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Planning Support Systems and Task-Technology Fit: a Comparative Case Study

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Abstract Studies in the Planning Support Systems (PSS) debate are increasingly paying attention to the support function of PSS. This involves among other things studying the usefulness of PSS to practitioners. This paper adds another dimension to this evolving debate by arguing that planning tasks should receive more attention. Although planning tasks are central in several PSS definitions, they have hardly received explicit attention in empirical studies. In an aim to fill this void we conducted an empirical study based on the perspective of task-technology fit. The latter consists of a combination ('fit') of analytical and communicative support capabilities ('technologies'), and three types of planning tasks: exploration, selection and negotiation. Next, we selected four case studies in the Netherlands, in which the same PSS was applied, which consists of a combination of the CommunityViz software and a touch-enabled MapTable. The cases differed in the planning tasks that were central during the workshop, resulting in different kinds of usefulness attributed to the PSS. For instance, in one case with a selection task the communicative support capabilities contributed to the transparency of the process, whereas in another the analytic support capabilities of the PSS improved the task of negotiation because of the iterative feedback it provided. The paper concludes with the observation that the concept of task-technology fit has potential be applied in different contexts and with different types of PSS.

Keywords Planning support systems · CommunityViz · Touch table · Task-technology fit · User experiences · Comparative case study

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Introduction

It is now widely acknowledged that in order to achieve a successful application of Planning Support Systems (PSS), it is necessary to pay attention to the demands and characteristics of planning practice (e.g., Geertman 2008; Te Brömmelstroet and Bertolini 2008). Geertman's (2008) definition of PSS underlines this by pointing out that a PSS should improve the work of planners, since PSS are: '… 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, cf. Klosterman 1997). However, in the literature the emphasis seems to be on two out of three letters in the PSS abbreviation (Geertman 2013). The first term, 'Planning' is increasingly receiving attention, particularly in more conceptually oriented articles (e.g., Couclelis 2005; Geertman 2006; Klosterman 1997). The third term, 'Systems', comprises the overwhelming majority in PSS studies, mainly describing the technical details, underlying models and structure of the instruments (e.g., Geneletti 2008; Demetriou et al. 2013, most of the chapters in Geertman et al. 2013). The middle term, 'Support', has only recently received more rigorous empirical attention (e.g., Arciniegas et al. 2013; Goodspeed 2013; Te Brömmelstroet 2013). In a range of applications the performance of PSS to support planning is evaluated, mostly in a quasi-experimental setting (Arciniegas et al. 2011, 2013; Jankowski and Nyerges 2001; Salter et al. 2006).

In addition, recent accounts provide conceptual frameworks to analyse this support function of a PSS (e.g., te Brömmelstroet 2013; Pelzer et al. 2014a). A central concept herein is 'usefulness', which entails the question of whether the application of a PSS leads to an improvement in comparison to a situation without a PSS (i.e., the added value). While these frameworks provide guidance in the broader debate about PSS, we argue here that the frameworks should be complemented with a focus on the different planning tasks they support. Developing a conceptual perspective that explicitly includes planning tasks is the first contribution this paper has to offer to the PSS debate. The second contribution of this paper is the empirical approach, which is a comparative empirical research in four planning situations with the help of the same PSS. To our knowledge and based on recent reports on PSS performance, such a comparative and real-world planning support assessment has hardly been conducted before (cf. Goodspeed 2013). Hence, the research question of this paper is: How can a better conceptual and empirical understanding of the relation between planning tasks and PSS lead to improved insights about the support function of PSS?

In answering this research question, this paper is structured as follows. In section two we will develop a conceptual framework to address the relationship between planning tasks and PSS. This framework is the basis for the case selection on which we will elaborate in section three, complemented by a description of the PSS we studied and the methodological approach. In section four to seven we will describe the characteristics of the four cases we studied, followed by a synthesis of the main findings in section eight. The paper closes with conclusions and recommendations for future research in section 9.

Conceptual Framework: Task-Technology Fit

The ideas central in this paper are inspired by research in fields adjacent to the PSS debate, most notably Management Information Systems (MIS) and Group Support Systems (GSS). While the potential of these fields for PSS and urban modelling has already been pointed out before (Guhathakurta 1999), these ideas have not been really picked up in the PSS debate. We argue in this paper that this strand of literature has relevant insights to offers. More specifically, the extent to which a PSS supports planning tasks is in this literature conceived as the so-called task-technology fit (Goodhue and Thompson 1995). Whereas several definitions exist for task-technology fit (see Furneaux 2012 for an overview), the one arguably most suited for the PSS debate reads: 'The matching of the functional capability of available information technology with the activity demands of the task at hand' (Dishaw and Strong 1998, p. 154). In the PSS debate, the notion of task-technology fit has received relatively little attention. This can be considered somewhat surprising, since 'supporting planning tasks' is part of several definitions of PSS (e.g., Geertman 2008; Klosterman 1997). We are only aware of the work of Vonk (2006), which paid explicit attention to this perspective, finding that the fit between PSS and planning tasks often tends to be problematic. This paper argues that the concept of task-technology fit is helpful to understand the usefulness of PSS in relation to planning tasks. In order to develop a conceptual framework that connects PSS and the concept of task-technology fit, three questions ought to be answered:

1. What are planning tasks, in the case of PSS?
2. What is technology, in the case of PSS?
3. What is the relation ('fit') between tasks and technology, in the case of PSS?

What are Planning Tasks, in the Case of PSS?

According to Hopkins (2001, p.187 – emphasis added): 'Tasks are combinations of planning behaviours that accomplish particular *functions or purposes*'. Hereby, the *function or purpose* is a critical defining element in the case of PSS. From a heuristic perspective, it is helpful to come to some kind of categorisation based on this function or purpose. For that, we focused on literature from three different debates about support technology: GSS (Dennis et al. 2002; Zigurs and Buckland 1998), geocollaboration (MacEachren and Brewer 2004) and PSS (Geertman and Stillwell 2009). We hereby aim to develop a synthesis of a set of more or less generic planning tasks, not to develop an extensive or very detailed description of planning tasks.

Zigurs and Buckland (1998, pp.317–318) coming from the GSS debate, discern tasks based on their complexity, and not necessarily on function or purpose. They come to five different tasks, which have the following characteristics: simple, problem, decision, judgment and fuzzy. Dennis et al. (2002), also from the GSS field, have a simpler classification. They discern two tasks: generation (exploring different options, ideas, etc.) and choice (selecting options, ideas etc.). This partly overlaps with work about geocollaboration by MacEachren and Brewer (2004, p.7), who discern four kinds of tasks: execute, choose, negotiate and generate. From the field of PSS, in the introduction to their 2009 edited volume, Geertman and Stillwell (2009), p.3) approvingly cite Batty (1995), when he notes that PSS are 'a subset of geo-information technologies, dedicated to supporting those involved in planning to explore, represent, analyse, visualize, predict, prescribe, design, implement, monitor, and discuss issues associated with the need to plan. While this is quite an encompassing overview of the way in which PSS supports planning, not all terms can be considered tasks. For instance, 'visualisation' facilitates other tasks, rather than having a specific goal or purpose.

In order to have a workable conceptual framework, we selected three tasks from these three strands of literature, which have a clear goal or purpose: exploration, selection and negotiation. Most of the terms mentioned by Batty (Batty 1995 in Geertman and Stillwell 2009, p.3) also fit within one or more of these three tasks, whereas these tasks quite neatly overlap with the categorization by Dennis et al. (Dennis et al. 2002, GSS) and MacEachren and Brewer (2004, geocollaboration). *Exploration* concerns the generation of a range of ideas, challenges or alternatives, and is sometimes referred to as divergence. For instance, developing a range of scenarios about how a city will look like in the future. Or using predictions to explore how the future of a city region might evolve. *Selection*, sometimes referred to as convergence, concerns choosing (a set of) assumptions, indicators, etc. Analysis can contribute to this selection process, which ranges from rather detailed tasks in professional settings (e.g., what will be the exact location of a convenience store?) to fundamental decisions taken by politicians (e.g., will a shopping mall be built in this neighbourhood or not?). In the case of PSS the emphasis tends to be on the former. In a planning situation where there is full agreement among the involvement stakeholders, exploration and selection tasks suffice. However, this is hardly ever the case as planning often involves conflicting interests. Therefore there is a third task: *negotiation*. Negotiation can be defined as a task in which actors try to reach an agreement through an iterative process, with elements of bargaining and compromising (Claydon 1996; Claydon and Smith 1997; Ruming 2009). Negotiations are usually about the creation or distribution of a monetary value, a share, a contribution or another, often monetary, concern (see Raiffa 1982, in Samsura 2013). For instance, negotiation could be required to reach an agreement on each actor's financial contribution to a common development project.

What is Technology, in the Case of PSS?

Technology can be conceived as the support capacities a PSS has for planning. Dennis et al. (2002) discern communication support and information-processing support, while Vonk (2006) distinguishes three types of PSS: informing, communicating and analysing. For the purpose of this paper, two PSS capabilities are distinguished: communication support and analytical support. The main reason is that we believe these two best reflect the contemporary debate in PSS and planning. *Communication support* concerns technology that aims to improve the information exchange among stakeholders. A MapTable, for instance, is an example of communication support (see section 3.2). As Pelzer et al. (2014a) show, it evokes a more dynamic and content-based dialogue. *Analytical support*, on the other hand, concerns some kind of – usually quantitative – calculation, which results in information that support the planning process. Impact analysis is in the case of PSS the most well-known application of this sort (Brail 2006). Deal and Pallathucherhil (2009), for instance, used their LEAM (Land-Use Evolution and impact Assessment Model) PSS to analyse the impact of a new bridge on traffic flows.

The distinction between communicative and analytical support reflects broader debates in planning. According to Hopkins (2001) there are two types of rationalities through which planning can be conceived: a rational comprehensive rationality and a communicative rationality. Sager (1994, ix – emphasis added) explains the difference succinctly: 'planning problems can be solved in two contrasting yet complementary ways: one can trust expert judgments based on *analytic technique* or *discuss* the matter and reach a *group* decision'. Whereas the former can be considered the part of the traditional, scientific-analytic approach to planning (Harris 1965; Salet and Faludi 2000), the latter reflects the more recent collaborative or communicative turn in planning (e.g., Healey 1992, Innes 1998). This is not the place for an extensive discussion about these two approaches; we agree with Sager (1994) that the two are complementary and therefore should both be part of the support capacities of a PSS, resulting in both communicative and analytical support.

What is the Relation ('Fit') Between Tasks and Technology, in the Case of PSS?

The fit between task and technology can be addressed as an *outcome*. Furneaux (2012) summarises the outcomes of TTF as described in MIS and GSS research. A range of possible outcomes are discerned, including the quality of the decision or solution and the attitude about the technology and the intention to use it. (*ibid*, p. 99). One category discerned by Furneaux (2012) is particularly relevant for this paper: the perceived usefulness. Recent PSS studies have developed frameworks and conducted empirical research into the question what the usefulness (or added value) of a PSS is according to practitioners. For instance, Te Brömmelstroet (2013) and Pelzer et al. (2014a) developed frameworks with different dimensions of the added value of PSS, such as learning, efficiency, consensus and a more informed outcome. In a somewhat different vein, Te Brömmelstroet (2010) and Goodspeed (2013) emphasize learning as an important added value of PSS. Figure 1 depicts the basic argument of this paper, whereas Table 1 provides some examples of outcomes in relation to task-technology fit. However, while recent research provide some insight about the different kinds of perceived usefulness of PSS, this notion has not been explicitly linked to the concept of task-technology fit. Therefore, the empirical study in this paper is set up as strongly inductive and exploratory, particularly with regards to the empirical outcomes (i.e., perceived usefulness).

Case Selection and Methods

In order to gain more insight in the task-technology fit of PSS, we conducted an empirical study in the Netherlands consisting of four different case studies. In this section we will describe the PSS that was used in all cases, the way in which we selected the cases and the research methods we applied.

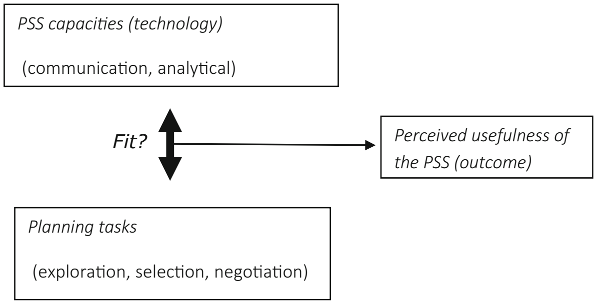

Fig. 1 Task-technology fit conceived as the fit between PSS capacities and planning tasks

Description of the PSS: the MapTable PSS

In this research we focus on one specific PSS, which we conveniently call the MapTable PSS. This PSS consists of two main elements: the MapTable hardware and the software ArcGIS/CommunityViz. The MapTable is a digital touch table developed and commercialized by the Dutch firm Mapsup (http://www.mapsup.nl). It contains a digital touch-enabled screen of large format (46 in.), designed to support group work around spatial information. The software in the MapTable is developed within the ESRI ArcGIS® environment using an ArcGIS extension called CommunityViz (http://www.communityviz.com). CommunityViz is widely used planning support software containing a wide variety of interactive planning support tools to model, analyse, and visualize geographic information (Walker and Daniel 2011). With the help of these tools users can draw on a digital layered map, make selections and perform calculations and view the results of their decisions in real time. We will now describe the way we selected the cases and the methods used to study the application of the MapTable PSS in the different cases.

Case Selection

Filling all the possible categories in Table 1 was the starting point for our research strategy, the case selection was both *diverse* and *most similar* (Gerring 2007, p.89–90). First, it was *diverse*, meaning the cases (two or more) illuminate the widest possible range of the two explanatory variables 'technology' and 'tasks', leading to six possible combinations. After surveying PSS applications in the Netherlands, we found four suitable cases, with only the combination 'analytical support' and 'selection' not being

Table 1 Examples of perceived usefulness of PSS as a result of a positive task-technology fit for the three planning tasks and two types of PSS capacities (technology)

Task Technology	Communication support ('improving knowledge exchange among stakeholders')	Analytical support ('provide information based on a calculation')
Exploration	Learning about others and learning about the object	Learning about the object
Selection	Efficiency	More informed outcome
Negotiation	Consensus	More informed outcome

present.[1] Second, the case selection was simultaneously *most similar*, which means the cases (two or more) are similar with regard to possibly confounding variables, which in this regard related to the specific characteristics of the PSS, such as the underlying model, the type of visual output and the supporting hardware. In order to have *most similar* cases, we studied four cases (from now on referred to as 'Rijnenburg', 'Arnhem', ''Deventer', and 'Achterhoek', see Table 2) in which the same PSS (the MapTable combined with CommunityViz) was applied. The following four sections 4, 5, 6 and 7 provide a description of each case study.

Research Methods

Interviews were conducted with stakeholders in all four cases. However, the way in which the interviews were conducted differed and in one case (Achterhoek) additional methods were applied. Therefore, we will now briefly elaborate on the research methods used for each case. For the Rijnenburg case four semi-structured interviews were conducted with the four key stakeholders, consisting of the project leader from the Municipality of Utrecht, a planner from the Province of Utrecht, the GIS advisor and technical operator from a consultancy firm, and the leading urban designer, also from a consultancy firm. For the Arnhem case, semi-structured interviews were conducted with two stakeholders of the project both representing the municipality of Arnhem, namely the city's project leader and the city's GIS office. The interviews were transcribed and analysed. In the Deventer case, semi-structured interviews were conducted with market vendors and one officer of the municipality of Deventer in charge of managing and supervising the market. A randomly selected sample of five market vendors was interviewed at each vendor's market stall. All respondents were present at the two workshop sessions. For all the three cases, the interviews were transcribed, and then analysed. In the Achterhoek case, the input for the game model was verified by different experts from the Province of Gelderland and the City Region Arnhem-Nijmegen. Two meetings around the PSS were videotaped and transcribed, and observations were made by non-participant experts present at the meetings. After the meetings, evaluative group discussions were held and questionnaires were filled in by all participants.

Rijnenburg, Utrecht: Developing a Sustainable Neighbourhood

In 2008 the Municipality of Utrecht started to develop a future-oriented land-use plan – a so-called 'structure vision', in which 7,000 new dwellings were allocated for the neighbourhood of Rijnenburg, an area of farmland south of the city of Utrecht in the Netherlands. Therein, a neighbourhood with above-average levels of sustainability should be realised (e.g., energy neutral and climate proof). To accomplish this, it was deemed necessary that the involved diversity of professionals and in particular the professions of environmental analysts and urban designers would collaborate intensively from the very early start of the planning process. The MapTable PSS was utilized

[1] It is important to note that this combination is logically very well possible, for instance in a case of site selection through multi-criteria analysis.

Table 2 The four cases of the MapTable PSS in the Netherlands selected for empirical study based on the task that was dominant

Task Technology	Communication support	Analytical support
Exploration	Rijnenburg+Arnhem	Rijnenburg+Arnhem
Selection	Deventer	n/a
Negotiation	Achterhoek	Achterhoek

to support this collaboration and to assist in the calculation of the sustainability scores (see Fig. 2).

In this case the PSS was coupled with the so-called Sustainability Profile of the Location (SPL), a tool for assessing environmental quality of urban developments (htttp://www.ivam.uva.nl). SPL makes it possible to calculate the environmental impact of a new plan in terms of sustainability scores. Within the tool environmental values are represented by a set of indicators, which concern environmental issues like noise, energy, water, and ecology (http://www.toolboxrijnenburg.nl). The sustainability score calculated for each environmental issue is portrayed by an indicator ranging from 1 to 10 (see Fig. 3). For a more elaborate description of SPL and its application within the Rijnenburg Utrecht case, please refer to Pelzer et al. (2013).

In the Rijnenburg case all the involved stakeholders were planning professionals, with no direct interest (e.g., ownership of land), therefore the negotiation task did not really play a role. Moreover, although some selection tasks were conducted during the workshops, the main focus was on exploration tasks, which we will consequently focus upon. With regard to the PSS capabilities, the MapTable PSS clearly involved both communication support and analytical support. Although the two are sometimes hard to disentangle in practice, the communicative support took mainly the form of a tabletop in combination with digital maps that facilitates the dialogue, whereas the analytical support was in this regard mainly the functionality of impact analysis, conducted with help of the SPL model.

Fig. 2 The MapTable PSS used at a demonstration session (photo: www.toolboxrijnenburg.nl)

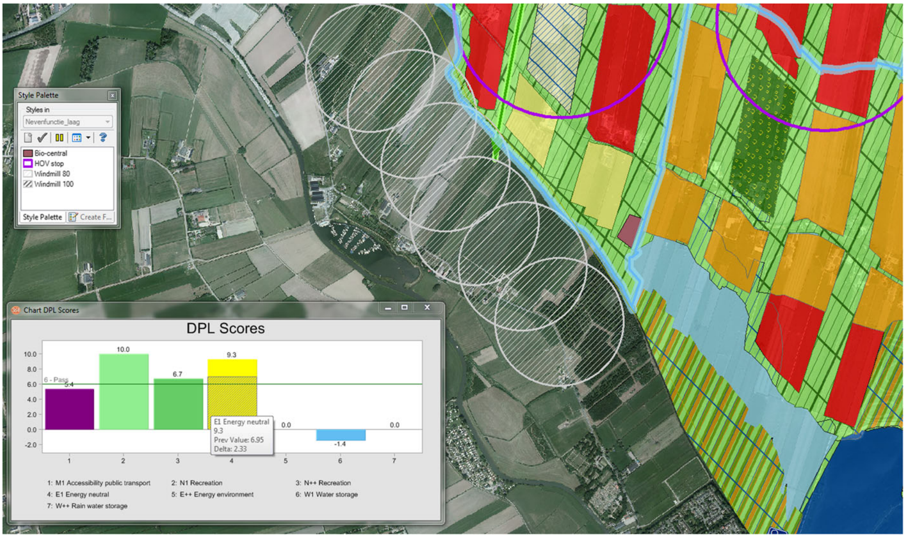

Fig. 3 Screenshot of the sustainability profile of the location

With regard to the task of *exploration*, the PSS was used to support the creation of three scenarios for the neighbourhood so that indicators of environmental quality and sustainability could be incorporated at the very start of the project instead of just at the end of it, which is usually the case in Dutch planning practice of environmental impact assessments. It enabled the different professionals to explore together the sustainability consequences of future land use scenarios for the area. More specifically, the involved environmental analysts stated that the PSS provided good integrative and spatially explicit assessments of sustainability effects of the plan scenarios. The moderator of the workshops provided an example of this notion: "*It is different when you see it on the MapTable PSS. Those wind power people know that here is a noise contour around a windmill, but now it is directly visible after placing a windmill and watching the number of dwellings go down* [*as a result of its noise effects*]. *That is a different effect than when you know that in theory there is a noise contour*".

Although these positive aspects were acknowledged, not all professionals were entirely convinced of the usefulness of the PSS for the task of exploration. The urban designer involved in the workshops noted that "*From a design standpoint, we work on a very abstract level, making sketches in which one meter does not matter that much. I do it approximately and find out later what the exact contours will be. But then* [*when using an interactive geo-information tool*] *there appears a number that is very precise, with three decimal digits. And that does not fit the idea that I have in mind.* (…) *I would prefer a rough sketch on the table* (…) *In the end it* [*the PSS*] *had little influence on the overall design. The primary reason is that it is a very difficult tool in terms of technique, in particular the software that was used*". Hence, to a certain extent the PSS was viewed as a barrier (i.e., a negative fit), rather than a support instrument to conduct the task of *exploration*.

Learning arguably was the most important perceived usefulness of the PSS. The environmental analysts indicated to have learned a lot from each other (e.g., noise specialists from energy specialists and vice versa), however not so much from the other discipline of urban designers. The moderator noted on these disciplinary barriers: "*It* [*the PSS*] *gets people off their islands*, *they come closer. It becomes much harder for a specialist to say*: '*that is impossible*'." As the urban designer noted: "*It is good that we are forced to think more like planners* [*and environmental analysts*] (…) *simultaneously we as designers want to stay at an abstract level and I think it is also good that planners* [*or environmental analysts*] *are becoming a bit less rigid*".

Besides the specific tasks the MapTable PSS aimed to support, it had a broader aim of supporting a constructive dialogue with increased collaboration and communication between different disciplines. In that, urban designers are forced to think at an earlier planning stage about sustainability indicators, while environmental analysts have to work in a much more design-oriented fashion. The workshop mediator literally described this as: "*The moderator and I agreed that the project would be successful if the urban designers would stay around the MapTable PSS until the end*". In turn, the urban designer involved had some positive thoughts on the communicative support function of the PSS: "*It is a very good communication tool during the design process*, *but as a calculation tool it is good in the final phase*. (…) *Its strength is that it evokes questions*".

Arnhem: Transition to Sustainable Energy

The Dutch city of Arnhem (150.000 inhabitants) has included in its policy the European Union goal to reduce greenhouse gas emissions by at least 20 % in 2020 (European Union 2008). As a consequence, about 20 % of the energy use in the city should be generated in a sustainable way, while a 20 % reduction in energy use should be accomplished by improving the energy efficiency. The city's ultimate goal is to become energy-neutral by the year 2050. In order to be able to meet these goals, the city of Arnhem needs to stimulate its citizens to reduce its fossil-based energy use. To accomplish this, the city is currently undertaking activities in cooperation with energy producers and others to stimulate the city's energy transition and the transition to greater energy efficiency. As part of this, all data relevant from the city of Arnhem and the other stakeholders were made available on an open-access database in such a way that these data and figures could be integrated, analysed and visualized with the help of the MapTable PSS. The city organized workshop sessions in which the PSS was utilized to support the following activities (see Fig. 4):

1) Visualize and discuss spatial distribution patterns of energy consumption to explore its relationship to current land use;
2) Monitor energy consumption over time based on the construction year of a building;
3) Highlight and discuss areas of excessive energy consumption to explore its relationship to current land use.

Figure 5 illustrates the working of the scenario-analysis tool built in the PSS. The focus of the PSS to the Arnhem case concerned primarily *exploration* tasks, which included the analysis and visualization of energy consumption patterns and the connection with the land-uses in the entire city of Arnhem, as well as the underlying

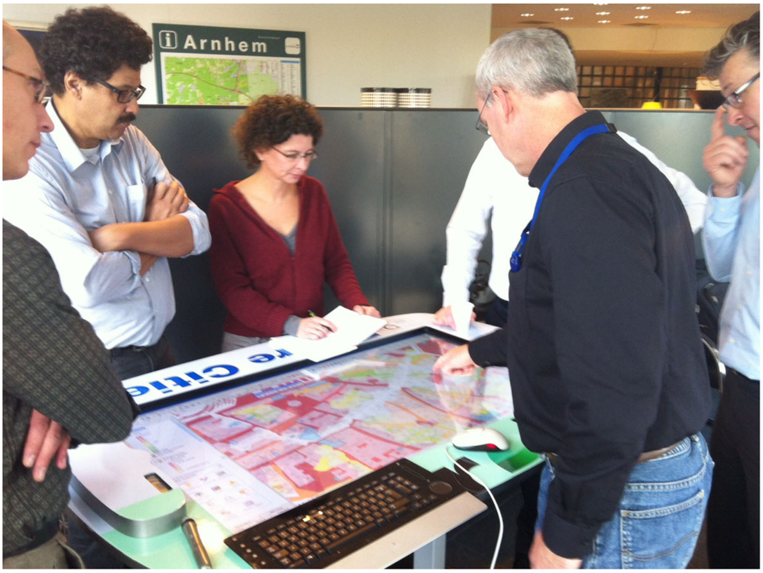

Fig. 4 The collaborative workshop in Arnhem with the MapTable PSS

existing geographical information collected from various sources. (stakeholders). The analytical support in the PSS consisted of three elements: a dynamic energy consumption map per postal code, a set of dynamic bar charts showing aggregate energy consumption values on several aspects, and an interactive consumption legend to define and portray ranges of consumption values on the map, for various levels of detail (i.e., city, district, or street level). Charts show total consumption values in kJ/m^2 or KJ/m^3 or

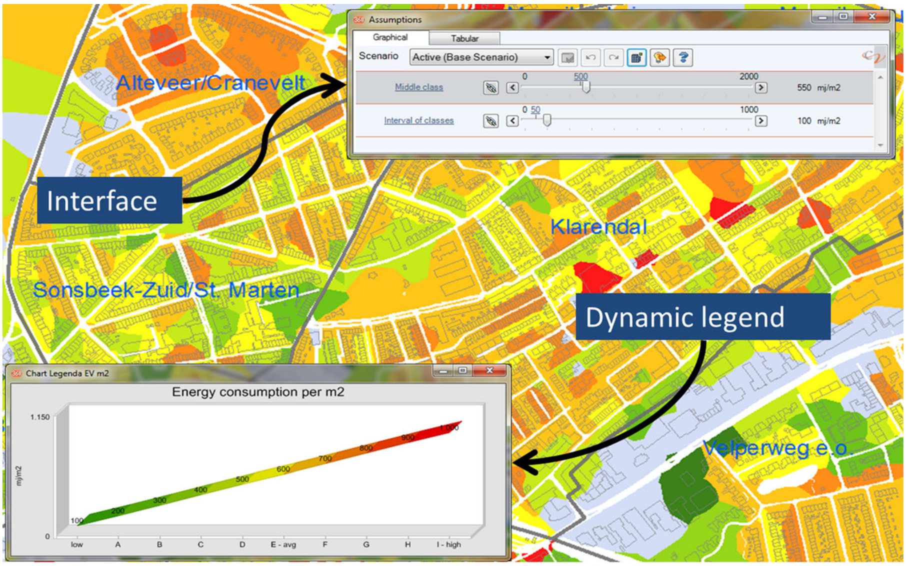

Fig. 5 Screenshot of the MapTable PSS showing energy consumption patterns per postal code zone in a neighbourhood in Arnhem. Map legend (*bottom left*) is dynamic as its class size and ends can be interactively modified by setting new values on the assumptions window (*top right*)

KJ/inhabitant for the entire city or per individual districts and on the basis of land use (schools, hospitals, restaurants, bars, etc.), m^2/inhabitant district and construction year. Figure 4 illustrates how the consumption map, its interactive legend and the dynamic charts are displayed on the MapTable PSS.

The city of Arnhem organized the workshops with the purpose of 1) assessing past and current energy consumption, 2) presenting its energy plans and 3) initiating a dialogue among the involved stakeholders. In doing this, the PSS was used as the main repository for the geographical information and the information on consumption originating from several sources. During the workshop all stakeholders were invited to present and explain to the other stakeholders their own information presented on the MapTable PSS. The MapTable PSS was used to first combine the information and then present it as past, current and expected patterns of energy consumption, overlaid with a map of current land use.

These activities can be captured under the header of the task of *exploration*. One of the goals of the workshop sessions was to visualize spatial distribution patterns of energy consumption and to explore its relationship to current land use. The participants of the workshop sessions were enthusiastic about how this information on consumption patterns was visualized and communicated. The connection between consumption and land use became very apparent. For example, through the use of the MapTable PSS, participants could associate high-consumption spots with information such as building year and land use. Several participants shared the quote that "*The MapTable* [*PSS*] *is a different way of visualizing and discussing energy consumption and land use*". The city's project leader noted that "*The possibility to combine and analyse as many map layers as possible and be able to explore spatial associations visible between these layers helps participants in the conversation to reach new perspectives*".

This quote shows how both analytical and communication support improved the task of *exploration* through the depiction of spatial patterns, which both provided insight in the planning issue (i.e., analytical support) and sparked the discussion (i.e., communicative support). Indeed, with regard to communicative support, the project leader noted that: "*An underestimated aspect of the MapTable PSS is its ability to keep participants active around it, their attentions focused on the information presented in the maps and the topic and less on each other*; *participants are physically there and cannot look away from each other*". Hereby, the fact that the MapTable PSS passively "forces" people to stand, rather than sit, around the table results in a more active and energetic workshop.

Deventer: Rearrangement of a Market Square

The Dutch city of Deventer has an outdoor shopping market called 'de Brink', which opens traditionally on Fridays and Saturdays and specializes in food items, flowers, clothing and fast food. Foremost due to bottlenecks in the access of emergency services and the insufficient functioning of the market, the municipal authorities decided to rearrange the spatial configuration of the market. This would involve a reallocation of 50 market stalls. Understandably, this caused a lot of commotion among the market vendors, because a large amount of them have their fixed position for a long time. In particular, the new locations for the stalls selling flowers, potatoes, vegetables, fruits, fish and fast food were debated heavily. The local newspaper ‘De Stentor’ published articles documenting these debates (De Stentor 2011a, b).

To address these issues, the city council organized two workshops at the municipality hall in which all market vendors were invited to select the new places for their stalls. The MapTable PSS was used to support this task of *selection*. Participants were asked one by one to come to the room where the MapTable PSS was situated and indicate on the map their desired location. The order was based on the seniority (the time they had been on the market) of the vendors. In the meantime, the other participants waited in another room next door where a projected image of the MapTable showed the choices already made by previous vendors. The MapTable PSS showed a high-resolution aerial photo, the current spatial allocation of the market stalls and the reallocation progress as it resulted from the picking process. The result of the picking process was a map showing selected locations and the names of the market vendors displayed on top of the locations (See Fig. 6).

The PSS offered support for the task of *selection*. The workshop participants considered the offered support to be generally adequate for this task. Reponses to the interviews revealed positive feedback about the MapTable PSS, particularly how it led to a fair, clear and transparent selection process. It was remarked that “*The integrated picture the PSS gives would guarantee transparency and fairness, given the sensitivity of the issues in question*”. The PSS facilitated this difficult selection process. As one market vendor puts it: “*If I am asked to describe the value of the system in one word that would be ‘clarity*’”. Or as stated by a textile stall owner: “*While I disagreed completely with the city’s plans to reorganize the market as I used to have a nice location, the system* [*MapTable PSS*] *worked well so that was not the issue*”. Hereby, several market vendors agreed that the selection process “*Could have never happened with only printed maps and markers or with a blackboard and chalk*”. In sum, this case study precisely demarcated the task of *selection*, in which the PSS provided communication support, and the main perceived usefulness was an increased transparency.

Fig. 6 Maps showing the original configuration of stalls (*left*) and the resulting new configuration with vendor names on top, after using the PSS MapTable during the session (*right*)

Achterhoek: Negotiating Planned Developments

In the Achterhoek area in the eastern part of the Netherlands, there is an oversupply of planned locations for future area development. Under the so-called 'active land policy', the municipalities in this area have actively invested in acquiring land for future development. The present economic crisis and the continuation of expected demographic shrinkage in this Achterhoek area forces its municipalities to readjust their plans. One solution could be that the municipalities cooperate more closely to decrease the amount of planned development locations in general. Competition between the municipalities with regard to attracting new businesses and new inhabitants hinders such a solution. A compensation and redistribution mechanism referred to as 'Transferable Development Rights' (TDR) could be introduced to help adjust supply and demand in the corridor and potentially lead to an increased overall development (cf. Levinson 1997) .

In order to deal with the competition and cooperation between these municipalities as well as to investigate the preconditions for introducing transferable development rights, two workshops were organized by the Radboud University Nijmegen. Therein, a negotiation process was simulated between the six municipalities involved using local and regional financial and geographical data on the development of housing and industrial estates. In the first workshop regional participants from the region of Arnhem-Nijmegen and the province of Gelderland participated. In the second session civil servants from the six municipalities participated.

The MapTable PSS supported the spatially-explicit negotiated allocation of municipal development rights on the MapTable map for the Achterhoek area (see Fig. 7). It featured an integration of the interactive GIS software and a gaming negotiation tool that included four rounds of a serious game (cf Samsura 2013). The gaming negotiation tool calculates financial impacts as a function of the intended spatial developments as

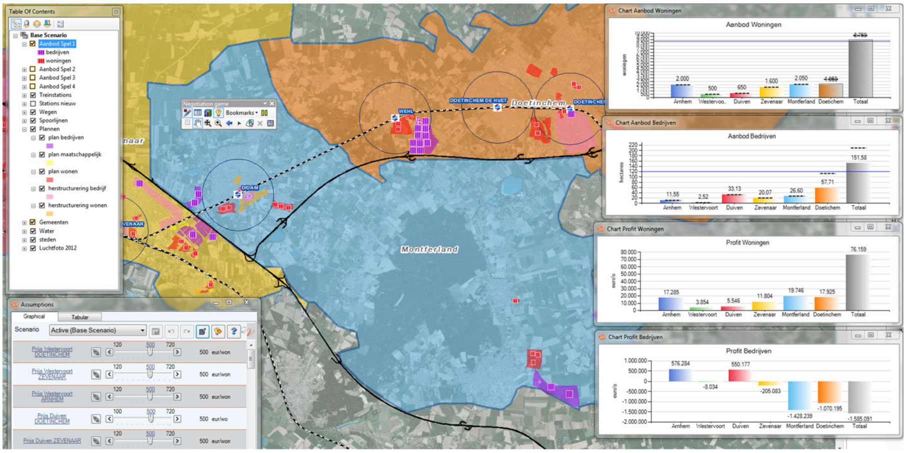

Fig. 7 Screenshot of PSS for the Achterhoek showing a list of background maps (*left*), map display (*middle*) and dynamic charts with financial impacts (*right*). Interactive sliders for price are also shown (*bottom left*). In the map display, development rights are represented by color-coded *boxes* of two sizes (*small and big*) for both housing (*red boxes*) and industrial spatial developments (*purple boxes*)

well as the maximum regional supply, individual municipal supplies, and the regional demand for future spatial plans. The goal of the game is that all players reach a fair distribution of spatial plans that generates profits as close as possible to their maximum theoretical profits. Players are required to negotiate with each other to increase and decrease their plans for housing and industrial areas. Changes made to these plans result in real-time calculations of the financial outcomes of all municipalities involved.

In the workshops, the PSS offered *communication support* for the negotiations between the participants. The municipalities needed to negotiate on their individual plans in order to solve the regional (Achterhoek) problem of oversupply of area development plans. The game was centred on the premise that by engaging in collaboration, the participants would come to a better outcome for the whole area; by applying a tit-for-tat exchange, everyone would be better off. Because the discussion took place with all participants standing directly around the MapTable PSS, the possibilities for participants to act as 'free riders' were limited. The participants could directly be addressed by other participants and convinced to participate in the collaboration process, in order to serve common regional public goals. Participants got the chance to communicate how they perceived the problem of oversupply of area development plans, and their perspective on how this could and should be solved. The MapTable PSS supported negotiations by making individual desires explicit, identifying the competitive tensions between the municipalities, and, potentially, supporting the achievement of agreements. However, when playing the game with the civil servants of the municipalities, the increased transparency through the communication support of the PSS did not always support reaching agreements, as illustrated by one of the civil servants: "*When I hear the plans of the other municipalities, I am not willing to reduce my plans. I expect a broader support for the reduction of development plans. I made a serious offer and I expect more* [from the other municipalities]". The competitive tensions, which fuel this behaviour of the municipal participants, did not obstruct the process of reaching consensus when the game was played with representatives from regional and provincial organisations in the first meeting. These participants were not burdened by local sensitivities, used the communications support of the PSS to act in the interest of the whole region and came to a decrease of the oversupply of development plans.

In terms of *analytical support* for the negotiation task, the MapTable PSS allowed participants to assess the impact of their negotiated business and residential development rights in financial terms. The economic model in the PSS calculates profits and losses, revenues and payoffs. Although the participants, especially those from the municipalities, contested some of the data for not being accurate and sufficiently up-to-date ("*Correct numbers are crucial for the game.*"), all participants expressed that they gained more insight into the plans of other municipalities and into the future economic consequences of these plans. As one participant remarked: "*The game did a fine job. We could stand around the map and zoom in and explore predicted outcomes of the plans*". In terms of usefulness, this was mainly perceived to be the iterative feedback from the MapTable PSS on the proposals and the wishes and desires of the other participants, which, in turn, facilitated a more focused negotiation.

Task-Technology Fit in the Four Case Studies

Table 3 depicts the main findings about task-technology fit based on the four case studies. We will now describe these findings more in-depth.

Exploration

In general, both communication support and analytical support have positive task-technology fit for the task of exploration. One of the notable kinds of usefulness related to communication support, which was mentioned both in the Rijnenburg and Arnhem case, is that standing around the table leads to an active and energetic dialogue (cf. Pelzer et al. 2014a). Hereby the focus of the workshop was on the content of the planning issue, and not so much on procedural aspects or irrelevant tangents. This was further exacerbated by the provided analytical support. In the case of Rijnenburg, giving direct feedback on proposed ideas showed the feasibility of certain ideas (e.g., placing a windmill in a certain location), but also led to new ideas (e.g., solutions for the way in which water management should be considered in the area). In Arnhem, combining different map layers allowed disclosing of similar patterns and associated existing spatial information, helping the participants to see new problems and solutions.

More generally, both the communication and analytical support capabilities of the MapTable PSS helped developing a spatial language, which enhanced both understanding the planning issue at hand and improving the dialogue among the involved stakeholders. Hereby, it should be noted that this spatial language might also have negative effects (i.e., a negative task-technology fit). The urban designer in Rijnenburg did not feel comfortable with the rather rigid maps and the quantitative impact analysis function, arguing the PSS hampers creativity and the flow of the process. While the dialogue around maps proved active and dynamic, some stakeholders of the Arnhem case felt overwhelmed with the amount of spatial information presented. Something which is confirmed by other studies about the relation between urban designers and GIS-based tools (Dias et al. 2013; Pelzer et al. 2014b).

Selection

As remarked earlier, the empirical analysis does not include a combination of analytical support and selection tasks. Therefore, we restrict ourselves to the combination of

Table 3 Main findings related to task technology fit

Task Technology	Communication support	Analytical support
Exploration	Active dialogue Spatial language	More insight into problem Spatial language Hampers creativity
Selection	Transparency Systematised approach	n/a
Negotiation	Learning about other stakeholders	Direct feedback

communication support capabilities of the PSS and selection tasks. The main added value in the Deventer case was that using the MapTable PSS led to a transparent selection process, in which all the market vendors could make their own choices and both clearly and systematically see the choices that were made before by others. This setup allowed for an effective way of communication between the city and the affected vendors. Moreover, it facilitated a procedure that was considered systematized and fair – provided the stakeholders agreed with the seniority principle.

Negotiation

The iterative element in negotiation makes both analytical support and communication support necessary. Participants need to be able to use the feedback from the analytical support on their proposed solutions in their communication to other participants. By providing relevant analytical support, the MapTable PSS facilitated the iterations in the negotiation task: participants could check whether their proposals would lead to realistic and acceptable outcomes. This way the MapTable PSS helped to effectively combine the financial negotiations with relevant spatial information and come to a more focused negotiation. The feedback from the MapTable PSS was considered to be useful for the negotiation task by all participants in the Achterhoek case. They got the possibility to spatially clarify both conflicts and opportunities for negotiations in addressing these conflicts. This played a crucial role in the analytical support of the MapTable PSS: participants could use the PSS to relate better to each other's financial-economic position and reach a more informed outcome. The MapTable PSS also generated more understanding of each other's behaviour. A better understanding can enhance the relations between the participants which can be seen as a first step towards solving the regional problem of area oversupply. This better understanding is partly a result of the analytical support, but can be primarily be attributed to the communication support of the Maptable PSS. By bringing the participants together around a MapTable and facilitating interaction between the participants supported by the MapTablePSS, the type of communication support is offered that could mean a first step towards reaching consensus.

However, the combined analytical and communication support can simultaneously be a potential bottleneck for the MapTable PSS. A first reason is that in some instances stakeholders might not want to share all information because of tactical reasons. The PSS makes the impact of choices very explicit, which might restrict the space to manoeuvre of the participants. A second reason is that the data quality in the MapTable PSS must be very high in order to directly facilitate decision-making negotiations. In the dynamic land and real estate market, it is nearly impossible to incorporate such up-to-date information in a model that effectively reflects the complexities of land development processes. In other words, the analytical support can hardly keep up with the communication support that is desired in real-world negotiations. Therefore, at first sight, the tool seems to fit best in the explorative stages of a decision-making process, when communication support seems more important than analytical support, because there is not yet a need for very detailed and quick reflections and solutions.

Conclusions and Recommendations

The research question raised in the introduction of this paper is: How can a better conceptual and empirical understanding of the relation between planning tasks and PSS lead to improved insights about the support function of PSS? In order to address this question, we investigated the concept of task-technology fit through a comparative case study. We believe this concept can lead to a better understanding of the usefulness that is reachable by different planning support capabilities of a PSS for different tasks. The task-technology fit depends on the support a PSS can offer to the planning tasks, in terms of analytical support and communicative support. In general, we can conclude that PSS can offer both these types of support, but that the usefulness for specific planning tasks differs. For instance, we found that analytical support can provide valuable feedback on the necessary iterations that are part of a negotiation task. With regards to communicative support, we found, among other things, that a table top displaying a digital map, sparks an active and content-based dialogue among the involved participants. However, some reflections about these findings should be noted.

The concept of task-technology fit means a PSS can both be positive and negative for conducting a specific task. The emphasis in this paper – arguably also that of the PSS debate in general – has been on the positive aspects related to a PSS application (i.e., 'usefulness' or 'added value'). However, support capabilities of a PSS can also have a negative effect on conducting a task. For instance, the urban designer felt the analytical support provided in the Rijnenburg case hampered successfully conducting the exploration task. This potentially negative role of technology is also found in a recent paper by Smith et al. (2013), arguing that GIS can become performative, and hereby steering rather than supporting the process.

Moreover, whereas the distinctions among different support capabilities and different planning tasks are generally helpful, in some instances they are very hard to disentangle in empirical research. For example, feedback by the MapTable PSS on proposed solutions is considered analytical support, it might, however, also lead to a discussion among involved stakeholders, in which it functions as communicative support. Planning tasks are arguably easier to discern. A notably finding, however, is that negotiation often consists of elements of both selection and exploration. Hence, it is not so much distinguishable from the other tasks by the activities it is comprised of, but by the involved stakeholders (usually with diverging or contrasting insights) and the outcome of the task (often some kind of consensus or agreement).

Nonetheless, while a focus on planning tasks is valuable, this is not the only way in which the usefulness of PSS can be conceived. In several of the case studies the usefulness of the MapTable PSS was found to be at a higher level. For instance, one of the broader aims of applying a MapTable PSS in the case of Rijnenburg was to improve the collaboration and communication among different disciplines, which seemed quite successful. Moreover, in the Achterhoek case, the MapTable PSS helped to cross regional boundaries, because actors that were not used to talk to each other were urged to literally stand around a table together and discuss matters with each other.

This paper has only started to scratch the surface of empirical research about the usefulness of PSS for planning practice. Although the concept of task-technology fit has been out there for quite a while, we believe it has value for future empirical research in the field of PSS. The concept does not only provide a better understanding of the usefulness of PSS, but it also has concrete implications for PSS developments. Besides considering the content of the planning issue, which should always be the starting point for PSS development, PSS have to take into account support capabilities in order to successfully support specific planning tasks. Although this paper has carefully considered different planning tasks and support capabilities in its case selection, both the PSS (MapTable PSS) and the context (the Netherlands) are fixed. Future research with different PSS and in other contexts would be very valuable. Methodologically speaking, we believe comparative case studies are a helpful way to research this, because it helps to see the instrument applied in their respective contexts and prevents focusing too strongly on instrumental characteristics. Furthermore, at present such studies are becoming feasible, because besides CommunityViz also other PSS like What If? are relatively frequently used in planning practice. Such a larger body of cases would also allow for conduction unified questionnaires, which is – next to the TTF-concept – a common and fruitful tradition in the MIS and GSS debate.

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