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Usefulness of planning support systems: A conceptual framework and an empirical illustration

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ABSTRACT

Planning support systems (PSS) are digital instruments to support planning. Comparatively little attention has been paid to understanding the usefulness of PSS for planning practice and studying its application in real-world planning situations. This paper aims to address this omission. Conceptually, usefulness is subdivided in seven dimensions, and explained by the usability and utility of the PSS. This framework is applied to a case study with *Urban Strategy* – a PSS based on combined environmental and traffic models. A workshop with this PSS was studied using a questionnaire, interviews and observations. The findings indicate that in addition to the more commonly used concept of usability, utility (understood as task–technology fit) is helpful to understand the usefulness of a PSS application. This concept, for instance, helps to indicate when a PSS has a negative effect on planning tasks. Moreover, in addition to usability and utility, context turned out to be critical to understand the usefulness of a PSS application.

1. Introduction

Computer technology is increasingly able to support urban planning. An example is planning support systems (PSS), which are dedicated digital instruments to support planning and policy processes. In the last two decades, a lot more academic attention has been paid to the way in which tools can be used not only to describe and predict spatial reality, but also to help planners. Two rough categories can be discerned within the debate about PSS: articles with a more conceptual focus, often combining insights from planning theory with insights from spatial analysis (Batty and Harris, 1993; Couclelis, 2005; Geertman, 2006, 2008; Harris, 1989; Klosterman, 1997; Moore, 2008), and case studies describing the application of a PSS in a specific planning context (for overviews: Brail and Klosterman, 2001; Brail, 2008; Geertman and Stillwell, 2003, 2009; Geertman et al., 2013). Although most researchers are strongly aware of the relation with planning practice, most of these cases studies are characterized by a central focus on the instrumental characteristics of the PSS (with the notable exception of the chapters in the edited volume by Geertman and Stillwell, 2009). Moreover, while increasing attention is paid to the added value of PSS for planning practice, this is hardly ever measured empirically (te Brömmelstroet, 2013).

Recent studies have responded to this omission or bias by conceptualizing and explicitly measuring the usefulness, performance and effectiveness of support instruments (Arciniegas et al., 2013; Goodspeed, 2013; Nyerges et al., 2006; Pelzer et al., 2014; te Brömmelstroet, 2014, 2013). Although the results of these studies are not conclusive, there is a tendency to conceptualize the usefulness of PSS in terms of scores on a range of sub-dimensions related to both the process and the outcome of planning and policy processes (e.g. Pelzer et al., 2014; te Brömmelstroet, 2013). However, it is not very

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clear how usefulness can be achieved. Whereas several ideas have been developed regarding explanatory variables, such as the involvement in the development of the tool and the transparency of the tool (e.g. Brömmelstroet, 2010; Vonk et al., 2005, 2007), the exact relationship with usefulness remains somewhat opaque. One of the problems in this regard is that many empirical studies report on experiments or workshops aimed at evaluating the tool, rather than studying the usage of PSS in practice. This paper addresses this omission by approaching the usefulness of PSS through both a refined conceptual framework and a case study in a real planning situation. It is important to note that this paper does not argue that rigour or validity of the instrument is unimportant in evaluating PSS, but that this should be complemented by assessing its usefulness for practice. The latter has received relatively little systematized empirical attention in the debates about PSS and the wider debates about instruments and models in planning, and is thus the focus of this paper.

This paper starts with a literature review describing earlier research and different terms relating to the usefulness of PSS, and then presents the conceptual framework that was applied in this study. Next, the methodology section introduces the case that was researched, including the research methods that were applied. Section 4 describes the main findings from the case study. This is followed by a discussion in Section 5. The paper ends with conclusions and recommendations for further research.

2. The usefulness of PSS

2.1. Usefulness: towards conceptual clarity

In a recent article, te Brömmelstroet (2013) observed that PSS case studies hardly ever systematically measure the claims about the performance of the instruments they describe. In several case studies, implicit assumptions are made about the usefulness of the PSS, such as it leads to more efficiency, better participation and a more sustainable outcome, but these are (perhaps very valid) leaps of faith rather than empirically grounded outcomes. However, in recent contributions more attention is paid to this aspect, although the different concepts used can be confusing. Therefore, the most commonly used terms are analytically distinguished in Table 1.

- Performance is used in the aforementioned study by te Brömmelstroet (2013) and in a recent contribution by Goodspeed (2015) in a similar vein as in this paper, namely as the extent to which the PSS has an influence on practice. Goodspeed (2015) focuses specifically on the performances of PSS on the dimension of social learning. However, in other studies, performance is used to describe the content of the PSS, for instance in terms of rigour and validity (e.g. Haasnoot et al., 2014). Hence, performance has a meaning that varies with the study one uses, which makes it not very suitable as an unambiguous conceptual building block.
- Effectiveness combines the two meanings used for performance described above; it includes dimensions of both the instrument and the influence the instrument has on practice, and complements this with the usability dimensions (e.g. Arciniegas et al., 2013; Inman et al., 2011). Whereas these studies are very precise about the dimensions or criteria that comprise effectiveness, no distinction is made between the functioning of the instrument and the influence on practice, whereas for the purpose of this paper the former (the functioning of the instrument) is an independent variable and the latter (the influence of practice) is a dependent variable.
- Added value has been used in some recent PSS studies. It refers to the positive influence a PSS can have on practice (Pelzer et al., 2014, 2015a; te Brömmelstroet, 2015). Added value is conceptually consistent with usefulness, the term used in this paper. However, usefulness is preferred over added value because the former is being increasingly used in empirical studies, such as the COST action related to this special issue (e.g. Larsson et al., 2014), and builds upon a tradition of studies on the usage of ICT (Nielsen, 1993).
- Usefulness, according to Nielsen (1993, p.24), is the 'issue of whether the system can be used to achieve some desired goals'. PSS usefulness has two interrelated dimensions: (1) the different kinds of usefulness a PSS can have, such as a more informed outcome and increased efficiency, and (2) the extent to which a PSS can help to achieve desired goals. Because in complex, real-world planning situations it is very difficult to precisely outline the 'desired goals' beforehand, the focus in this paper is on different kinds of usefulness, which are assessed *ex post*. In doing so, this paper uses a conceptual framework developed by Pelzer et al. (2014). In this framework (see Table 2), usefulness is subdivided into seven dimensions, based on for example earlier work in group model building (Rouwette et al., 2002). Empirical studies have shed light on

Table 1
Commonly used measurements of PSS.

Concept	Description	Relevant articles
Performance	The kind of influence a PSS has on practice *or* the quality of the instrument	te Brömmelstroet (2013), Goodspeed (2013), and Haasnoot et al. (2014)
Effectiveness	The extent to which a PSS has a positive influence on practice *and* the quality of the instrument	Arciniegas et al. (2013) and Inman et al. (2011)
Added value	The kind of influence a PSS has on practice	Pelzer et al. (2014, 2015a) and te Brömmelstroet (2015)
Usefulness	The kind of influence a PSS has on practice	Larsson et al. (2014)

Table 2
Overview of different kinds of usefulness. Source: Pelzer et al. (2014).

Kind of usefulness	Definition
Learning about the object	Gaining insight into the nature of the planning object
Learning about other stakeholders	Gaining insight into the perspective of other stakeholders in planning
Collaboration	Interaction and cooperation among the stakeholders involved
Communication	Sharing information and knowledge among the stakeholders involved
Consensus	Agreement on problems, solutions, knowledge claims and indicators
Efficiency	The same or more tasks can be conducted with smaller investments
Better informed plans or decisions	A decision or outcome is based on better information and/or a better consideration of the information

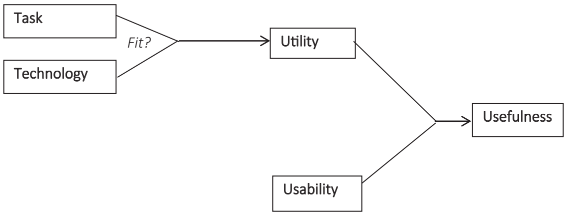

Fig. 1. Usefulness as an outcome of utility and usability.

some of these dimensions. Pelzer et al. (2014) found that frequent users of a PSS based on a map table emphasize process-oriented variables, like collaboration and communication. Goodspeed (2015) found in a case study in Austin, Texas, that the PSS *Envision Tomorrow* had a positive effect on learning. Moreover, in a comparative case study of four different PSS applications, Pelzer et al. (2015a) observed that learning was mentioned as an important usefulness in all case studies. In most of these studies, usefulness is addressed as perceived by users, often through questionnaires. However, it would be more methodologically rigorous to combine this with methods that address revealed usefulness, such as observational techniques (e.g. Nyerges et al., 2006).

Understanding how usefulness can be achieved is at least as important as understanding what usefulness is. Put differently: what are the causal factors explaining usefulness? Based on the work of Nielsen (1993),[1] this paper proposes two main explanatory variables: utility and usability. This results in the conceptual framework outlined in Fig. 1, in which utility and usability influence usefulness. The two concepts are elaborated in more detail below.

2.2. Utility

According to Nielsen (1993, p.25), 'utility is the question of whether the functionality of the system in principle can do what is needed'. In the context of PSS, 'do what is needed' refers to the effect on the planning tasks a PSS is intended to support (Klosterman, 1997; Geertman, 2008). A way to make sense of utility in the case of PSS is offered by the concept of 'task–technology fit' (Goodhue and Thompson, 1995, cf. Vonk, 2006). The basic premise of this concept is rather straightforward: utility can only be achieved if the characteristics of the technology (i.e. the PSS) are suited to the planning task that has to be fulfilled. The work of Dennis et al. (2002), applied in the context of group support systems, inspired this paper in the conceptualization of tasks and technology.

Planning tasks are 'combinations of planning behaviours that accomplish particular functions or purposes' (Hopkins, 2001, p.187). Dennis et al. (2002, p.171) distinguished between 'generation tasks' and 'decision-making tasks'.[2] Generation tasks refer to a process of exploration, in which problems and possible solutions are explored. Decision-making tasks (from here on, 'selection tasks'), on the other hand, refer to choosing the issues that are put on the agenda in the context of problem identification or selecting a planning intervention, a process that can also be cast in terms of 'opening up' (generation) and 'closing down' (selection) (Rydin, 2007; Pelzer et al., 2015b).

Technology refers to the capability of the PSS to support the planning tasks. Dennis et al. (2002) argue that there are two types of such support: communication support and information processing support. Based on earlier work in planning and PSS (Hopkins, 2001; Vonk, 2006), the support capabilities of PSS can be considered either analytical[3] or communicative. Analytical support refers to the capabilities of the PSS to improve the understanding of the planning issue. The most notable, if not the defining (Brail, 2006) characteristic of PSS in this regard is the ability to perform impact analyses, revealing the effect of

[1] Note that the conceptualization in this paper differs somewhat from that of Nielsen (1993). Whereas in his conception usability and utility are components of usefulness, in this paper usability and utility influence usefulness.
[2] Note that Britton Harris, one of the godfathers of PSS, made a very similar distinction in 1965.
[3] This is similar to information processing as perceived by Dennis et al. (2002). Analytical is considered a more common concept in planning and is therefore used.

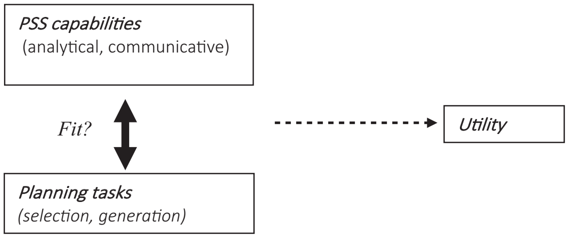

Fig. 2. Utility conceived as task–technology fit.

conducting a planning intervention. Another important characteristic, particularly for long-term planning issues, is the ability to perform scenario analyses (e.g. Couclelis, 2005; Hopkins and Zapata, 2007). Communication support, on the other hand, recognizes that planning tasks are not conducted in laboratories, but are collaborative processes that involve a range of stakeholders. The capabilities of a PSS should facilitate the communication among the involved stakeholders. Put differently, the focus is on knowledge exchange rather than information provision. The way in which utility is conceived in this paper is shown in Fig. 2.

2.3. Usability

A reason why several PSS can now be applied for communication support is that their usability has increased significantly over the last decade. Usability, according to Nielsen (1993, p. 25), is about 'how well users can use that [utility] functionality'. Recent studies have done a fairly thorough job in making explicit the usability variables relevant for a PSS (in particular: Goodspeed, 2013; Brömmelstroet, 2010; Vonk, 2006). In Table 3, the 10 most important usability variables of PSS that are mentioned in the literature are summarized. Note that the importance of these usability variables differs from planning issue to planning issue. For instance, when analysing the future of a brownfield area with a group of environmental analysts, it might be very important to get an extremely detailed insight into the environmental factors (e.g. noise, air quality, etc.), whereas when a long-term vision for a region is developed coarser information might be more suited (usability variable: level of detail).

2.4. Understanding usefulness in planning practice

The purpose of this study was to evaluate how and to what extent the conceptual framework on usefulness outlined above is suitable to study PSS in planning practice. In addition, the study investigated a common notion in PSS studies about how to achieve usefulness: tool involvement. According to a wide range of literature, models and PSS have the highest level of usefulness for policymaking when the intended users are involved in their development (Brömmelstroet 2010; McIntosh et al., 2011; Van Delden et al., 2011; Voinov and Bousquet, 2010; Wassen et al., 2011). This can range from collaboratively developing a complete model, as in the case of group model building (e.g. Rouwette et al., 2002; Vennix, 1996), to asking participants to give input about the parameters (Pelzer et al., 2013). Hence, the proposition is that close involvement in the development of the PSS will increase usefulness.

3. Case description & methodology

In order to thoroughly research the usefulness of PSS in practice, this study looked for a situation in which a state-of-the-art PSS was used and that reflected practice as closely as possible. In order to do so, a workshop was organized together with TNO (a Dutch research company) and the Municipality of Utrecht (a city in the Netherlands).

3.1. The PSS: Urban Strategy

The PSS this case study is *Urban Strategy*, an interactive digital support instrument developed by TNO (www.tno.nl/urbanstrategy). *Urban Strategy* is based on a framework that combines a range of impact models in a GIS environment, including noise, air quality and traffic.[4] For instance, dwellings can be added to a plan area, which will change the land use. This then causes an increase in traffic in and to the area, which again generates changes in scores for noise and air quality. The outcomes from the model runs are visualized in a 1D environment (tables with scores), a 2D environment (a map) and a 3D environment (a digital Marquette), as illustrated in Fig. 3. *Urban Strategy* has been applied in several case studies, particularly in the Netherlands and often in instances where the environmental situation is challenging, such as brownfield developments or areas close to arterial roads. Moreover, prior to the case study in this paper, *Urban Strategy* was extensively tested in experiments with students (see e.g. te Brömmelstroet, 2015).

[4] See also a YouTube movie by TNO about Urban Strategy: https://www.youtube.com/watch?v=5QRcnZTKasQ.

Table 3
Commonly used usability variables in PSS research, based on Arciniegas (2012), Goodspeed (2013), Brömmelstroet (2010), and Vonk (2006).

Usability variable	Description
Transparency	The extent to which the underlying models and variables of the PSS are visible to users
User friendliness	The extent to which participants are able to use the tool themselves
Interactivity	The extent to which the tool can directly respond to the users' questions and suggestions
Flexibility	The extent to which the tool can be applied for different planning tasks
Calculation time	The time participants have to wait before an analysis is completed
Data quality	The extent to which the input data is considered valid
Level of detail	The extent to which the level of detail of the tool matches the perspective of participants
Integrality	The extent to which the tool takes all the relevant dimensions into account
Reliability	The extent to which the outcomes of the tool are considered reliable
Communicative value	The extent to which the visual output is useful for the participants

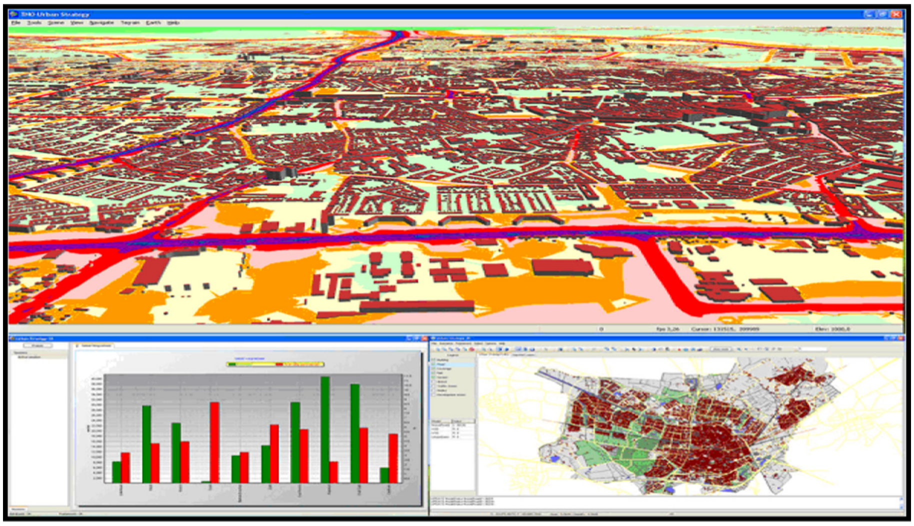

Fig. 3. The three interfaces of *Urban Strategy*: 3D (above), 2D (below right) and 1D (below left).

3.2. Case description: Cartesiusdriehoek

The plan area, called the Cartesiusdriehoek, is located in the city of Utrecht. It is bordered by two railway tracks, which give it a triangular shape. The area has traditionally had a primarily industrial function, with some residential zoning. In recent years it has become an explicit aim of the municipality to make the area more diverse in terms of functions. The main arterial road in the area is Cartesiusweg, which cuts the area in two. East of Cartesiusweg is the actual Cartesiusdriehoek. This is a 'transformation' area, where the municipality aims to encourage the location and development of, for example, housing, amenities and commercial functions. The area west of Cartesiusweg (Werkspoorkwartier) contains industry and is bordered by a large industrial area (Lage Weide). No dwellings are planned in this area, since the main aim is to attract small commercial firms. The screenshots from Urban Strategy in the Cartesiusdriehoek are shown in Fig. 4. The upper screenshot depicts traffic flows, the lower screenshot noise contours. The triangular shape in the centre is the Cartesiusdriehoek.

3.3. Workshop description

The three-hour workshop was conducted in 2014 at TNO in Utrecht. A group evaluation was conducted after the workshop. The workshop was held in TNO's workshop room (see Figs. 5 and 6), which contained a large table, several screens and a touch table. To facilitate brainstorming in separate groups, an additional room was available.

In addition to *Urban Strategy*, several complementary support instruments were available: large paper maps, a whiteboard, a touch table, and internet connected computers with large screens to access Google Streetview and the website of the Municipality of Utrecht, which also has an extensive information base. The support tools had a twofold function: to gather knowledge from the involved stakeholders (whiteboard, paper maps) and to provide information to the stakeholders (*Urban Strategy*, web browsers).

The involved stakeholders (n = 9) were all part of the area team for the Cartesiusdriehoek of the Municipality of Utrecht. Central roles were fulfilled by the area manager (who led the meetings) and the area secretary (who facilitated internal and

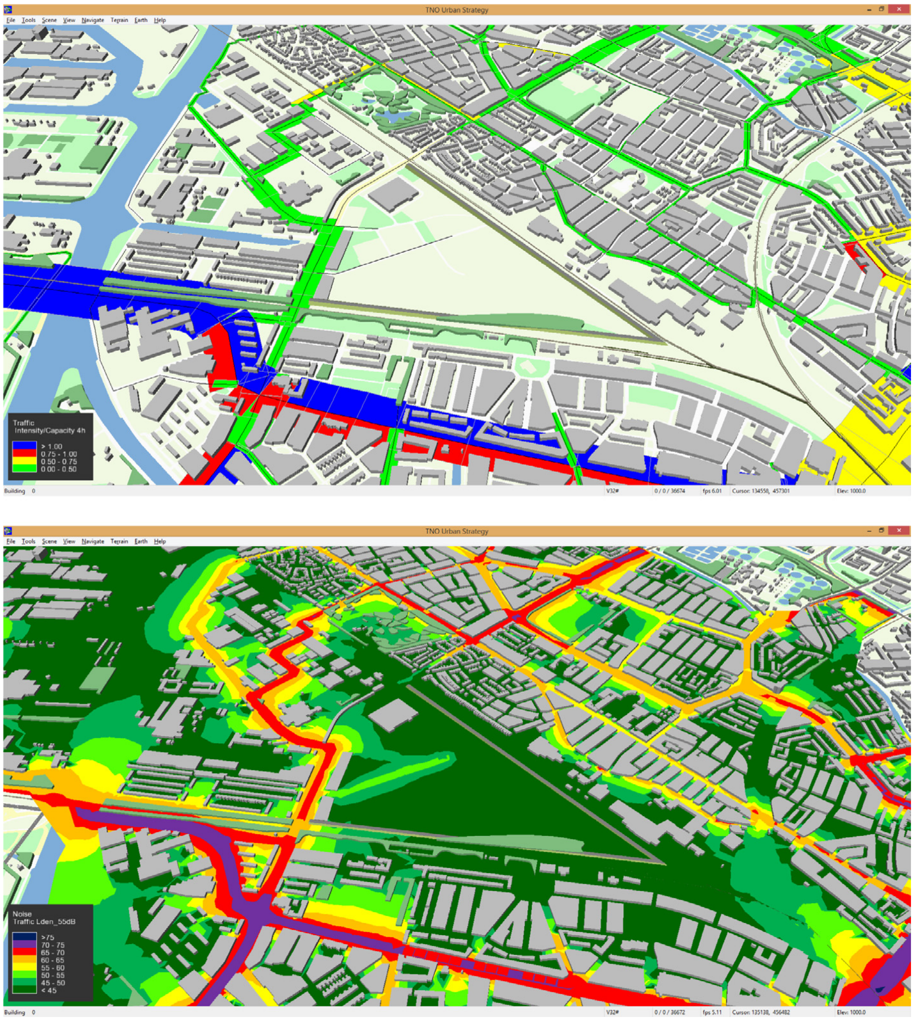

Fig. 4. Two screenshots of *Urban Strategy* showing traffic flows and noise contours, respectively, in the Cartesiusdriehoek.

external communication). The area team included several disciplinary experts, including an environmental analyst, a transport planner, a housing expert and an urban designer.

The workshop consisted of two main stages. The first 45 min were used to explore challenges and opportunities in two groups (generation tasks). This resulted in a list of problems and solutions, which were written on a whiteboard. A selection was then made of the topics that could be further analysed with the help of *Urban Strategy*. The remainder of the workshop was devoted to iteratively analysing the problems that had been raised during the brainstorming (selection tasks).

3.4. Research methods

A questionnaire, observations and qualitative evaluations were applied to study the workshop. The post-workshop questionnaire focused on four dimensions: the background characteristics of the participants, the focus of the workshop, the usability of the PSS and the usefulness of the workshop. It mainly consisted of Likert items and scales on a scale of 1–7 (1 = strongly disagree, 7 = strongly agree). Participants were also asked to identify the most important usefulness of *Urban Strategy* based on their experiences during the session. The questionnaire started with some open background questions and ended with open questions about the session.

The workshop was observed in two ways. First, two external researchers observed the session and made notes, resulting in brief reports. Second, the workshop was recorded with cameras and audio devices. All that was said during the session was transcribed verbatim. After the session, a qualitative evaluation was conducted in a group with all the participants, in which they reflected on the workshop and *Urban Strategy*. In order to get the participants to speak frankly, the chauffeur

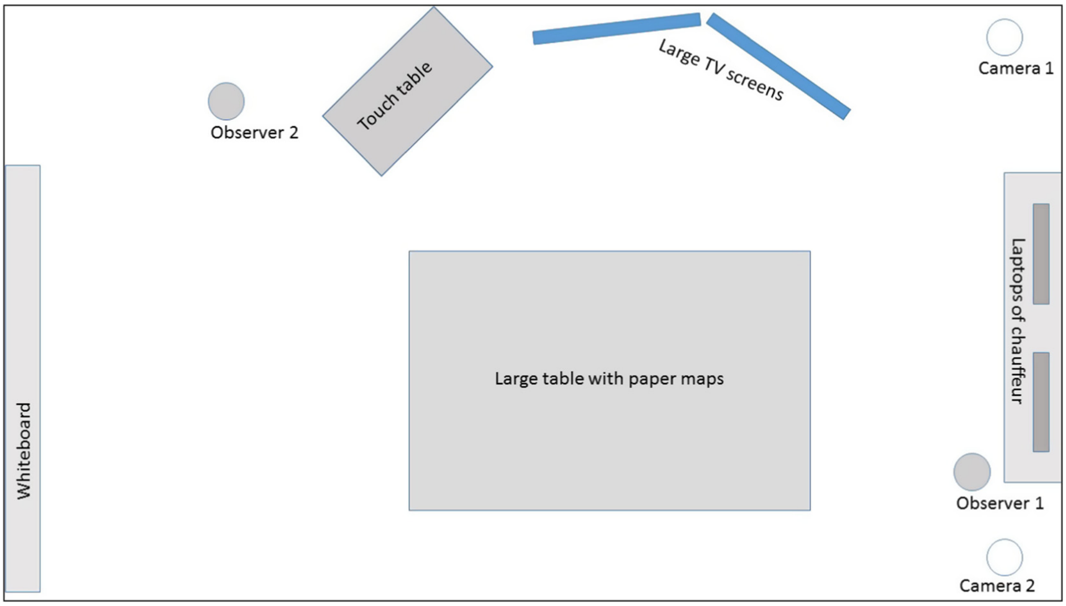

Fig. 5. Schematic depiction of the workshop room. *Urban Strategy* was shown on the large TV screens and operated by the chauffeur via laptops.

Fig. 6. The workshop.

and moderator were absent during this session. In addition, a feedback interview was conducted with the transport planner from the Municipality of Utrecht, who was involved in organizing the session.

3.5. Analytical approach

The empirical strategy was aimed at making full use of the mixed methods that were applied during and after the workshop. The three research methods outlined above were used to achieve methodological triangulation, that is, to study the research object from different viewpoints (Denzin, 2006). Each of the methods has its specific benefits and shortcomings. The questionnaire was used to discern patterns in terms of usability and usefulness. Because of the low n, more sophisticated quantitative methods were not possible. The group evaluation provided a more nuanced and sometimes different insight into the utility, usability and usefulness of the PSS, whereas the observations led to both descriptive and explanatory insights into the workshop. Moreover, they provided a different perspective because they reflected the perspective of experienced PSS researchers, a perspective that is different from that of the practitioners. The empirical results from the three methods were analysed as follows.

The findings from the questionnaire were analysed to gain insight into the patterns of perceived usefulness and perceived usability. The two observers wrote a short report based on their observations during the session. In addition, the transcripts and video images of the session were analysed by a third researcher to corroborate and refine these findings. These did not lead to new or additional findings. The group evaluation and feedback interview were coded using NVivo© qualitative data analysis software. This was done in an open coding process (Corbin and Strauss, 1990), whereby the focus was on identifying and understanding the positive and negative aspects of the session.

4. Findings

4.1. Usability

Fig. 7 depicts the average usability scores for *Urban Strategy* as measured by the questionnaire. Because the scores differ from participant to participant (e.g. indicated by high standard deviations in the questionnaire results), these results should be treated with caution. Nevertheless, it is notable that the user friendliness of *Urban Strategy* was considered to be relatively low. When asked about this topic, the main reason the participants gave for the low score was the fact that they themselves had not been able to use *Urban Strategy*: they had always needed the support of a chauffeur.

Moreover, during the group evaluation it became apparent that the waiting time for the results of requested analyses was experienced as being relatively long; however, this was not considered a fundamental problem. The group evaluation conducted directly after the session revealed that *Urban Strategy* was not considered very transparent with regard to its structure of analysis, and the models and calculation rules included in it. As one of the participants said: *'I would have liked to get a better understanding of how this works. I mean, what is Urban Strategy based upon?'* This is somewhat puzzling, since transparency was given a relatively high score in the questionnaire.

Because the tool was intensively prepared with their co-workers from the Municipality of Utrecht (transport modellers, who were not at the session), the outcomes seemed to be trusted by most participants. Moreover, the chauffeur, besides helping the users to navigate the tool, also helped them to interpret the results, for instance about the way in which the various environmental models (noise, air quality) work and what the implications are. This need for interpretation seemed to be related not so much to *Urban Strategy*, but to the fact that the workshop took place in an interdisciplinary setting, which required extra explanations about the outcomes of transport and environmental models.

4.2. Utility

Since the participants already had very extensive knowledge and ideas about the plan area, the selection tasks focused on refining challenges and solutions for the area. The support function of *Urban Strategy* for these tasks was evaluated as mixed. Although the participants found it positive that *Urban Strategy* could assess how much extra spatial development (i.e. dwellings, commercial functions) could be realized in the area before it would lead to significant problems in terms of traffic congestion and environmental hindrance. However, at various moments during the workshop they felt that certain thematic dimensions were lacking in the models included in *Urban Strategy*. Omissions were in particular felt with regard to transport by modalities other than car, notably bike and public transport. The lack of a financial analysis model was also noted. In addition, not all the analytical support provided by *Urban Strategy* was understood by all the stakeholders. This could be partially explained by some of the aforementioned specific usability issues, such as a lack of transparency and low user-friendliness.

In addition, a notable observation is that some of the tasks were simply too complex for and unfamiliar to most of the stakeholders. For instance, understanding how traffic flows work requires quite a lot of background knowledge and perhaps even prior education. Hence, grasping how the analytical support of *Urban Strategy* works can be quite challenging. Similarly, part of the lack of understanding was related to the lack of experience of working with this particular technique, which required delving deeply into other disciplines, in particular transport planning and environmental analysis. After the session, the area manager said *'It took quite a while before I really understood the tool'*, to which the environmental analyst added *'A second time it would go very differently, because then you would know what the tool can do.'*

Although the primary aim of *Urban Strategy* was to provide analytical support, it turned out to play a role in the communication support as well. The communication related to the selection tasks was between the participants on the one hand and the chauffeur and *Urban Strategy* on the other hand. Someone would raise an issue or put a question to the chauffeur, and he would enter it in *Urban Strategy*. After the calculation was finished, the chauffeur would help to communicate the outcome to the participants. Although this approach worked because it was well structured, it was also considered a somewhat tedious exercise, rather than an energetic and dynamic dialogue in which knowledge was rapidly exchanged.

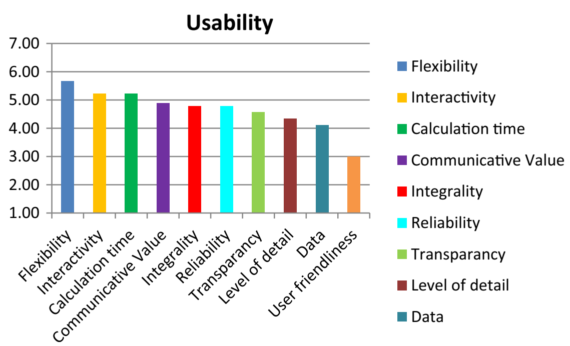

Fig. 7. Scores for the 10 usability indicators on a scale of 1 (very negative) to 7 (very positive) (n = 9).

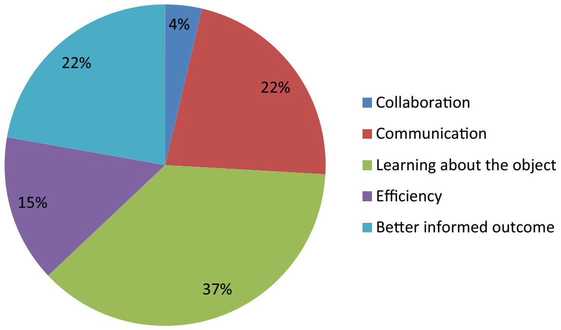

Fig. 8. The most important usefulness ('added value') according to the participants, (n = 9).

Urban Strategy influenced not only the process but also the substance of the workshop. As mentioned, topics that emerged from the brainstorming were filtered based on their match with the available analytical support capabilities in *Urban Strategy*. However, as the workshop evolved it became clear that the focus on transport dimensions (i.e. car traffic) and environmental dimensions (i.e. legal restrictions) were perceived as limiting the discussion. For instance, there is a railway track and a train station adjacent to the plan area, but they were not in the model. Participants indicated that they would have liked to perform more analyses on this dimension (e.g. by changing the frequency of passing trains).

4.3. Usefulness

The users of US were asked what they considered the most important kind of usefulness of *Urban* Strategy and had to select one option out of the seven kinds of usefulness in Table 2 (no participant choose the option 'other').[5] Fig. 8 shows a rather mixed picture in this regard. It is clear that there is no consensus about what the usefulness of *Urban Strategy* exactly involves, although learning about the object, better informed outcome and communication were mentioned a couple of times. Interpreted a little differently, it can be argued that about half of the users indicated that usefulness is related to substance (learning about the object, more informed outcome), and the other half related it to process characteristics (communication, collaboration, efficiency).

When asked in the group interview about the extent to which *Urban Strategy* is useful for their daily practice, the participants acknowledged the potential of *Urban Strategy*, but argued that a high level of usefulness could be achieved when the tool is used selectively. More precisely, it was indicated that its analytic support capabilities are particularly useful at specific stages of the planning process (i.e. at a much earlier stage) and for specific planning issues (in particular with a complex interaction of car traffic and environmental concerns).

Moreover, the two observing researchers pointed out that not all the practitioners experienced the same kind of usefulness; it can be questioned for whom the PSS is useful. A case in point is that during the workshop, the project manager was rather dominant and posed most of the questions that resulted in calculations by *Urban Strategy*. Hence, whereas the project manager indicated afterwards that he got most of the answers he was looking for, this is less likely the case for all the other participants, because they were less able to get the answers from *Urban Strategy* that they wanted.

5. Discussion

This section discusses the extent to which the conceptual framework as outlined in Section 2 is helpful for PSS studies, reflects on the notion that tool involvement increases the usefulness of PSS and introduces a critical additional variable: context.

5.1. Reflections on the conceptual framework

In general, the case study shows that the conceptual framework outlined in Section 2 has potential, but also points at issues that need further development. Whereas the distinction between usability and utility is helpful in principle, some overlap between the two concepts (e.g. communicative value as a usability indicator and communicative support capabilities as part of utility) emerged in the empirical analysis. With regard to utility, this paper made the various planning tasks and the related planning support capabilities explicit, which is helpful in evaluating the usefulness of PSS. For instance, the

[5] The participants were only allowed to select one kind of usefulness. However, one respondent misinterpreted the questionnaire and selected three options. Because each perception is important with an n of 9, this respondent's responses were included in the findings, and the three options were each weighed for one third. The findings are therefore given in percentages. Moreover, other measurements for usefulness were also made using Likert scales, but Cronbach's alpha (the association between scores on the three Likert items in the questionnaire) was too low to derive meaningful findings and these are thus left out of the paper.

insight that a PSS can implicitly have a negative communicative effect on a selection task would be relevant to further explore in future research. Moreover, the questionnaire indicated that the participants had varying opinions about the usefulness of *Urban Strategy*, which could be partly explained by their different backgrounds. The aim of the *Urban Strategy* was not very precisely delineated beforehand, making it hard to compare this with the perceptions of users. This could be addressed more explicitly in future research.

Although the conceptual framework helped to understand these issues, some issues remain. Notably, the user's background is key in understanding the perceived usefulness of a support tool. Vonk (2006) calls this the technology–user fit. The fact that the utility (task–technology fit) of *Urban Strategy* was sometimes problematic is also related to the fact that for most users these kinds of selection tasks were both new and rather complex. Hence, when evaluating the support function of a PSS, users' experience of a task and the complexity of the task itself should also be taken into consideration, since this might be an important confounding variable (Zigurs and Buckland, 1998).

5.2. Tool involvement

It is important to note that most of the participants were not involved in the development of *Urban Strategy*. The main reason was that there was not much for the users to choose, as *Urban Strategy* is based on fixed models representing legal environmental norms in the Netherlands. To a certain extent, the lack of involvement in the development of *Urban Strategy* limited the understanding of the functioning of the underlying models, and hence the usefulness dimension of learning about the object (cf. Brömmelstroet, 2010). At several moments during the workshop, participants were not sure how to interpret the outcomes of the model runs. This could explain why 'learning about the object' was mentioned in the questionnaire, but was not emphasized during the group evaluation. More involvement in tool development could lead to more learning. Moreover, some of the frictions with utility could have been prevented had the users been more involved. For instance, *Urban Strategy* produced results that were already known by the group or was not able to address all relevant issues. Earlier involvement could have prevented this by focusing on analyses that would better fit the selection task.

Nonetheless, most of the participants did seem to trust the outcomes of *Urban Strategy*. This is probably because the municipality's environmental and traffic modellers (their immediate colleagues) were closely involved in preparing *Urban Strategy* for the session. Hence, there was a sense of ownership related to the outcomes the models produced, which had a positive influence on the usability scores of *Urban Strategy*. Although the tool was not considered to be very transparent, the participants indicated that they nevertheless trusted the findings. This can be considered a kind of indirect tool involvement, which can improve usefulness. Hence, with some caution it can be argued that the role of involvement is dependent on the intended usefulness. If efficiency is the primary usefulness aim, a relatively light form of tool involvement will suffice (e.g. having trustworthy colleagues involved). However, if the primary aim is to learn about the object, a much stronger involvement in setting the parameters and underlying models might be needed (e.g. a 'structured dialogue' in which the model is developed; see Brömmelstroet, 2010). A caveat here is that the workshop was held in the Netherlands, where civil servants trust their colleagues – a situation that is not necessarily transferrable to other countries. This brings us to the next section.

5.3. The importance of context

In addition to the Dutch context mentioned above, several unexpected and context-dependent factors played out in the case study, such as existing organizational hierarchies and the timing of the policy process, which was already further ahead. This underlines a point made by Geertman (2006), who argued that when addressing the role of planning support, contextual variables, such as the planning issue, the users and the phase in the planning process, should be taken into account. The workshop made clear that while Nielsen's (1993) framework is a good analytic starting point, it should be complemented by contextual variables, which describe the real-world situation of planning practice.

The best way to understand usefulness is to integrate the frameworks of Geertman (2006) and Nielsen (1993). One of the main premises of such a combined framework is that precise yet generic causal descriptions are difficult, because each PSS application is unique and therefore generates its own dynamics during application. A notable lesson from the last decade is that PSS have to be developed in close cooperation with users and connect to existing practices. Although the findings from the workshop underline the need for researchers to be aware of contextual variables, it seems almost impossible to capture all of these in a deterministic conceptual model. Nonetheless, three illustrative examples with regard to the influence of context deserve attention in future PSS applications.

First, the importance of hierarchical structures and power relations. It is increasingly common in PSS studies to do research-driven pilot studies and/or experiments with students. The benefit of these laboratory-like settings is that they enable control and hence a precise assessment of the causal relationships at work (te Brömmelstroet, 2015). This case study revealed, however, the importance of power relations related to organizational structures, which are less likely to be found in pilot-like settings. For example, the area manager was rather dominant in the usage of the PSS, giving him a user experience that was very different from that of the other stakeholders and influencing the group dynamics.

Second, and related to this point, is the importance of users from different disciplinary backgrounds. The characteristics of users (disciplinary background, existing habits, etc.) influence how the role of a PSS is perceived. Hence, the application of a PSS should always cater for the users. For instance, *Urban Strategy* could be applied without a lot of explanation and interpretation in a transport planning and environmental analysis setting, because the participants will be aware of the underlying models. However, studies in an urban design setting showed that the tool should be applied less intensively and that the steps taken should be explained so that all the participants understand what is going on (Pelzer and Geertman, 2014). It is also crucial to be aware of the users' existing habits. This is something that has been emphasized at length in earlier studies about technology acceptance (Davis, 1989; Vonk, 2006).

A third and final example concerns the timing of the PSS application. The case study revealed that the usefulness is closely related to the stage of the planning process. The workshop would have been more useful in terms of learning effects for the stakeholders had it taken place at a much later stage of the planning process. In a different vein, it could also lead to efficiency gains at a later stage, for instance when a limited set of proposed interventions have to be quickly compared on their effect on traffic and the environment.

6. Concluding remarks and future research

6.1. Conclusions

The aim of this paper was to develop a better understanding of the usefulness of PSS. The focus on planning tasks as applied in this paper enables researchers to go beyond users' perceptions of the potential of a support tool, and to analyse how a PSS functions in specific parts of the planning and policy process. Whereas usability can be a necessary condition to achieve usefulness, it is never a sufficient condition. A PSS can be extremely user-friendly and transparent, but if it does not connect to the planning tasks at hand, it is not useful at all. With regard to these tasks, the categorization in terms of selection and generation tasks is perhaps too simple and crude. It might be necessary to distinguish more tasks, for instance 'negotiation tasks' and 'fuzzy tasks' (cf. MacEachren and Brewer, 2004; Pelzer et al., 2015c; Zigurs and Buckland, 1998). Because this paper studied only one case, the number of tasks was limited to two.

Moreover, the task–technology fit approach enables the negative effects of applying a PSS to be discerned. For instance, support tools can be analytically robust, but a lack of communicative support capabilities can disturb tasks, because the social interaction is limited. Studies into the performance, effectiveness or added value of support usually focus not on this issue, but on the underutilized potential of instruments. Since support technology is now increasingly available, it is even more critical to also be aware of the potentially negative effect PSS can have on planning tasks.

In addition, this study led to insights into the role of tool involvement, which could be studied in more depth in future research. It can be hypothesized that for the usefulness category of learning, users have to be involved in the tool development (see also Brömmelstroet, 2010). However, for other usefulness categories, like efficiency, it might suffice if trusted colleagues are involved in the tool development. While this might not lead to the full utilization of the potential of the PSS, it will save the involved stakeholders a lot of time. This implies that participants should be involved in the development of the tool only when learning is a central aim of the PSS application. In other words: be selective with tool involvement.

The notion of selectivity can be applied more generally to the usefulness of PSS. One should apply a PSS only when it is likely to achieve a usefulness that is worthwhile. Whether the latter is the case is dependent on a range of contextual variables: the background of the users, the stage of the planning process, the kind of problem, etc. (see Geertman, 2006). Context influences both the extent to which a PSS is useful and the kind of usefulness that is achieved. For instance, at an early stage of a policy process learning about the object might be the prime usefulness (cf. Brömmelstroet, 2010; Goodspeed, 2013), whereas at a later stage efficiency might be more important.

6.2. Future research

Future research could address these topics more systematically. The rigour with which support tools are developed should also be applied to the measurement of their usefulness. If a PSS is repeatedly applied and studied through questionnaires, the resulting higher n would enable more advanced statistical analysis. However, in many cases each application is unique and the context is hard to take into account statistically. In this regard, applying mixed methods, as was done in this study, in order to achieve triangulation might be a way forward. A notable insight from this study is that these mixed methods should not only focus on the perception of users, but also try to analyse what actually happens (i.e. revealed behaviour). Video observation or observation by researchers are helpful for this purpose. Here, practical limitations should obviously be taken into account. Many PSS studies can be characterized as experiential: the researcher is involved in the development of the tool and attempts to improve it (Straatemeier et al., 2010). Such a research approach makes it difficult to rigorously control the causal relationships under study, because the variables are continuously modified. The challenge for the researcher is to be involved in the process, but at the same time to maintain sufficient distance to study what happens as objectively as possible.

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