300 customers ≤ 500m daily					(P) Cafés & restaurants clustered
(A) 300 units ≤ 500m (P) Change to no. of students, dwellers & workers per unit/area and appropriate mix (S) Change to 300 customers ≤ 500m daily				(M) Along extended path through campus	(P) Cafés & restaurants clustered (M) Competition from basement bars
(A) 300 units ≤ 500m (S) Better cycling route from train station to housing					(M) Remove this option (S) Install bridge/tunnel instead
(S) Integrate parking and housing on existing campus parking areas				(M) Centralized parking near innovation path and Cubicus (S) Traffic lights at entrance are barrier	(P) Catchment area; access to garage; capacity to be profitable
				(A) Adjacent to (P) Cluster work, ...near but not next to path (S) Classrooms proximity not important	(M,P) Building height limits 20-30m; New ITC building requires an exemption to build 60m
(A) 200 units ≤ 4 ha. or 50 units ≤ 1 ha.					
(A) 200 units ≤ 4 ha. or 50 units ≤ 1 ha. (M) 3-4 large buildings for salaried students					
(A) 200 units ≤ 4 ha. or 50 units ≤ 1 ha. (S) Integrate international with undergrad housing					
(M) Row of housing from station with ca. 300 units for salaried students/start ups				(A) Adjacent (S) Connect to Hi-tech pedestrian tunnel or bridge over Hengelo Str. Showcasing company techs	(M) Path use

relationships was the game elements, specifically the game board and action cards. All three of the actor groups formalized relationships between spaces for work and study and service facilities. For example, the planners suggested to cluster restaurants and cafés with other facilities, while the students stated that most students do not have the finances to eat in restaurants and that they prefer to have a supermarket nearby that also carries imported products. Like the facility managers, they indicated a need for more daytime eating options such as food trucks that served lunches and cafés for meeting with friends on the weekends. Both the planners and the students adjusted our parameterized assumptions about the viability of restaurants and cafés. Our parameters for restaurant and café viability based on the number of housing units – which was the data we had available – would have excluded a large number of potential daytime customers working and studying in the area. Instead, these actors suggested we should allocate these facilities based on the number of potential customers, i.e. students, workers and dwellers.

There are indications that working with parameterized assumptions about the planning issues in individual sessions facilitated divergent thinking. Separate discussions with the actor groups revealed differences in the way the actors framed and formalized the accessibility issue compared to our parameterized assumptions. Instead of modelling proximity in terms of a distance radius in meters, the actors suggested several alternative means based on travel time and transport mode. The planners based their framing of accessibility on prior knowledge of student behaviors at other Dutch universities, while the students based their framing of the issue on personal experience and that of students they know. The planners suggested to locate all facilities for daily use (i.e. living, working, education, meeting spaces, cafés and restaurants) within a 5-minute biking or walking distance from housing. When we cross-checked their expert knowledge with the experiential knowledge of the students, we learned that the 5-minute cycling distance was applicable to Dutch students but not to most international students who prefer to walk the equivalent distance.

The actor groups used different frames of the issues to critique our assumptions about which facilities should be located near housing. The facility managers stated the café issue was not a priority for dwellers, whereas the students themselves expressed a need for more cafés on campus. The planners put forth a different proposal to include cafés in a combined hotel, restaurant and catering concept (In Dutch: *horeca*) in the business park area adjacent to campus. In another instance, the facility managers agreed with our assumption to place housing within 300 meters of classrooms, while the students preferred to create a 'noise buffer' between on-campus housing and spaces for work or study, explaining that students were willing to travel up to three kilometers to their

classes. This again demonstrates the crosschecking of expert knowledge with experiential knowledge that occurred during the sessions.

While critiquing the game rules, relationships between the parameterized assumptions and regulations were formalized spatially as the actors changed land uses, allocated facilities and housed dwellers (see Figure 5.3). This experimentation in rapid scenario development allowed the planners to reflect on uncertainties about their area redevelopment strategy. For example, measuring out areas and distances on the game board allowed the planners to experiment with design of a 'model cluster' in terms of dimensions, composition of facilities and occupancy levels. We identified complementarity between levels of knowledge abstraction, specifically regarding the integration of operational-level knowledge from the facility managers about the actual state of housing demand into strategic discussions conducting by the planners concerning how many dwellers, workers and students to include in a cluster. From a strategy-making perspective, the inclusion of this operational knowledge could reduce uncertainties not just about the housing forecast, but also for the strategic discussions about area redevelopment scenarios.



Fig. 5.3 A facility manager allocates low-budget housing for students in the Kennispark while critiquing the game rules.

The flexible game rules allowed actors to play the game based on their own domains of knowledge, levels of abstraction and framing of issues. Process and tool-related facilitation brought structure to the free play of critiquing the game rules. Together with the actors, we decided that rather than create a game with a fixed set of game rules, the rules of play should remain open so that how the game is played is determined by the learning objectives of the players. Each group of actors indicated an interest in playing the game with the other actors once it was complete. The facility managers stated that playing the game with the planners may help the two sides communicate better.

5.5 Discussion and conclusion

This paper documents the development, description and evaluation of a game co-design method for the elicitation of context-specific knowledge from planning actors during model building. It responds to an omission in planning support literature identified by te Brömmelstroet and Schrijnen (2010) by engaging in pragmatic, design-oriented research to grasp the relationship between the mechanisms of dialogue structuring methods, context and outcomes. We have explored the potential of tangible game co-design as a means of building simpler, contextualized models given that according to Lee (1973) attempts to capture the complexity of spatial systems in large-scale models are considered flawed. Still, the ambition towards hypercomprehensive models persists (te Brömmelstroet et al., 2014). Citing the apparent mismatch between the information frameworks of planning support tools built upon such models and the information needs of planning actors, we introduced a game prototype that serves as a third space where actors and support experts can meet halfway between their domains of expertise to engage in learning and communication. This third space approach serves as an inclusive method for collaboration among both experts and non-experts as suggested by Vonk and Ligtenberg (2010).

By applying flexible game rules and easily recognizable parameterized assumptions derived from a limited number of planning issues, the game co-design method provides a framework for both sides to engage in a structured dialogue. Planning support experts could become more adept at facilitating the use of tangible games as a simpler, more flexible means of rapid scenario development and evaluation of outcomes. Facilitation will likely continue to play an important role in mediating discussions triggered by the use of games and simplified models, in general. Less flexibility in the facilitation of content, processes and tool use may help to structure the use of these adaptive planning support tools in work session settings like the one described in this study (see also Champlin et al., 2018b).

Meeting separately with the different actor groups made us more aware of the biases in the underlying assumptions of our game. These assumptions aligned more with the frames and knowledge domains of the planners than with the other actor groups. This alignment may reflect our own training as planners, but it also suggests that our own knowledge of the project under investigation had been predominantly influenced by conversations and encounters with our main points of contact, the city planners. At the same time, the level of abstraction of our assumptions was mostly operational, which matched the operational-level knowledge of the facility managers. Such biases reflected our own interpretation of the knowledge and information made available to us prior to the sessions. Potential benefits of making these biases explicit and crosschecking it with system experts during the early stages of model building may be improved model calibrating, sensitivity testing and the determination of parameter ranges and thresholds using the knowledge of system experts as well as greater transparency and trust in model outputs (see Ford & Sterman, 1998).

We also found that asking what assumptions were missing from the game served as an important mechanism for distributing influence in the model-building process to the actors themselves. This question was especially important since most of the actors were not involved in determining the subset of planning issues used in the sessions. Asking actors what issues and relationships are missing during model building may help to ensure that models reflect the salient issues and the perspectives of different model users. Such exercises in divergent thinking are important in the early stages of both model building and planning alike and they deserve more attention from academics at different stages of both processes.

Recent studies have also pointed to a need for more research into the development and testing of planning support tools that are designed to support individual work and their integration into communicative planning processes (see Champlin et al., 2018b). Russo et al. (2018) identified a paucity of studies evaluating the individual use of such tools. It is our impression that even less attention has been granted to the role of individual work in GMB, despite divergent thinking being an integral part of group work. Organizing separate but identical scripted sessions with the different actor groups resulted in considerably more divergence about the planning issues than we had previously observed in group meetings. We found that divergent thinking about the issues could be used in complementary ways, giving support to Healey's (2007) assertion that involving the knowledge of those who have a stake in an area can make expert arguments more robust. The game co-design method helped us to identify aspects of issues where there was agreement or complementarity between knowledge domains at different levels of abstraction and in some cases a need for more knowledge. This approach

also prevented group dynamics that are known to inhibit idea generation (see Lamm & Trommsdorff, 1973), thereby supporting our aim to gain as much insight as possible into the project.

It is important to clarify that the sessions we conducted represent a small portion of the work that must be conducted during early model-building stages (see Vennix et al., 1992). Model building, particularly with non-professional modelers, is a long and arduous process. Stave (2002) provides a detailed account of a GMB process that required an investment of 1200 person-hours from her three-person research team, 80 hours of which involved group work with system experts. That said, the game co-design method detailed in the paper provides a comparatively rapid means of externalizing the tacit knowledge of system experts in bi-space, i.e. spatially parameterized descriptions of issues and their attributes. Working with parameterized assumptions about a spatial system allowed the planning actors to mimic the formalized language of the assumptions when formulating their critiques. Elicited critiques of the game rules, in particular, served the dual purpose of providing us insight into relationships between the parameterized assumptions while granting the actors the opportunity to reflect on their strategy-making process. It follows that conducting GMB in a game environment may advance what Couclelis (2005) refers to as the future-oriented mission of planning by allowing actors to experiment in a safe environment with the outcome of different planning strategies.

We recommend explorations into the development of hybrid planning support methods that integrate more sophisticated models for analysis with tangible game environments like the policy game described in this study. Such methods could benefit from the flexibility of tangible games for rapid brainstorming and experimentation in scenario development without the obstructing influence (see Pelzer, 2015) of sophisticated knowledge technologies, while relying on dedicated, contextualized models for running simulations and conducting spatial analysis, thereby contributing scientific information to supplement user intuition (R. Duke, 2011). The integration of knowledge technologies with models in the form of games could facilitate the continued involvement of planning actors in determining where scientific information may be of added value during later-stage spatial planning tasks. Lee (1973) asserts that what to disregard in the model should be left to the skill and discipline of the modelling expert. This means that in GMB contexts where users are part of the design team, model users should be involved in choice making beyond the determination of system boundaries. Planning actors should be continuously engaged in critiquing model assumptions, as suggested by Goodspeed (2016b), particularly when it comes to the collection and selection of data, quantification of model parameters and development of equations and indicators

for scenario assessment. Moreover, further research is needed into means of filtering elicited knowledge based on theory about choice making and convergence in group settings. Finally, this paper has shown that during the strategic stages of planning such 'modelling as learning' (Lane, 1992) exercises may provide an effective means of informing communicative planning processes, perhaps more than the models themselves.



Chapter 6

Conclusions

Chapter 6

This concluding chapter synthesizes the results of the studies included in the dissertation as follows. The central findings are discussed before reflecting on the applied concepts and research methodology. Subsequently, recommended directions for future research are proposed and concluding remarks are made concerning the implications of this research towards improving the adoption of PSS.

6.1 Discussion: Answers to the research questions

The aim of this research has been to contextualize planning support based on an enhanced understanding of the divergent and convergent dynamics that occur during the strategic stages of spatial planning. Insight gained from the studies is discussed here in the form of answers to the four research sub-questions introduced in Chapter 1.

RQ1: What are the dynamics that require support during strategy making and how does tool use influence these dynamics?

In Chapter 2 complex systems theory was applied as a lens to examine the dynamic communicative interactions that occurred in a strategy-making session. Prior research has concluded that, considering communicative approaches to planning, divergence and convergence may be important dynamics to pay attention to when developing PSS (see Pelzer et al., 2015a; te Brömmelstroet & Schrijnen, 2010). The purpose of this first study of the dissertation has been to conceptualize how divergent and convergent dynamics power the adaptation of planning issues from their wicked problem state into the strategies that guide the routine tasks of planning and decision-making. Mapping a network of these adaptations served as a means to evaluate how planning support can be used to trigger issue adaptations irrespective of the planning task being conducted. This study drew attention to the agency of these tools that, if better understood, could be harnessed to move the strategy-making process forward in a nonlinear fashion.

Findings from this study suggest that the intensity of planning support use by planning actors may vary between divergent and convergent dynamics. Numerous associations were identified between instances of divergence and the use of planning support tools that spatially represent planning issues. For example, when a preliminary spatial model featuring an area deterioration indicator was introduced as the session ice breaker, participants immediately identified a number of key issues, including non-spatial ones. These issues were later adapted into attributes for scenario development primarily while sketching on paper maps. In other words divergent dynamics of dialogue more often than not were supported by these tools. Comparatively, during moments of convergence, the facilitation of a structured dialogue when making selections among options may be preferred over the use of planning support tools. Developing an alternative means for assessing planning support use with respect to divergent and convergent communication dynamics has been a first step towards identifying appropriate forms of planning support for dealing with the conundrum of context-specific issues that actors encounter during strategy making.

RQ2: How do different conditions of use influence PSS performance?

In recent years, particular attention has been paid to PSS performance in group settings and to the engagement of planning actors in developing both the technical and softer aspects of their underlying models as a means of improving PSS performance. Authors have suggested that the involvement of these actors in model building should be both flexible and facilitated (te Brömmelstroet & Schrijnen, 2010; Vonk & Ligtenberg, 2010). Since little is known about the influence of auxiliary factors to the performance of the actual PSS software, this study investigated the influence of varying degrees of facilitation flexibility and different types of visualization hardware use on PSS performance. The study produced the following findings: (1) a higher number of generated ideas (divergence) by those who worked on tablets compared to mappable users, (2) an inverse relationship between idea quality scores (as a measure of convergence) and the level of facilitation flexibility, (3) higher perceived quality of process under conditions where indicators were pre-determined by the facilitator rather than chosen by the participants themselves and (4) a high percentage of strong correlations between perceived usability and perceived quality of process, especially when measured at the individual level.

Contrary to the findings of earlier PSS performance research cited above, these results indicate that facilitation should serve to *structure* the involvement of actors when interacting with models. As Findings 2 and 3 show, less flexibility in the choices available to the actors was associated with both higher idea quality and higher perceived quality of process. Two forms of structuring – that which places limits on the number of variables so that actors do not explore the world of options (divergence) and facilitating dialogue as groups engage in choice making (convergence) – provide more conceptual clarity to what is meant by facilitating a structured dialogue in the Chapter 2 discussion. Findings, furthermore, point towards the need for enhanced support of individual work during divergent dynamics (Finding 1). The provision of dedicated support for individual work challenges the dominant direction of PSS development over the past two decades towards facilitating group communication and interaction (see discussions in te Brömmelstroet, 2017b; Klosterman, 1997). Considering the broader discussion surrounding PSS usability, this finding warrants further testing with a larger number of groups to claim statistical significance. Finally, the findings corroborate claims in literature that enhanced tool usability may be needed to overcome the numerous barriers blocking the widespread adoption of PSS, particularly during strategy making (te Brömmelstroet, 2017a). Towards overcoming these barriers, the study confirms the need for structured formats for applying simpler, more flexible forms of planning support that can be contextualized to divergent and convergent process dynamics. Towards this aim, the skillful facilitation of planning process, content and tool use (Pelzer et al., 2015b) remains key.

Findings from the studies in Chapters 2 and 3 were used to determine a set of design principles for two methods aimed at creating a structured dialogue during strategy making and at linking the outcomes of strategy making to model building. In light of the known factors of simplicity, transparency and flexibility that influence the performance of PSS during strategy making (te Brömmelstroet, 2012), these studies indicated that the structuring of divergence and convergence is also required. Support methods that reflect this notion of 'structured flexibility' should respond to user demands for simpler, more flexible information models while limiting the number of options up for discussion and structuring processes of exploring, debating and making choices among these options. Moreover, appropriate methods should be packaged in formats that promote engagement with the tool without obstructing the divergent and convergent communication dynamics between actors that power strategy making forward. Since sophisticated technologies and overly complicated methods tend to obstruct communication dynamics, the usefulness of simpler, tangible alternatives may be worth exploring. This set of design principles led to the experiments in Chapters 4 and 5 with game-based methods designed to improve communication in complex strategy-making settings.

Additionally, Chapter 3 laid out an explicit set of variables for measuring PSS performance based on idea generation and choice making as outcomes of communication and learning that are measured at both the individual and group level. These variables were applied in the subsequent two studies to evaluate the contribution of game design towards intertwining planning and PSS development in the early stages of both processes.

RQ3: Does the gamification of strategy making provide a useful means for supporting divergence and convergence in group settings?

Gamification was selected as a means of supporting strategy making in Chapter 4 based on several of its affordances such as its ability to support autonomy and human-human interaction while packaging processes in engaging, goal-oriented formats. Each of these motivational affordances can be associated with various aspects of strategy making. During strategy making, actors engage in the divergent and convergent dynamics that are required to move the process towards their goal of developing strategies for dealing with an uncertain future. The usefulness of a gamified strategy-making method was tested in a control-rich setting with students and in two context-rich case studies. The comparative study involved the introduction of several gamified elements to support problem formulation tasks in addition to sketching to support a scenario development exercise. The results indicate that the game elements provided a structured, visually engaging means of supporting divergence and convergence during the formulation of

the planning problem. Game elements that were considered intuitive such as the game board and score card also facilitated human-human interaction. Unique features of these elements that likely contributed to their perceived usefulness were that the game board and score card were constructed in a tangible format in lieu of digital alternatives and that they structured the contribution of user-generated content. Comparatively, the non-gamified sketching tools used to support scenario development did not support autonomy or the expression of self-identity, which seemed to hamper divergence. These findings confirm a main conclusion from Chapter 3 that more dedicated support to individual work is required during divergent dynamics. In addition, results indicate a link between the absence of game elements in the scenario development exercise and a perceived lack of support in the formalization of planning issues.

In conclusion, the findings of this study point towards two channels of communication that require support during strategy making. First, with respect to the dialogue between planning actors, finding structured means of diverging and converging effectively during problem formulation is paramount. These early communication dynamics determine the boundaries of what issues will be included in scenario development and evaluation stages and ultimately in the selection of a strategy. Second, during scenario development actors require a more effective means of communicating about their issues in the spatially parameterized terms of bi-space than what was achieved by the gamified support method applied in this study. Structuring the dynamics of dialogue between planning actors and planning support experts, i.e. facilitators and model developers, along with supporting autonomous work to reveal the various divergent aspects of the actors' knowledge about the planning issues may be beneficial. These conclusions led to the final study in which a method was developed to structure the dialogue between planning actors and planning support experts around the act of model building.

RQ4: How can game co-design contribute to the elicitation of knowledge that is needed to contextualize models used by PSS?

Having established in the previous chapter that games may be useful in structuring the dynamics of strategy making, Chapter 5 introduced game co-design as a means of eliciting knowledge from planning actors for the purpose of contextualizing spatial models. The premise of the design study was that a game prototype could serve as a 'third space' where planning actors and support experts could meet halfway between their respective realms of policy and technology to engage in communication and learning about a spatial system. Recent research has shown that co-designing games with intended users can help to ensure that the rules and mechanisms of the game reflect the planning context (Ampatzidou & Gugerell, 2018). In close relation to this,

my venture into game co-design aimed at contextualizing the models used during strategy making by eliciting divergent types of knowledge about planning issues in the formalized terms of bi-space. While there are numerous techniques for eliciting knowledge about a system from the mental models of system experts, spatially explicit knowledge formalization remains a challenge (Voinov & Bousquet, 2010).

A central finding was that the presentation of planning issues in the form of parameterized assumptions modelled to participants how to communicate about their issues in bi-space. By displaying the assumptions in a map view, a spreadsheet view and a game view, knowledge about the issues could be triangulated and elicited in several forms as suggested by (Ford & Sterman, 1998). Moreover, hosting separate sessions with different actor groups maximized the opportunity to generate ideas while avoiding group dynamics that tend to inhibit divergence. In addition to serving as an effective means of eliciting context-specific knowledge of the spatial system from planning actors in formalized terms, the game co-design method in return granted planning actors the opportunity to experiment and reflect through engagement in modelling as learning (Lane, 1992) at an early stage in the strategy-making process.

6.2 Reflections

Having answered the four research sub-questions in the discussion above, attention can now return to the central research question:

How can planning support be designed to fit the context-specific requirements of spatial strategy making?

This discussion of the central research question is carried out in the form of reflections on several main topics emerging from the thesis. The first four topics concern conceptual aspects of the research while the remaining two topics pertain to methodological considerations. First, I reflect on the need for more dedicated support to the dynamics of divergence and convergence during strategy making. Second, I reflect on what contextualization means based on a broadened view of PSS as proposed in this dissertation. Third, I elaborate on the packaging of planning support for dedicated use during strategy making. Fourth, I explain the relevance of intertwining strategy making and model building for PSS contextualization. Fifth, I look back on my experience designing and conducting planning support interventions and on PSS research based on group work, in general. Sixth, I discuss the challenges of representing real-world phenomena in games and in testing them in simulated environments.

6.2.1 Conceptual reflections

Reflection 1. Only recently has planning theory moved 'beyond metaphor' in its adoption of the complexity sciences as a basis for exploring methods of engagement with dynamic processes (Sengupta et al., 2016, p. 970). The emergence of this young field has opened opportunities for the development of tools and methods that provide dedicated support based on the dynamics of spatial planning processes. This dissertation has leaned on complexity theory to analyze the dynamics of divergence and convergence in group settings with the overall aim of contextualizing planning support based on these dynamics. The analysis method introduced in Chapter 2 untethered the components of the task-technology-user fit model so that patterns of planning support use could be identified irrespective of planning task or user need. Instead, the analysis method mapped that adaptation of planning issues and indicated links between planning support use and the divergent and convergent dynamics that power these adaptations.

Understanding the capacity of planning support to trigger desired communication dynamics based on a systems view of planning issues and their relationships could facilitate a more nuanced approach to planning support interventions. Support oriented towards triggering divergence and convergence could help to structure rather than steer inter-actor communication. The identification of lever points for triggering desired adaptations in the strategy-making process may maximize the ability of planning actors to communicate and learn effectively while avoiding what Pelzer (2015) referred to as tool performativity, or instances where the tool steers the process being supported. Such an approach to planning support may provide the combination of structure and flexibility necessary for actors to develop strategies for dealing with unforeseen change that arises both in the planning process and in the spatial systems that are affected by plans and decisions. This dissertation has demonstrated that tangible games can fulfill these requirements for dedicated support to helping actors identify salient planning issues and formalizing them as input for models. Related research has shown that the use of tangible forms of support that make divergent frames of issues and problems explicit may help actors later on in strategy making when negotiating scenario alternatives (see Matos Castaño, 2016). Thus, the benefits of using tangible tools and methods to support these dynamics can be seen across the different stages of strategy making.

Reflection 2. Since each planning process contains its own unique set of relevant factors that influence the potential supportive role of dedicated tools and methods (Geertman, 2006), the contextualization of planning support has been the core focus of this dissertation. Contextualization hereby has been dealt with in accordance with three interdependent objectives. The first objective concerned the adaptation of relevant knowledge about planning issues into content for PSS and its underlying models. These

issues have been referred to as perhaps the most relevant of all contextual factors that influence the quality of PSS (Biermann, 2011). The second objective dealt with developing appropriate methods for triggering these adaptations. The third objective aimed at developing simpler exploratory models for strategy making that can aid in identifying key issues and informing debate about wicked problems (Batty, 2013).

The topic of contextualization was, hereby, investigated within the two main streams of PSS research covering both the prototyping of new tools and methods and the use of existing ones. This two-pronged approach adheres to the PSS pragmatic research agenda and its aim of propelling the domain forward by connecting conceptual and practical studies in reciprocal loops (te Brömmelstroet & Schrijnen, 2010). Rather than reinventing the wheel for each new case, the stance of this dissertation is that PSS contextualization should entail a combined approach of contextualizing the underlying models of PSS based on user knowledge of planning issues and developing intuitive, engaging and flexible means of eliciting this knowledge from users based on an enhanced understanding of planning dynamics.

This dissertation has established that without the participation of relevant planning actors in building the underlying models used in PSS, key context-specific knowledge may be lacking from the tools and methods intended to support spatial planning. A contextualization approach focused on planning issues rather than the technical components of PSS is consistent with other recent PSS research. Planning actors, so it seems, perceive their role in ensuring the system reflects their unique issues to be important than their involvement in the 'technical construction of PSS and other policy-relevant models' (Goodspeed, 2016b, p. 458). While prior socio-technical PSS development approaches have involved mainly planning professionals (see Biermann, 2011; Vonk & Ligtenberg, 2010; te Brömmelstroet & Schrijnen, 2010), the contextualization of planning support based on planning issues and their adaptive networks requires the involvement of a broader range of actors who possess varying degrees of expert and experiential knowledge about these issues. Involving residents and other participants who have a stake in the area can generate an interplay between their knowledge and that of strategy-makers (Healey, 2007), ultimately leading to more robust strategies.

The importance of bringing a participatory voice to PSS contextualization became more evident over the course of this study and ultimately led to the inclusion of potential residents in the knowledge elicitation study in Chapter 5. This actor group had not been involved in any strategy-making sessions leading up to this study. Yet, the experiential knowledge elicited from them proved important for crosschecking the expert knowledge of the planning professionals. This participatory approach was effective in

eliciting multiple parameterized descriptions of a spatial system from different actor perspectives. What remains unknown is the form a participatory approach to scenario development would take when making choices among these variables (i.e. convergence).

Reflection 3. The question of how to contextualize PSS to the processes they are intended to support belongs to the larger topic of demand-driven PSS development. Advancements in PSS development so far remain firmly centered on the application of GIS to support planners in dealing with ‘long-range problems and strategic issues’ (Geertman et al., 2015, p. 3). This thesis has demonstrated that demand-driven approaches to PSS development do not necessarily need to incorporate GIS or rely heavily on formal models. Particularly early on in strategy making, the sheer number of planning issues being introduced by an ever-growing field of actors makes modelling both complicated and time-consuming. As the number of variables included in a model increases, the number of potential interactions between variables increases to the square (Lee, 1973). In light of this, the benefits of using formal models and other technological components of PSS during the wicked problems stage of planning may not outweigh the potential costs – i.e. added complexity – of using them. Instead, actors may benefit from the application of simpler, more flexible means of supporting problem formulation and scenario development that are therein capable of helping to reveal the need for analytical insight – a strong point of GIS-based models – into the relationships between a narrower set of variables.

The findings of this dissertation suggest that tangible game design may be a promising direction for planning support development considering the ability of games to represent a large set of variables and relationships in flexible, adaptable formats for rapid experimentation. Such game-based approaches can incorporate simpler, more intuitive tools such as paper maps and preliminary spatial models that were found in Chapter 2 to be effective in triggering the divergence and parameterization of planning issues. Indications are that the principles of simplicity, transparency, flexibility and structure embodied in the gamified strategy-making method (Chapter 4) and game co-design method (Chapter 5) can serve as useful means of triggering divergence and convergence during strategy making in small group settings where knowledge in high-quality formats is required. Furthermore, tangible games could be used in combination with existing GIS-based technologies for a more holistic planning support approach. At the 2018 AESOP Congress, Maarit Kahila-Tani and I presented a conceptual framework for the integration these tools and methods based on the planning process dynamics studied in this dissertation. The framework combined tangible games dedicated to objective setting (convergence) and scenario design (divergence) with SoftGIS methods that facilitate a participative approach to information gathering (divergence) and existing PSS

software packages for scenario evaluation. Thus, if the aim is to provide contextualized planning support across a full range of planning tasks and to stimulate human-human interaction that can lead to meaningful communication, then it may be worth opening the PSS conversation to a wider range of planning support. This expanded view of PSS considers geoinformation-based technologies to be one tool in a larger 'methodbox' of contextualized planning support and reinforces the need for more attention to traditional and less technical tools. Tangible games that are used for support during strategy making could be matured into more sophisticated PSS if both planning tool and planning process are intertwined in a process of co-evolution. By intertwining these two processes, the intended users of PSS play an active role in determining the 'ways that the social is written into technology' (Schuurman, 2000, p. 669)

Reflection 4. Methodologies are needed for intertwining planning practice and planning support and should draw on insight into how context, mechanism and outcome are connected (te Brömmelstroet & Schrijnen, 2010; Geertman, 2006). This dissertation has laid out a methodology for intertwining the strategic stages of planning and the early stages of model building as a means of contextualizing planning support. By connecting these two processes, context-specific knowledge that is shared, explored, discussed and contested by planning actors while determining a strategic direction for their project can, in turn, be used in building the models that provide scientific feedback to the planning process. The conceptual framework in Figure 6.1 depicts the intertwining of these two processes based on the dynamic view of strategy making introduced in Section 1.2. Since strategy making does not neatly follow its conceptual depiction as a series of well-defined steps (Bishop, 1998), linking model building and its requirement for concrete input, as demonstrated in this research, can help to structure divergent and convergent communication dynamics while providing incremental feedback necessary to trigger the progression of strategy making a nonlinear, iterative way.

Divergent thinking during the early stages of model building is required to determine system boundaries, quantify parameters and brainstorm about how to evaluate scenarios (Vennix et al., 1992; Vennix & Gubbels, 1992). When linked to strategy making, the formalized language used by spatial models requires planning actors to communicate more concretely and selectively about their strategic planning issues. Under conditions of high complexity where communication about issues is borderline chaotic, limiting options for brainstorming and structuring divergent dynamics was shown in each of the studies to be beneficial. Facilitation performs an essential function in determining appropriate structuring mechanisms and limitations to apply to group work.

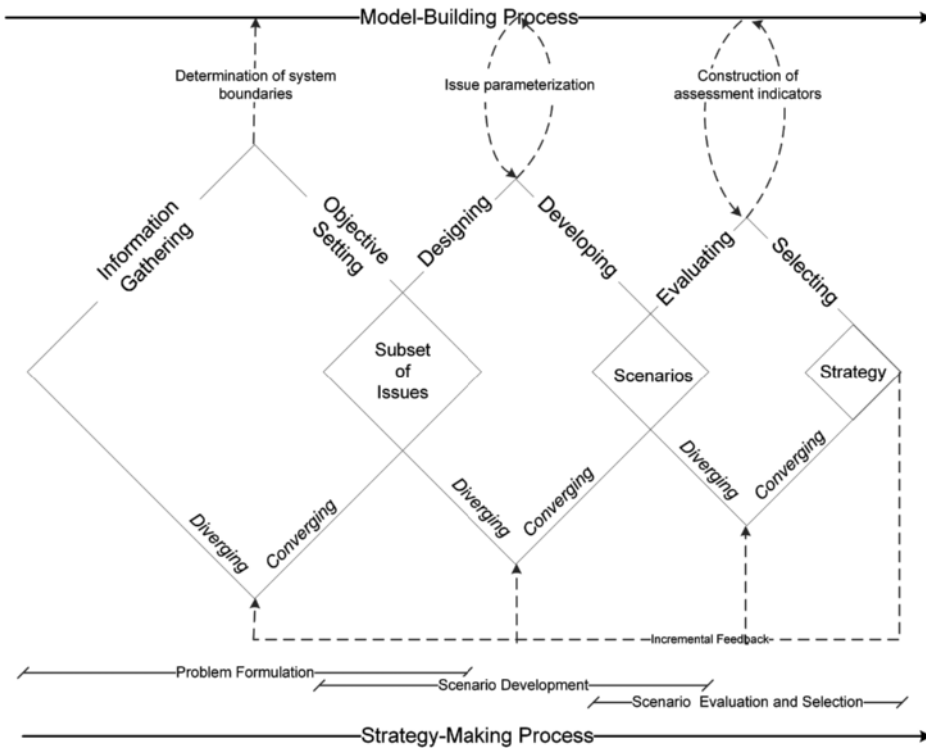


Fig. 6.1 Conceptual framework of model building and strategy making intertwined in a reciprocal, dynamic process.

The benefits of supporting group work while engaging in communicative approaches to planning are well known. However, the resulting dominant orientation of planning support research and development towards supporting group work in the past has overshadowed the contribution of individual work as an essential component of the group process. For this reason, I have emphasized the importance of supporting individual work especially during divergence. Since planning actors have the tendency to explore the world of options in group sessions, facilitated model-building sessions that combine a pre-selected set of key planning issues with tools and methods that support individual work may be preferable to zoom in on the divergent aspects of salient planning issues. The contribution of individual work during divergent dynamics was explored conceptually in Chapter 3 and was incorporated into the design of game elements used in the Chapter 4 study and in the organization of individual sessions with different actor groups in Chapter 5. The benefits of highly systemized communication about options during convergent thinking while making choices have been touted in the past (see Vennix et al., 1992). Based on the findings of this thesis, limiting options during

divergence and structuring convergence through the intertwining of these dynamics with model building can lead to a better match between tool and process.

Engagement in building the underlying models of PSS can be mutually beneficial for both planning actors and planning support experts. Planning actors who have been incrementally introduced to the technological aspects of the PSS during development and who have played an active role in translating key planning issues into parameters, attributes and indicators for scenario evaluation may be more willing to accept the feedback generated from modelling and simulation. Furthermore, engagement in model building has proven to bring planning support experts and developers closer to the contexts of intended tool use. The resulting understanding of the planning context can help them better determine data needs for formal modelling along with expertise needed to further develop models. Including planning support experts in this reflective process can lead to deeper understanding of planning issues, to enhanced trust between planning actors and support experts and to early indications of what types of geoinformation-based modelling could play an informative role in the planning process.

6.2.1 Methodological reflections

Reflection 5. Conducting intervention-based research aimed at influencing practice entails certain risks. For planners and project leaders, collaboration with researchers requires a willingness to expose the challenges and potentially politically-sensitive issues of their project to a group of academics who may have limited experience in the field. If this is the case, interventions may be more reflective of planning theory than of actual planning practice. Bridging this gap between theory and practice requires significant time and effort both in building a relationship of trust with planning actors and in observing practice to determine a context-appropriate intervention. A common challenge for researchers lies in the mismatch between the research trajectory and that of the planning process under investigation. Faludi and Waterhout (2006) point out, 'while research normally follows a set process of formulating hypotheses, research design, collecting empirical evidence and drawing conclusions, a process that has a relatively long gestation period, policy development and implementation tend to be less predictable and more dynamic' (p.11). Gaining access to cases for longitudinal study proved to be a considerable challenge in this research, particularly in terms of staging planning interventions. It took months and in some cases years to build trust with project managers and to identify appropriate moments in a planning process to be able to conduct an intervention.

The choice to engage in design research was in part motivated by the open and fuzzy nature of the strategic stages of planning under investigation and in part by the need to

remain open and flexible to unforeseeable changes in the projects themselves. Engaging in design research permitted me to create a patchwork of cases and experimental set ups for the testing of planning support probes, toolkits and later prototypes without being dependent on a single case for every research step. That said, use of a design research approach requires a willingness on behalf of planning actors to participate in experimental research without the certainty of knowing what the end product of the research will be. It also requires an open attitude towards new tools and method prototypes to improve and support their process. These actors may be more open to support tools and methods that have already been proven to be effective. I found that running trial uses of probes, toolkits and prototypes in multiple iterations with students and with colleagues in combination with conducting demonstrations of the methods with project leaders prior to an intervention to be effective means of mitigating the risk perceived by these actors.

While studies on the usefulness of PSS have been conducted predominantly in group sessions, these group-based forms of intervention contain their own set of challenges. The pragmatic research approach, for one, proved difficult to implement in the various group settings. With sufficient preparation and rehearsal, most but not all of the errors in the setup of the controlled studies with students could be anticipated and prevented. However, what I had not anticipated in applying the game-based interventions was the 'beat the game' mentality of some students. This mentality can be attributed to role-playing, which removes accountability from the player, resulting in an experience that may be deemed inauthentic and subjective (Woods, 2004). Because of this tendency it was important to focus on relative rather than absolute differences, for example, when evaluating divergence and convergence scores among students in Chapter 3. Comparatively, when working with the case studies there were many unanticipated situations that occurred during the work sessions. For example, actors would leave before the end of the session or surveys would not be returned. Under the circumstances of conducting group sessions with real cases, the military wisdom holds true that no plan survives first contact. Fortunately, by collecting as much raw data as possible through surveys, interviews, session recordings and on session materials such as the game boards, I was left with sufficient comparable results after purging incomplete and non-comparable data.

Reflection 6. The analysis conducted in this dissertation focused on observing the performance of strategy-making tasks to understand the potential influence of different game-based planning support interventions. The combination of testing in controlled settings and case studies proved an effective means of producing initial evidence of causality. The principles of transparency, flexibility, simplicity and structure experi-

mented with in this study need to be researched further in the context of game-based planning support. The prototyping of support methods and tools based on these principles should be tested extensively in real-world settings and in different contexts. As games for planning continue to gain popularity, the capacity of these games to represent real-world processes is an important consideration, particularly for games that simulate social processes like the strategy-making processes studied in this thesis. The representativeness of real-world processes should be taken into account when applying social simulation games in both education and real-life planning contexts. For frame games where players contribute input into the game, learning may be facilitated by designing fictional contexts that are as reflective as possible of participant experiences and knowledge domains so that they are more capable of relating to the issues and can claim a sense of ownership of the issues.

Also, the multi-stage processes simulated in group sessions such as the ones described in this dissertation may go several steps further than the current stage of the planning project under investigation. To avoid misunderstandings about the overall goal of such interventions, planning experts and system developers should emphasize how the outcomes of the intervention relate directly to the current planning situation. At the same time, the freedom for experimentation permitted by such interventions may help actors to anticipate future needs for later steps such as information needed to create assessment indicators for scenario evaluation and selection. As one planning practitioner in a PSS use study put it, if the session is planned so that the support tool fits the needs of the spatial planning process, you can gain several months (Pelzer et al., 2014).

The main conclusion is that while complex spatial strategy-making processes require more flexible forms of planning support, the use of this support must be facilitated in ways that structure both process dynamics and the content of these communicative processes. This means that planning support should facilitate a structured dialogue centered on the adaptation of planning issues while limiting the number of issues up for debate and, at the same time, should remain open enough to adapt to unforeseen change. In addition, this research has drawn attention to the contribution of individual work as a fundamental part of the group process. Tangible games can serve as useful tools for facilitating processes of communication and learning at both the group and the individual level. These games embody the characteristics of simplicity, transparency and flexibility to which PSS aspire and are packaged in engaging formats that help to structure communication and learning processes. In return, planning actors and the knowledge these games help to elicit play a pivotal role in the design of the planning support. These actors and their knowledge, as the preliminary findings of this disser-

tation show, will likely be essential to forging a link between tangible game-based support methods and more advanced tools for analysis and decision making. This co-design approach favors a broader view of PSS that embraces different forms of dedicated planning support tools and methods, both formal and informal, for a more comprehensive and demand-driven approach to supporting spatial strategy making.

6.3 Recommendations for research and beyond

First, since spatial planning is principally concerned with linking knowledge to action in a process of strategic change framed by an uncertain future (Couclelis, 2005; Friedmann, 1993), the role of planning support in triggering the adaptation of planning issues in a desirable direction is worthy of more attention. Towards this aim, new methods could be developed that advance the manual mapping of issue adaptations in communication networks developed in this research. Such methods could look for causal relationships by relying on computer-based analysis for visualizing and exploring large multi-actor processes or across multiple projects. In this way new light could be shed on the relationships between the planning system and its environment, the spatial system that seeks to influence this system and the models and simulations that inform the spatial system (see Couclelis, 2005).

Second, research could continue to explore games as third spaces capable of bridging the realms of policy and science for partners from government, research, industry and the public to meet and exchange their expertise (see for example van Amstel, 2015). Game co-design as a means for determining the soft sides of the PSS technology package could be integrated with socio-technical PSS development methods that are more focused on the technological aspects of these systems (see Figure 2 in Vonk & Ligtenberg, 2010) towards a more comprehensive PSS development approach. One need only to browse the pages of the journal *Computers, Environment and Urban Systems* to find ample examples of hybrid GIS-based technologies and modelling approaches for supporting complex and integrated analyses. However, if the aim is for simpler, more transparent and flexible PSS, the combination of GIS-based technologies and simpler forms planning support that include tangible games may be appropriate.

Finally, there is a paucity of courses dedicated to teaching planning support instruments (Geertman, 2017). The absence of these courses in planning studies could help to explain the general lack of awareness and adoption of these systems in practice. For future planners to understand the potential added value of PSS, they also need to gain a sense of real-world planning problems. Long-term engagement in transdisciplinary research (Lang et al., 2012) to forge links between research and practice will surely

be essential to build trust within communities and among planners for conducting empirical research and to provide students access to real-world issues outside of the classroom. Towards this aim, games and simulations have a strong reputation for being used in practice as pedagogical tools (Raghothama & Meijer, 2015). The motivational affordances attributed to gamification could enhance the representativeness of strategy-making processes. The potential for game-based learning was evident in the learning outcomes of students reported in Chapter 4. And lastly, this dissertation has shown that tangible games can assist the work of the facilitator in providing procedural and substantive support in strategy making sessions. However, if games are not situated to the requirements of both the process and the user, they may not be deemed useful by participants. This means that for games and gamified forms of planning support to gain adoption in practice, there is a need to train facilitators of group processes in identifying appropriate situations for their introduction.

6.4 Concluding remarks

As planners and other actors become more attuned to the complexity of the processes they are conducting, appropriate methods and instruments for planning support may seem more elusive. During the strategic stages of planning when issues seem connected to everything and strategies for taking action in the public domain are clouded by uncertainty, dedicated support that structures the exploration of options and choice making is required. Transparency, simplicity and the structured application of more flexible information frameworks emerge under these complex conditions as more than the aspired characteristics of improved PSS (see te Brömmelstroet, 2012); they also serve as guidelines for a collaborative design process that is centered on the elicitation of context-specific knowledge. The purpose of co-designing simpler forms of planning support such as the game-based methods described in this dissertation has not been to downplay the demonstrated added value of more technologically sophisticated PSS. These geoinformation-based technologies incorporate visually engaging means that may help actors to communicate better, to analyze and experiment with interventions on the spatial system and to inform about the potential impacts of these interventions. Instead, the co-design of these simpler tools and methods should be viewed as a gateway for planning actors to enter the technical realm of formal models incorporated into PSS and for planning support experts to become better acquainted with the context-specific requirements that ultimately will contribute to the adoption of PSS.



Summary
Samenvatting
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Appendices
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Curriculum Vitae

Summary

Chapter 1 of this dissertation embarks on a search for an appropriate role for computer-based tools and other support methods for spatial planning by examining the context of their intended use. An exploratory study is conducted to gain a sense of the complexity that actors encounter when sorting out their knowledge about an urban area and its complex, interlinked networks. The strategic stages of this communicative process are brought under the loupe using complex systems theory to grasp the dynamics involved in adapting the issues of these planning actors out of their wicked problems state and into the objectives and strategies that guide decisions and plan formation. The argument is then made that for dedicated planning support to be considered useful under these complex conditions, it must be contextualized in ways that fit the dynamics that power strategy making forward. Co-designing methods that intertwine strategy making with model building is subsequently introduced as an approach to engage planning actors and their knowledge in the contextualization of planning support.

The subsequent four chapters have both a conceptual and a practical research purpose. The first two chapters aim at conceptualizing relationships between the dynamics of strategy making and planning support use as well as the conditions surrounding tool usage. The subsequent practical studies (Chapters 4 and 5) involve the design and testing of methods that support the various stages of strategy making based on principles derived from the conceptual studies. Each chapter attempts to shed light on one or more aspects of the following research question:

How can planning support be designed to fit the context-specific requirements of spatial strategy making?

Chapter 2 examines a range of planning support tools based on their potential to trigger dynamics associated with idea generation and choice making. These dynamics have been referred to within the discourse surrounding planning support systems (PSS) as divergence and convergence. Definitions of PSS appearing in the past decade reflect a need for a systematic introduction of relevant (spatial) information to support dynamic processes of interrelated tasks. Following suit, this study adopts the stance that the aim of planning support during strategy making should be to support dialogue in its handling of planning issues rather than provide dedicated support to a specific planning task. Thus, the adaptation of planning issues during the course of a strategy-making session is mapped into a network of dynamic communicative interactions, revealing the potential influence of various types of planning support on these adaptations irrespective of strategy-making task. Preliminary modelling and sketching on a map were

shown to support actors in identifying salient planning issues and communicating about these issues in formalized terms. Findings indicate that the introduction of planning support in visually engaging, flexible and intuitive formats may be useful for triggering divergence while the structuring of dialogue by a facilitator is likely essential to facilitate the convergent dynamics associated with choice making in group settings.

After investigating the potential influence of different types of planning support, Chapter 3 reports on the conditions surrounding the use of a PSS software package. Varying degrees of freedom were granted to participants in the choice of assessment indicators and in determining the process structure when working with the PSS, which was displayed on a mactable with some groups and on a tablet device with others. The conclusion is drawn that while dedicated support to group work during convergence remains important, more attention should be paid to the support of individual work, seeing as tablet use was more effective in supporting divergence. Moreover, the study confirms that to contextualize tools to the complex world of planning practice, there appears to be a need for structured ways of applying more adaptive PSS.

Chapters 4 and 5 incorporate a set of design principles derived from the first two studies on planning support use into two game-based methods, one that supports inter-actor communication and another that supports communication between planning actors and planning support experts. Both methods are based on the premise that if strategy making and model building are intertwined, it is more likely that the outcomes of these processes will reinforce one another, resulting in contextualized PSS that are better equipped to perform their supportive role.

Chapter 4. The point of departure for the third study is the recognition that salient planning issues can be difficult to identify at the outset of a new project, particularly in wicked problem contexts where these issues seem connected to everything. Therefore, planning actors require structured and visually engaging means of brainstorming and sorting through the ideas they generate to collectively make choices. These means should facilitate, rather than obstruct communication and learning. Through a pragmatic research approach (te Brömmelstroet, 2017b), gamified elements are introduced in a controlled setting with students and in two context-rich studies with strategic area redevelopment projects. Mixed methods are used to evaluate the usefulness of the gamified elements based on a quantitative assessment of idea generation and selection and on a qualitative assessment of participant feedback on perceived usefulness. Results showed that game elements such as zones, levels and token restrictions provide a structured means for participants to engage in silent, individual idea generation and in a structured dialogue when communicating about their issues. These results indicate

that the gamification of strategy making conducted in group sessions can provide a structured, visually engaging means of supporting divergence and convergence when formulating planning problems. However, the gamified method falls short of sufficiently supporting actors in the formalization of their knowledge about these issues, a topic that is revisited in the next chapter.

The final study of the thesis introduces a game co-design method for eliciting knowledge about the context of planning support use for building the underlying models of PSS. Requirements for the method design are outlined in Chapter 5 and findings from an initial use case of the game co-design method are reported. The game format of the method is conceived as a visually engaging and intuitive 'third space' where experts of a spatial system and support experts can meet halfway between the realms of policy and technology to engage in dialogue. Actors are tasked to critique a set of parameterized assumptions and flexible game rules with the aim of eliciting knowledge about the spatial system in terms of space and its attributes. Findings show that presenting the assumptions in multiple views – a game, a geo-referenced map and a spreadsheet can help actors to formalize their knowledge. Moreover, conducting separate facilitated sessions with individual actor groups can reveal divergent frames, domains, levels of abstraction and uncertainties concerning their context-specific knowledge in addition to unearthing biases in the underlying assumptions of the game. The study concludes by discussing the role that games can play in informing debate by serving as simpler models for simulating the complex dynamics of spatial systems.

Chapter 6 concludes the dissertation with a discussion of the main findings from the four studies and provides reflections on key conceptual and methodological aspects of the research. Insight from each of the studies is used in answering the central research question. A central conclusion of the dissertation is that to contextualize planning support to the dynamics of spatial strategy making, planning support in simpler, more flexible formats is needed that are capable of helping planning actors identify the salient issues of their project. The application of more flexible support, however, requires skilled facilitation that structures the group process, with particular attention to supporting individual work. Moreover, working with components of PSS in a preliminary state and co-evolving the support system together with relevant planning actors during strategy making may serve as a gateway for planning actors to enter the technical realm of PSS, while at the same time, familiarizing planning support experts with key issues that may be essential for contextualizing PSS on a project by project basis.

Samenvatting

Hoofdstuk 1 van dit proefschrift vangt aan met een zoektocht naar een toepasselijke rol voor computer-gebaseerde hulpmiddelen en andere ondersteunende methodes voor ruimtelijke planning door het onderzoeken van de context van hun beoogde gebruik. Een verkennende studie is verricht om inzicht te verkrijgen in de complexiteit die actoren tegenkomen bij het uitzoeken van hun kennis over een stedelijk gebied en de daarin aanwezige complexe, met elkaar verbonden netwerken. De strategische stadia van dit communicatieve proces worden uitgelicht met behulp van 'complex systems theory' om de dynamica te begrijpen die betrokken is bij het aanpassen van de kwesties van deze actoren, betrokken bij het planningsproces, uit hun 'wicked problems' staat naar doelstellingen en strategieën die richting geven aan besluiten en plan formatie. Vervolgens wordt het betoog gehouden dat om gespecialiseerde planning ondersteuning als bruikbaar te beschouwen onder deze complexe omstandigheden, deze gecontextualiseerd moet worden op manieren die passen bij de dynamica die besluitvorming vooruit stuwt. Het co-designing van methodes die besluitvorming verweven met modelvorming wordt vervolgens geïntroduceerd als een aanpak om planning actoren en hun kennis te betrekken bij het contextualiseren van planning ondersteuning.

De volgende vier hoofdstukken hebben zowel een conceptueel als praktisch onderzoeksdoel. De eerste twee hoofdstukken hebben als doel om conceptuele relaties te leggen tussen de dynamica van strategie bepaling en het gebruik van planning ondersteuning alsook de omstandigheden rondom hulpmiddel gebruik. De daaropvolgende praktische studies (Hoofdstukken 4 en 5) bevatten het ontwerp en testen van methodes die de verschillende stadia van strategie bepaling ondersteunen gebaseerd op principes afgeleid van de conceptuele studies. Ieder hoofdstuk probeert om inzicht te geven in een of meer aspecten van de volgende onderzoeksvraag:

Hoe kan planning ondersteuning ontworpen worden zodat het past bij de context-specifieke vereisten van ruimtelijke strategie vorming?

Hoofdstuk 2 onderzoekt een reeks van planning ondersteunende hulpmiddelen gebaseerd op hun potentieel om dynamica, geassocieerd met idee generatie en keuzes maken, op gang te brengen. In de discussie rondom planning support systemen (PSS) wordt naar deze dynamica gerefereerd als divergentie en convergentie. Definities van PSS die in het afgelopen decennia zijn verschenen geven een behoefte weer voor een systematische introductie van relevante (ruimtelijke) informatie om de dynamische processen van samenhangende taken te ondersteunen. In lijn met deze behoefte, adopteert deze studie het standpunt dat het doel van planning ondersteuning gedurende

strategie vorming gericht moet zijn op het ondersteunen van de dialoog over plannings kwesties in plaats van gespecialiseerde ondersteuning bieden aan specifieke plannings taken. De aanpassing van plannings kwesties gedurende een strategie vorming sessie is in kaart gebracht als een netwerk van dynamische communicatieve interacties, wat de potentiële invloed laat zien van verschillende types van planning ondersteuning op deze aanpassingen onafhankelijk van de strategie vorming taak. Voorlopige modellering en schetsen op een kaart ondersteunde actoren bij het identificeren van saillante planning kwesties en bij het communiceren over deze kwesties in geformaliseerde termen. De bevindingen wijzen erop dat de introductie van planning ondersteuning in visueel boeiende, flexibele en intuïtieve manieren nuttig kan zijn voor het op gang brengen van divergentie, waarbij het structureren van de dialoog door een facilitator waarschijnlijk essentieel is voor het begeleiden van de convergente dynamica geassocieerd met het keuzes maken in een groep.

Nadat de potentiële invloed van verschillende types van planning ondersteuning onderzocht is, beschrijft Hoofdstuk 3 de omstandigheden rondom het gebruik van een PSS software pakket. Deelnemers kregen verschillende mate van vrijheid in het kiezen van beoordeling indicatoren en bij het bepalen van de structuur van het proces bij het werken met het PSS, welke getoond werd op een mactable bij sommige groepen en op een tablet bij andere. De conclusie wordt getrokken dat hoewel gespecialiseerde ondersteuning bij groepswork gedurende convergentie belangrijk blijft, meer aandacht besteedt moet worden aan de ondersteuning van individueel werk, doordat het gebruik van tablets effectiever was in het ondersteunen van divergentie. Bovendien bevestigde de studie dat om hulpmiddelen te contextualiseren naar de complexe wereld van de planning praktijk, er een behoefte lijkt te zijn aan gestructureerde manieren om meer adaptieve PSS te gebruiken.

Hoofdstuk 4 en 5 belichamen een set van ontwerpprincipes afgeleid van de eerste twee studies met betrekking tot planning ondersteuning gebruik in twee spel-gebaseerde methodes, een die inter-actor communicatie ondersteund en een tweede die communicatie ondersteund tussen planning actoren en planning ondersteuning experts. Beide methodes zijn gebaseerd op de stelling dat als strategie vorming en model vorming verweven zijn, het waarschijnlijker is dat de uitkomsten van deze processen elkaar zullen versterken, resulterend in gecontextualiseerde PSS die beter uitgerust zijn om hun ondersteunende taak te vervullen.

Hoofdstuk 4. Het uitgangspunt voor de derde studie is de erkenning dat het moeilijk kan zijn saillante planning kwesties te identificeren bij de aanvang van een nieuw project, met name in een 'wicked problems' context waar deze kwesties met alles verbonden

lijken te zijn. Daarom hebben planning actoren behoefte aan gestructureerde en visueel boeiende middelen voor brainstorming en het doorzoeken van de ideeën die zij genereren om gezamenlijk keuzes te maken. Deze middelen moeten communicatie en leren vooral niet in de weg staan, maar juist faciliteren. Middels een pragmatische onderzoeksaanpak (te Brömmelstroet, 2017b), worden elementen in spelvorm geïntroduceerd in een gecontroleerde omgeving met studenten en in twee context-rijke studies met strategische gebied herontwikkelingsprojecten. Gemengde methoden worden gebruikt om het nut van de elementen in spelvorm te evalueren op basis van een kwantitatieve beoordeling van idee generatie en selectie en op een kwalitatieve beoordeling van deelnemer terugkoppeling over de waargenomen bruikbaarheid. Resultaten lieten zien dat spel elementen zoals zones, niveaus en voorgestelde beperkingen gestructureerde middelen bieden voor deelnemers om deel te nemen aan stille, individuele idee generatie en in een gestructureerde dialoog bij het communiceren over hun kwesties. Deze resultaten wijzen erop dat de gamification van strategie vorming verricht in groep sessies, gestructureerde, visueel boeiende middelen kan bieden voor het ondersteunen van divergentie en convergentie bij het formuleren van planning problemen. Echter, de gamified methode komt tekort bij het voldoende ondersteunen van actoren bij het formaliseren van hun kennis over deze kwesties, een onderwerp dat opnieuw bekeken wordt in het volgende hoofdstuk.

Het laatste hoofdstuk van dit proefschrift introduceert een spel co-design methode voor het uitlokken van kennis over de context van planning ondersteuning gebruik voor het bouwen van het de onderliggende modellen van PSS. Vereisten voor het ontwerp van de methode zijn beschreven in Hoofdstuk 5 en bevindingen van een initiële use case van de spel co-design methode worden beschreven. Het spel formaat van de methode is bedacht als een visueel boeiende en intuïtieve 'derde ruimte' waar experts van een ruimtelijk systeem en ondersteuning experts elkaar kunnen ontmoeten voor een dialoog halverwege tussen de domeinen van beleid en technologie. Actoren krijgen de taak om een reeks van geparameteriseerde aannames en flexibele spelregels te bekritisieren met als doel om kennis te ontlocken over het ruimtelijke systeem in termen van de ruimte en de eigenschappen daarvan. Bevindingen laten zien dat het presenteren van aannames op meerdere manieren – een spel, een geo-gerefereerde kaart en een spreadsheet – actoren kan helpen om hun kennis te formaliseren. De uitvoer van aparte begeleide sessies met individuele actoren groepen kan bovendien divergente frames, domeinen, niveaus van abstractie en onzekerheden met betrekking tot hun context-specifieke kennis aan het licht brengen alsook enige bias in de onderliggende aannames van het spel. De studie sluit af met een discussie over de rol die spellen kunnen spelen bij het informeren van discussies door als versimpelde modellen te dienen voor het simuleren van de complexe dynamica van ruimtelijke systemen.

Hoofdstuk 6 sluit dit proefschrift af met een discussie over de belangrijkste bevindingen van de vier studies en reflecteert op belangrijke conceptuele en methodologische aspecten van het onderzoek. Inzichten van alle studies worden gebruikt bij het beantwoorden van de centrale onderzoeksvraag. Een centrale conclusie van het proefschrift is dat om planning ondersteuning te contextualiseren naar de dynamica van ruimtelijke strategie vorming, planning ondersteuning in simpelere, meer flexibele uitvoeringen nodig is die in staat zijn om planning actoren te helpen bij het identificeren van saillante kwesties van hun project. Echter, de toepassing van meer flexibele ondersteuning vereist bekwame facilitatie die het groepsproces structureert, met bijzondere aandacht voor de ondersteuning van individueel werk. Werken met componenten van PSS in een voorlopige staat en het ondersteunende systeem samen met relevante planning actoren laten co-evolueren gedurende strategie vorming kan bovendien als een toegangspoort dienen voor planning actoren om het technische domein van PSS te betreden, waarbij gelijktijdig planning ondersteuning experts bekend worden met belangrijke kwesties die noodzakelijk kunnen zijn voor het contextualiseren van PSS op een project per project manier.

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Appendices

Appendix 1

Quality of Process Statements	N
<i>Individual</i>	
I have a positive feeling about the session	132
The session produced useful results	132
I trust that the outcome is good	133
The result offers a real solution to the problem	133
The result of the session is based on correct assumptions about the urban system	133
My insight into the problem has increased	133
The cause of the problem is clear to me	133
For me, the session has led to new insights	132
I now better understand the suggested solutions from the other participants	119
The session was successful	132
<i>Group</i>	
The other participants understand my view of the problem	127
I now understand how the other participants view the problem	125
During the session we developed a shared professional language	121
We have achieved a shared vision about possible solutions	131
There was conflict about the task we were to conduct*	127
Alternative perspectives were taken seriously	130
I was able to share my ideas and opinion	130
We used our time efficiently	130
During the session a platform emerged that supported the sharing of ideas	132
There was a strong sense of group during the session	132

All statements are rated on a 7-point Likert scale

Appendix 2

Usability Statements	N
The instrument was transparent	132
The communicative value of the output was high	133
The output was clearly displayed	133
The process was well organized	133
Engagement with the tool was well supported	130
The output was credible/believable	133
The instrument was comprehensive enough	133
The instrument helped us to reach consensus	130
The instrument helped me to imagine which developments could be realized	133
The focus of the instrument was sufficient	130
The level of detail of the maps was sufficient	133
The instrument was easy to understand	133
Through use of the instrument, sense and nonsense could be distinguished	130
Through use of the instrument, our creativity was limited	132

All statements are rated on a 7-point Likert scale

Appendix 3

Quality of process scores

	Degree of Flexibility				Visualization Hardware					
	None		Indicator		Process & Indicator		Tablet		Mactable	
	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N
<i>Individual</i>										
Feeling	5,80	45	5,74	47	5,35	40	5,63	97	5,69	35
Usable results	5,65	46	5,55	47	5,05	39	5,52	98	5,21	34
Trust outcome	5,70	46	5,36	47	5,05	40	5,51	98	5,03	35
Real solution^a	5,43	46	5,26	47	4,63	40	5,24	98	4,80	35
Correct assumptions^e	5,43	46	5,23	47	4,85	40	5,22	98	5,09	35
Insight problem	5,80	46	5,45	47	5,15	40	5,42	98	5,66	35
Insight cause	5,54	46	5,36	47	5,18	40	5,29	98	5,60	35
New insights	5,37	46	5,21	47	4,85	39	5,21	97	5,03	35
Solutions of others	5,00	43	5,15	39	4,81	37	4,89	89	5,30	30
Successful	5,83	46	5,62	47	5,28	39	5,61	97	5,54	35
<i>Group</i>										
My vision clear^a	5,42	45	5,25	44	4,92	38	5,19	95	5,28	32
Problem of others^b	5,31	42	5,16	44	5,18	39	5,09	93	5,59	32
Shared language	4,34	41	4,52	44	4,19	36	4,33	88	4,45	33
Shared vision	5,76	45	5,72	46	5,35	40	5,62	97	5,62	34
Conflict*	2,57	44	2,64	45	2,82	38	2,61	93	2,82	34
Diversity	5,59	44	5,15	46	5,28	40	5,27	95	5,51	35
Share my ideas	5,96	46	5,78	45	5,77	39	5,83	95	5,86	35
Efficiency	5,67	45	5,40	45	5,43	40	5,49	96	5,53	35

Appendix 3 (continued)

Platform^b	5,47	45	5,23	47	5,35	40	5,24	97	5,66	35
Group feeling	5,33	45	5,28	47	5,10	40	5,30	97	5,09	35
Usability Scores										
	Degree of Flexibility					Visualization Hardware				
	None	Indicator		Process & Indicator		Tablet		Maptable		
	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N
Transparency	5,49	45	5,62	47	5,43	40	5,53	98	5,47	34
Communicative value	5,72	46	5,57	47	5,55	40	5,55	98	5,80	35
Clarity of output	6,15	46	5,94	47	6,00	40	6,01	98	6,09	35
Process organization	5,70	46	5,72	47	5,35	40	5,65	98	5,46	35
Tool support	5,76	45	6,23	47	5,82	38	5,95	95	5,94	35
Credibility	5,70	46	5,60	47	5,58	40	5,59	98	5,71	35
Comprehensiveness	5,89	46	5,64	47	5,78	40	5,69	98	5,97	35
Consensus	5,65	46	5,47	45	5,56	39	5,52	95	5,69	35
Imaginative	6,15	46	5,79	47	6,10	40	5,96	98	6,14	35
Focus	5,70	44	5,32	47	5,33	39	5,47	96	5,41	34
Level of detail^b	5,57	46	5,64	47	5,70	40	5,52	98	5,94	35
Easy to understand	5,63	46	5,62	47	5,40	40	5,49	98	5,74	35
Disambiguation	5,25	44	5,06	47	5,21	39	5,15	95	5,23	35
Creativity limited*	2,98	46	3,33	46	3,48	40	3,15	97	3,51	35

^a Significant at the 0.05 level (2-tailed) for flexibility

^b Significant at the 0.05 level (2-tailed) for hardware

^c Significant interaction effect at the 0.05 level (2-tailed)

* Statement relates to a potentially negative sentiment

Appendix 4

Correlation between quality of process and usability (N between 119 and 133)

<i>Individual</i>	Transpar- ency	Commu- nicative value	Clarity of output	Process organiza- tion	Tool support	Credibility	Compre- hensiveness
Feeling	0,225**	0,436**	0,176*	0,468**	0,455**	0,360**	0,194*
Usable results	0,223*	0,448**	0,187*	0,434**	0,383**	0,371**	0,219*
Trust outcome	0,217*	0,413**	0,200*	0,328**	0,288**	0,308**	0,177*
Real solution	0,161	0,327**	0,342**	0,210*	0,160	0,402**	0,332**
Correct assumptions	0,186*	0,395**	0,325**	0,305**	0,270**	0,497**	0,360**
Insight problem	0,157	0,486**	0,350**	0,479**	0,438**	0,431**	0,393**
Insight cause	0,269**	0,422**	0,331**	0,447**	0,326**	0,342**	0,360**
New insights	0,064	0,186*	0,129	0,378**	0,182*	0,195*	0,132
Solutions of others	0,143	0,273**	0,060	0,224*	0,156	0,215*	0,086
Successful	0,206*	0,402**	0,360**	0,551**	0,416**	0,409**	0,341**
Group							
My vision clear	0,163	0,309**	0,214*	0,382**	0,196*	0,309**	0,330**
Problem of others	0,215*	0,337**	0,248**	0,328**	0,177	0,196*	0,320**
Shared language	0,208*	0,268**	0,130	0,256**	0,165	0,251**	0,300**
Shared vision	0,168	0,310**	0,181*	0,330**	0,297**	0,251**	0,249**
Conflict	-0,164	-0,081	-0,025	-0,087	-0,032	-0,123	-0,195*
Diversity	0,224*	0,307**	0,286**	0,085	0,080	0,349**	0,329**
Share my ideas	0,156	0,295**	0,142	0,125	0,162	0,278**	0,157
Efficiency	0,030	0,209*	0,105	0,327**	0,128	0,129	0,060
Platform	0,114	0,479**	0,345**	0,449**	0,296**	0,318**	0,293**
Group feeling	0,028	0,200*	0,179*	0,290**	0,189*	0,268**	0,186*

**Correlation is significant at the 0.01 level (2-tailed)

*Correlation is significant at the 0.05 level (2-tailed)

Consensus	Imagina- tive	Focus	Level of detail	Easy to un- derstand	Disambigu- ation	Creativity
0,105	0,283**	0,233**	0,152	0,164	0,293**	-0,150
0,048	0,254**	0,390**	0,160	0,109	0,117	-0,152
0,173*	0,214*	0,400**	-0,025	0,041	0,187*	-0,206*
0,254**	0,242**	0,356**	0,192*	0,188*	0,187*	-0,194*
0,193*	0,254**	0,410**	0,201*	0,155	0,239**	-0,123
0,248**	0,319**	0,372**	0,212*	0,172*	0,282**	-0,227**
0,229**	0,291**	0,292**	0,214*	0,173*	0,260**	-0,238**
0,039	0,204*	0,270**	0,055	0,042	0,245**	-0,108
0,066	0,140	0,140	0,172	0,139	0,158	0,013
0,124	0,239**	0,328**	0,159	0,062	0,130	-0,220*
0,174	0,261**	0,295**	0,262**	0,161	0,252**	-0,085
0,198*	0,338**	0,299**	0,189*	0,233**	0,313**	-0,096
0,106	0,061	0,261**	0,089	0,180*	0,254**	-0,029
0,242**	0,210*	0,265**	0,084	0,110	0,120	-0,364**
-0,251**	-0,237**	-0,063	-0,156	-0,084	-0,166	0,300**
0,141	0,255**	0,310**	0,145	0,215*	0,156	-0,145
0,018	0,294**	0,256**	0,245**	0,149	0,145	-0,051
0,184*	0,154	0,062	0,014	0,093	0,212*	-0,097
0,146	0,232**	0,277**	0,234**	0,108	0,180*	-0,025
0,193*	0,287**	0,182*	0,064	0,130	0,215*	-0,161

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Curriculum Vitae



Carissa Franken-Champlin (1981) is an urban planner originally from Oklahoma in the United States where she received her BSc. in Political Science and German in 2003 and her MSc. in International Trade and Development in 2005. She subsequently gained a professional Master's degree in Urban Management from the Technische Universität Berlin and remained at that university to work as a research assistant and lecturer in the departments of Integrated Transport Planning and the Habitat Unit. She conducted her doctoral work in the Department

of Construction Management and Engineering at the University of Twente in the Netherlands. Carissa co-founded a Berlin-based urban planning consultancy and has also received national recognition for her contribution to the capacity building mission of the United States Peace Corps. She is a member of the AESOP Planning and Complexity thematic group and conducts research in the fields of Planning Support Systems, serious gaming, urbanization, the global south and sustainable mobility.



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Rapid advancements in computer technologies have had a significant impact on the field of spatial planning. However, their added value during the strategic stages of this process remains limited. This thesis takes spatial strategy making under the loupe to examine the dynamics involved in these highly complex and communicative stages. Planning support in the form of serious games is designed together with planning actors as a means of facilitating inter-actor communication and of involving actors in the model building process. The main conclusion of the thesis is that skilled facilitation is needed that structures group processes involving more flexible support, with dedicated support given to individual work.