Investigating Usability of Planning Support Systems and Improving their Adoption and Use by Land Use Planners

Patrizia Russo

Faculty of Architecture Building and Planning
The University of Melbourne, Victoria 3010, Australia

p.russo@student.unimelb.edu.au

Abstract. Planning Support Systems are (PSS) are software tools developed for assisting planning professionals. Despite the potential attributed to these tools in supporting planning processes, their adoption and use in planning practice is rather low. One major reason for this is their low usability. This paper presents the motivation, objectives, approach and current status of a PhD research that aims to support developers and researchers with strategies for improving PSS usability.

Keywords: Planning Support Systems, usability, user experience, land use planning, evaluation

1 Research Problem

Planning Support Systems (PSS) refer to a set of tools that incorporate different functionalities such as spatial analysis, modelling and visualisation, and that are designed to support planning professionals in dealing with the complex nature of planning tasks. Much potential is attributed to these tools [1]. However, both literature and field experts indicate that their adoption in planning practice is very limited so far [2]. This is remarkable, considering the extensive and wide range of available PSS and therefore the resources put into their development.

Currently, other computer-based tools, not primarily dedicated to assist planning professionals, are more commonly used in planning practice than PSS. These are, for example, Geographic Information Systems (GIS), Computer Aided Drafting (CAD) software, and sketching and visualisation tools [3]. In principle, planning professionals are supportive of the idea of more assistance through specialised software. However, past research [e.g. 4] showed low adoption and use of PSS to be a phenomenon shared at least among industrialised countries.

Research argues that PSS use could assist land use planners in their decision-

Proc. of CHItaly 2015 Doctoral Consortium, Rome (Italy), September 28th 2015 (published at http://ceur-ws.org).

making process by providing a more systematic and evidence-based approach to planning problems [5]. In fact, planning, specifically of land use, is regarded as a complex field of public policy [6]. Its aim to coordinate land use effectively and sustainably is a challenging task considering that it has to reconcile requirements related to current trends, future developments (e.g. population growth, economy), community needs and the environment. Decisions made by land use planning have significant long term impact on the development of built and natural environments which form the basis for achieving overarching principles such as social and environmental well-being [7].

To date, research has identified the factors that hamper the adoption and use of PSS. Factors can involve instrumental, human, organisational and institutional characteristics. One of the most important factors has been identified in the low usability of PSS [2, 4].

In particular, PSS have been stated to be "far too generic, complex, inflexible, incompatible with most planning tasks, oriented towards technology rather than problems, and too focused on strict rationality" [8]. Experts of the field argue that in-depth research on PSS usability is required. Especially, evaluating and improving PSS usability has been considered a priority in recent research [9]. [10] reported that most PSS are not subjected to well-considered design processes and evaluations. Our experience indicates that PSS design does not sufficiently take into account the user interface, which is the most important component from the point of view of users. User-centred design and usability evaluation of PSS are rather rare (e.g. [11]). During design and development of PSS, very little attention has been devoted to user-oriented aspects that might improve the overall experience of planning professionals, such as the effectiveness and efficiency of the interaction with such systems and the user engagement and satisfaction. Instead, PSS development has been very much technology-oriented [1]. Few studies for evaluating PSS usability have been performed, possibly because developers do not regard it as their task and have not so far been stimulated to conduct them. [12] suggested rigorously conducting evaluations of PSS in order to encourage developers to increasingly consider user-oriented aspects.

It is worth remarking that conducting usability evaluation requires specific skills that PSS designers usually do not possess. While there are many books and websites that describe evaluation methods, novice evaluators actually need more guidance on how to plan and perform the overall evaluation. As long as the use of PSS connotes frustration and bad experiences, it is likely the adoption and use of PSS to stay relative low.

The present thesis is dedicated to advancing the research on PSS usability and UX in the endeavour to contribute towards improving PSS adoption and use.

2 Research Aim and Questions

This thesis examines factors that influence PSS usability and consequently can have obstructive or supportive effects on the adoption and use of this software. It

Proc. of CHItaly 2015 Doctoral Consortium, Rome (Italy), September 28th 2015 (published at http://ceur-ws.org).

furthermore provides strategies and recommendations that might help developers, researchers and land use planners improve PSS usability, adoption and use. Specifically, this research aims to identify usability constraints and opportunities for the adoption and use of PSS by land use planners. To achieve this aim, the following research questions (RQ) are addressed:

(RQ 1) *What affects usability of PSS for planners?*

Influence factors of PSS usability are not only restricted on limitations of PSS technology. According to the definition in ISO 9241-210 [13] ("The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use") usability is affected by the user (e.g. education), his/her goals (what does he/she want to achieve?) and by the context in which the product is used (where and how?). Based on this, this thesis aims to identify factors that influence usability of PSS as for land use planners by looking at factors that influence adoption and use of PSS (e.g. work environment, user requirements)

(RQ 2) *What are strategies for improving the usability of PSS for planners?*

For some usability influence factors merely the awareness of the planning community can be increased. For others, strategies for improving the situation can be identified. This thesis aims to define such strategies, especially in the ambit of software design, and provide tools for improving PSS development and evaluation.

3 Theoretical Framework

The theoretical framework of this research draws on the contributions of two scholars: [14] usability problem concept and [15] innovation-decision process. In particular, this research examines the influence of usability problems on the innovation-decision process, specifically for PSS.

The usability problem concept is used for describing and reporting usability problems. In this research, it was chosen because it allows dissecting usability problems and analysing their components. In fact, it suggests breaking down usability problems into five components: cause, breakdown, outcome, design change and context (see Figure 1a). *Breakdown* refers to an inappropriate action, such as a user performing a wrong action or misunderstanding a feedback that triggers a usability problem. The severity of breakdowns can differ. *Cause* is the origin of a breakdown and of a usability problem. An example of a cause is a design fault. *Outcome* is the consequence of a breakdown. Two different types of outcomes are distinguished: user behaviour and performance. Examples of the first type are the user is dissatisfied or tries another action. Task failure and/or loss of time are examples of the performance type. *Design change* refers to modifying an aspect of the system. An example is introducing a new feature. *Context* relates to each usability problem and its components occurring in a specific context. For instance, users of different

Proc. of CHItaly 2015 Doctoral Consortium, Rome (Italy), September 28th 2015 (published at http://ceur-ws.org).

organisations might have different requirements for the design of a new feature.

The innovation-decision process describes the stages that an individual undergoes from being exposed to an innovation for the first time to deciding whether to continue to use or rejecting the innovation (see Figure 1b). Five stages are distinguished in this process: I) knowledge, i.e. the individual is made aware of the existence of the innovation and gains an understanding of its functionality, II) persuasion, i.e. the individual forms a positive or negative attitude towards the innovation, III) decision, i.e. the individual makes a decision whether he/she considers adopting or rejecting the innovation, IV) implementation, i.e. the individual starts using the innovation with some uncertainty and V) confirmation, i.e. the individual decides whether to continue to use or reject the innovation. The number of individuals who adopt an innovation in a specified period of time is given by the rate of adoption. Various factors influence the rate of adoption, such as communication channels or the nature of the social system. However, it has been recognised that from 49 to 87 percent of variance in rate of adoption can be explained by five attributes of innovations. These are relative advantage, compatibility, complexity, trialability and observability. Compatibility has been defined as the "degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters" [15:224]. Evidence suggests that the higher the compatibility of the innovation, the higher the rate of adoption.

This process was chosen because it allows examining the potential adoption process of an innovation from the perspective of potential users without necessarily taking into account, for example, organisational factors as suggested by other theories (e.g. Technology Organisation Environment Framework).

This research examines the influence of usability problems on the innovation-decision process, specifically for PSS. By doing this, it assumes that usability problems (breakdowns) occur when potential adopters use PSS, i.e. during the knowledge and implementation stage, and it rather ignores that potential adopters might have positive experiences. Furthermore, this research does not take into account that other factors than usability, such as of organisational and social nature, might affect the innovation-decision process, specifically for PSS.

While breakdowns occur in the knowledge and implementation stage, this research suggests that the other components of usability problems, i.e. the causes, outcomes and possible design changes, influence potential adopters in the persuasion, decision and implementation stage. For instance, in the persuasion stage, potential adopters form their attitude towards the innovation and perceive the degree of the innovation's compatibility based on the experience (outcome) they had during the knowledge stage. Furthermore, this research expects that planning professionals' decisions whether to adopt and use a specific PSS can be both, negatively and positively influenced by, for example, a negative outcome (e.g. dissatisfaction of potential adopter) and a design change (e.g., improved information presentation), respectively.

While the innovation-decision process claims compatibility to directly affect the rate of adoption, this research assumes that the lack of compatibility of PSS with planning professionals' needs, to be a major cause for the occurrence of usability problems. Indeed, this research supposes the rate of adoption of PSS to be low because of the occurrence of usability problems.

Proc. of CHItaly 2015 Doctoral Consortium, Rome (Italy), September 28th 2015 (published at http://ceur-ws.org).

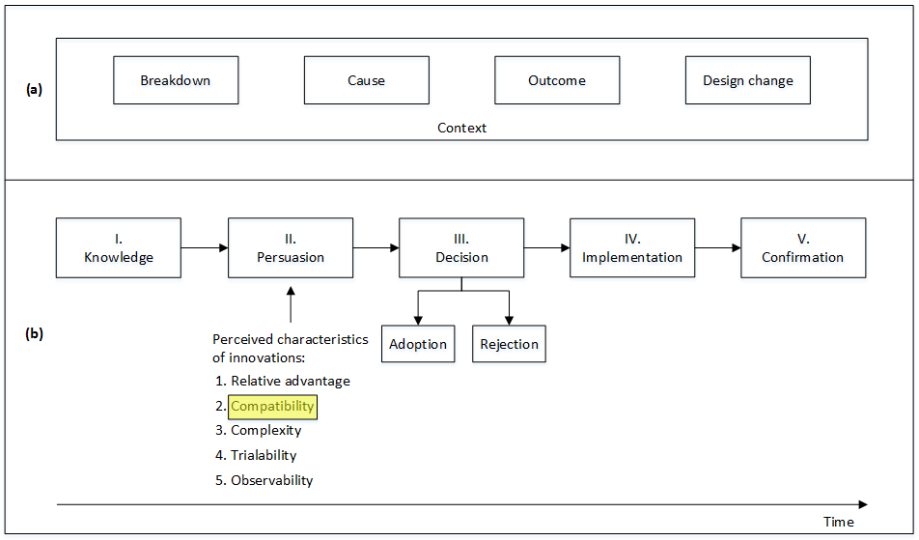

Fig. 1. Usability problem components [14] (a) and the innovation-decision process simplified [15] (b).

4 Research Approach, Current State and Next Steps

Three activities were undertaken to identify factors that influence PSS usability for land use planners, these are a literature review, interviews and a user test (see Figure 2).

A literature review has been performed to understand the state-of-the-art in PSS use and usability and what are potential reasons for low usability of PSS from the perspective of experts in the field. From the literature review it mainly emerged that user-centred design and usability evaluation of PSS are rather rare. Thus, poor fit of PSS to user requirements was reported.

To support PSS developers intended to perform usability evaluations, a framework, called PSS_EvalF (short for PSS Evaluation Framework), has been developed in collaboration with usability experts that provide the necessary guidance for non-expert evaluators on how to plan and carry out evaluations.

Interviews with academic experts in the field of planning have been conducted in Australia and Switzerland to understand what planning students are taught at different educational institutions in relation to learning how to use PSS.

Interviews have been carried out with planning professionals to understand what software is used in planning organisations, what this is influenced by (including educational background of planning professionals) and what the context of use is. The interviewees worked for different planning organisations (i.e. private and government) in Australia and Switzerland to examine potential differences.

An online resource (http://docs.aurin.org.au/projects/planning-support-systems/) that comprises PSS developed and/or applied in Australia and internationally, as well as some information on their functionality and use requirements has been created.

Proc. of CHItaly 2015 Doctoral Consortium, Rome (Italy), September 28th 2015 (published at http://ceur-ws.org).

A user test following PSS_EvalF has been carried out with a small group of land use planners working in Australia to evaluate three PSS that perform Land Suitability Analysis (LSA) tasks. The three PSS have been selected based on the PSS in the online resource. The user test allowed identifying usability problems and usable characteristics of the three PSS as well as planners' mental models and requirements. Based on this outcome, recommendations for designing more usable PSS were defined. Furthermore, lessons learned from conducting the user test allowed refining PSS_EvalF.

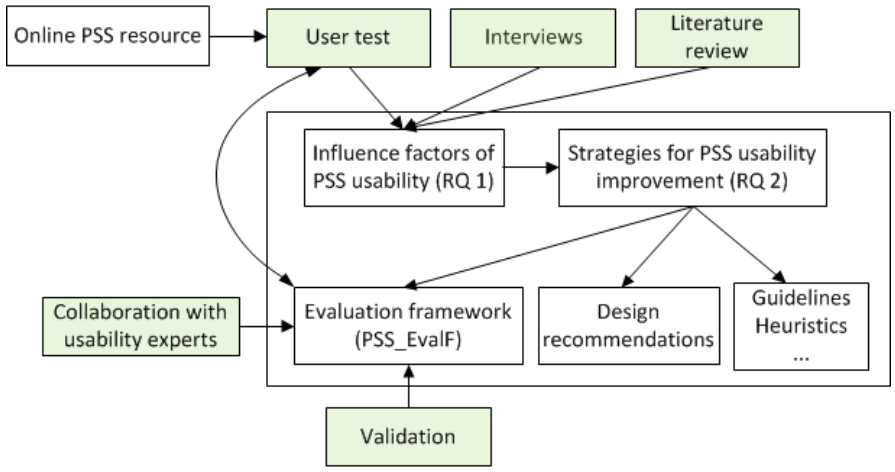

Fig. 2. Research approach

Next steps of the research are:

i) validating PSS_EvalF through its adoption by potential users, i.e. developers, for PSS evaluation.
ii) about drawing conclusions from the knowledge gained through the activities undertaken. Through converging the outcomes of the interviews and user test, it is aimed to formulate a set of guidelines for improving PSS usability and/or heuristics for facilitating the design and evaluation of PSS.

5 Preliminary Results

As stated above, the results of this thesis will be a series of strategies that if implemented, potentially improve the usability of PSS for land use planners. Two strategies are presented as follow.

5.1 PSS_EvalF: a usability evaluation framework

PSS_EvalF represents a framework providing guidance on performing usability and UX evaluation that has been developed specialised for the evaluation of PSS. Inspired by a more general evaluation framework provided in [16], PSS_EvalF is

Proc. of CHItaly 2015 Doctoral Consortium, Rome (Italy), September 28th 2015 (published at http://ceur-ws.org).

composed of six activities which are briefly documented in the following. A more complete version can be found in [17].

1. Determine the evaluation goals

To clarify what is the scope of the evaluation and what should be achieved once the evaluation is carried out, evaluation goals are defined as a first activity. Typical goals of PSS evaluation might be:

- Assess the ease of use of a PSS for its adoption by planning professionals
- Compare the functionality and usability of multiple PSS
- Identify design suggestions for the next version of a PSS

2. Explore the questions

As a second activity, more specific questions that underpin the goals and should be answered through the evaluation, are formulated. A question can be "is the PSS usable?" and furthermore "is the user interface easy to navigate? Is the terminology confusing because it is inconsistent? Is the feedback provided to users sufficient? Is the response time too slow?".

3. Choose the evaluation and data collection methods

PSS_EvalF proposes inspection and/or user-based methods and illustrates their advantages and disadvantages in order to facilitate the choice. Among user-based methods, PSS_EvalF suggests using:

- thinking-aloud technique,
- questionnaire and interview for assessing user satisfaction and other hedonic qualities of UX,
- video and screen recording for complex tests and for reviewing participant's interaction and behaviour if something is unclear, and
- measures of user performance.

4. Identify the practical issues

Many practical issues have to be considered when conducting an evaluation. For example, before beginning with an inspection, it should be ensured that all evaluators i) use the same inspection criteria, ii) have the same understanding of the criteria and iii) apply them in the same way. Novice evaluators might consider using Nielsen's heuristics [18]. After the inspection, the evaluators should compare and discuss the results.

In user-based methods, the following issues have to be addressed:

- Choice of the participants
- Choice of the experimental design (between- or within-subjects design)
- Choice of the task(s)
- Choice of the facilities and equipment.

5. Decide how to deal with the ethical issues

This activity informs evaluators about the ethical issues involved in user-based methods. PSS_EvalF provides an example of a consent form and a plain language

Proc. of CHItaly 2015 Doctoral Consortium, Rome (Italy), September 28th 2015 (published at http://ceur-ws.org).

statement.

6. Evaluate, analyse, interpret and present the data

Before actually running the evaluation, decisions have to be made about how data are analysed and presented. PSS_EvalF refers to books [16] that address these issues and highlights possibilities for demonstrating data quality, analysing and presenting data.

5.2 Recommendations for designing PSS

The following recommendations emerged from the user test and are intended to support developers in designing more usable PSS:

- Layout, colours and fonts for the presentation of data, legend and items have to be carefully chosen to make it easier to understand for the user.
- The terminology used in PSS should be close to the one used by planners and in the regions and countries where the PSS are applied.
- PSS should allow users to seek visual information in a way that is effective, e.g. by following Shneiderman's [19] mantra.
- A map display should be provided during the whole work process.
- Provide the possibility to display a boundary around the case study area for improving the distinction from surrounding area.
- PSS should include functionality required by planners. Planners' requirements might also differ depending on the regions and countries in which they work.
- Features and techniques that provide improved guidance such as greying out items to make them not selectable or 'back' and 'next' buttons should be more widely considered.
- Visualisation techniques such as moving over or brushing should be more widely used in PSS where suitable.
- PSS should provide outputs in other formats, e.g. PDF or spreadsheet as well as their export.
- The speed of PSS operations, through the selection of appropriate methods and technology optimisation, should be maximised.
- Help documentation, including examples and short demo of system use, should be available.

6 Contributions

This thesis advances the research on PSS usability and UX in that, to our knowledge, it represents a first work that puts the emphasis on usability by relying on current body of knowledge in usability and therefore providing a solid basis for further work.

As a novel contribution, this research developed a framework for performing usability and UX evaluation of PSS, called PSS_EvalF. By providing people with little expertise on conducting usability evaluations with six activities specialised for the

Proc. of CHItaly 2015 Doctoral Consortium, Rome (Italy), September 28th 2015 (published at http://ceur-ws.org).

evaluation of PSS usability, it aims to improve evaluations and usability of PSS.

A user test allowed identifying usable characteristics and design recommendations for both, PSS that address LSA and PSS in general. This contributes to increasing developers' awareness and understanding of what are planning professionals' needs and expectations. Only by knowing these, PSS that consider user-oriented aspects, are more usable and capable of supporting good user experiences, can be developed.

An insight into the state-of-the-art of PSS adoption has been provided. Differences in the working context, software use and requirements of planning professionals working for different planning organisations (i.e. private and government) in Australia and Switzerland have been identified.

An insight into the state-of-the-art of planning students' education of PSS use has been provided. This insight has emphasised the controversy between researchers stressing the low use of PSS in planning practice and the limited provision of GIS and PSS courses for planning students and limited encouragement to attend such courses at educational institutions.

Another contribution has been the development of an online resource that lists a large set of PSS developed around the world. Where available, information in relation to technical specifications, analysis functionality, use requirements and user assistance of the PSS has been provided. This information supports planning professionals in choosing appropriate PSS, improving PSS application as well as raising the planning communities' awareness of PSS availability and potential.

7 Acknowledgments

I would like to thank my supervisors, C. Pettit, M. F. Costabile and R. Lanzilotti, for the support and guidance provided in this research.

References

1. Vonk G, Geertman S (2008) Improving the Adoption and Use of Planning Support Systems in Practice. Applied Spatial Analysis Policy 1:153–173.

2. Te Brömmelstroet M (2010) Equip the Warrior instead of Manning the Equipment: Land Use and Transport Planning Support in the Netherlands. Journal of Transport and Land Use 3:1–17.

3. Zeile P, Farnoudi F, Streich B (2007) Landscape Design. Fascination Google Earth–Use in Urban Landscape Design

4. Vonk G, Geertman S, Schot P (2005) Bottlenecks blocking widespread usage of planning support systems. Environ Plan A 37:909–924.

5. Geertman S, Stillwell J (2009) Planning Support Systems : Content , Issues and Trends. In: Geertman S, Stillwell J (eds) Planning Support Systems Best Practices and New Methods. Springer Science+Business, pp 1–26.

6. Biermann S (2011) Planning Support Systems in a Multi-Dualistic Spatial Planning Context. Journal of Urban Technologies 18:5–37.

7. Gurran N (2007) Australian urban land use planning: Introducing statutory planning practice in New South Wales. Sydney University Press

8. Batty M (2003) Agents, Cells and Cities: New Representational Models for Simulating Multi-scale Urban Dynamics.

9. Pelizaro C, Arentze T, Timmermans H (2009) GRAS : A Spatial Decision Support System for Green Space Planning. 191–208.

10. Geertman S, Stillwell J (2003) Planning Support Systems in Practice. Springer, Berlin

11. Arciniegas G, Janssen R, Rietveld P (2013) Effectiveness of collaborative map-based decision support tools: Results of an experiment. Environmental Modelling Software 39:159–175.

12. Allen E (2008) Clicking toward better outcomes: Experience with INDEX. In: Brail RK (ed) Planning Support Systems cities, Regional Lincoln Institute of Land Policy, Cambridge, Massachusetts, pp 139–166.

13. 9241 I (2010) ISO/IEC 9241-210: Ergonomics of human-system interaction - Part 210: Human-centred design for interactive systems.

14. Lavery D, Cockton G, Atkinson MP (1997) Comparison of evaluation methods using structured usability problem reports. Behavioural Information Technologies 16:246–266.

15. Rogers E (1995) Diffusion Of Innovations. Simon and Schuster

16. Rogers Y, Sharp H, Preece J (2011) Interaction design: beyond human-computer. John Wiley & Sons Ltd, West Sussex

17. Russo P, Costabile MF, Lanzilotti R, Pettit CJ Usability of Planning Support Systems: an evaluation framework. CUPUM 2015, 14th Int. Conference Computers Urban Planning Urban Management July 7-10, 2015, Cambridge, Massachusetts, USA. print.

18. Nielsen J (1993) Usability Engineering. Academic Press, Boston

19. Shneiderman B (1996) The Eyes Have It: A Task by Data Type Taxonomy for Information Visualizations. In: Proceedings., IEEE Symp. Vis. Lang. pp 336–343.