Environmental Modelling & Software 94 (2017) 63–72

Contents lists available at ScienceDirect

Environmental Modelling & Software

journal homepage: www.elsevier.com/locate/envsoft

Realizing modelling outcomes: A synthesis of success factors and their use in a retrospective analysis of 15 Australian water resource projects

W.S. Merritt [a, *], B. Fu [a], J.L. Ticehurst [a], S. El Sawah [b], O. Vigiak [c, d], A.M. Roberts [e], F. Dyer [f], C.A. Pollino [g], J.H.A. Guillaume [h], B.F.W. Croke [a], A.J. Jakeman [a]

[a] Fenner School of Environment and Society, Australian National University, Canberra ACT 2601, Australia
[b] School of Engineering and Information Technology, University of New South Wales, Canberra 2610, Australia
[c] European Commission, Joint Research Centre, Directorate D - Sustainable Resources, Ispra, VA, Italy
[d] Ludwig-Maximilians-Universitaet Muenchen, Department of Geography, Munich, Germany
[e] Natural Decisions Pty Ltd, PO Box 123, Newstead Victoria, 3462, Australia
[f] Institute for Applied Ecology, University of Canberra, Canberra, ACT, Australia
[g] CSIRO Land and Water, Canberra, ACT 2601, Australia
[h] Water and Development Research Group, Aalto University, Finland

ARTICLE INFO

Article history:
Received 21 March 2017
Accepted 22 March 2017

Keywords:
Decision support
Evaluation
Water resources
Stakeholders
Social learning
Integrated modelling

ABSTRACT

We review several papers that have afforded insights into determinants of positive outcomes (e.g. the adoption of tools, improved learning and/or collaboration) from modelling projects. From a subsequent internet search in the environmental domain we identified 33 such factors that are then invoked in a transferable survey-based method to facilitate structured reflections by model developers on 15 projects. Four factors were considered most necessary to realize overall success for any modelling project. Three factors related to aspects of stakeholder engagement in the modelling process; the other to critical thinking around problem framing and the role(s) of models. The latter factor was considered reasonably well-achieved across the projects. Harder to control were the stakeholder engagement factors which, along with project management considerations, can constrain or enable achievement of other factors. The paper provides further evidence of the critical need to consider non-technical aspects in the design and implementation of modelling projects.

1. Introduction

Effective environmental management can be enhanced with a comprehensive, evidence-based understanding of how complex interactions within the socio-ecological system in question may play out under different settings and policy conditions. Modelling can play a central role in building this understanding and supporting different aspects of management and policy design (Black et al., 2014). Environmental modelling or Decision Support System (DSS) projects, however, often constitute a large investment of time and money, typically involving a team of modellers, software developers, and end users. Evaluation of the beneficial and negative outcomes of modelling projects is therefore critical given this substantial investment.

Furthermore, with what is now a long history of environmental modelling, integrated modelling and construction of decision support tools, it has been recognised that such modelling projects can often fall short in achieving whatever outcomes were expected (e.g. Uran and Janssen, 2003; Voinov and Shugart, 2013). Often-cited reasons include a mismatch in the problem understanding or expectations of model developers and model users, a failure of developers to adequately scope required functionality with intended users, or organisational change within the target user organisation. Crucial, however, to any analysis aimed at understanding the factors influencing successful outcomes of a project is a characterisation of what success entails.

McIntosh et al. (2008) pointed out that success is often informally assessed based on whether the tool was used for the purpose that the developer intended. McIntosh et al. critique this, noting that the implication is that a tool was not a success if it was not applied to solve the target problem. In this paper we consider success to be either the accomplishment of a specified aim or

* Corresponding author.
E-mail address: wendy.merritt@anu.edu.au (W.S. Merritt).

http://dx.doi.org/10.1016/j.envsoft.2017.03.021
1364-8152/

purpose (e.g. use of the tool to negotiate aspects of a plan) or an improved learning or collaboration at any of the four levels given by Huz et al. (1997): individual (e.g. positive reaction), group (e.g. increased quality of communication), organisational (e.g. performance improvement), and method (e.g. further use). This broader interpretation reflects in part that integrated environmental models and DSS are developed for a range of purposes including prediction (Guillaume et al., 2015; Robson and Dourdet, 2015), exploration of alternate options through scenario definition and analysis (Liu et al., 2008; Maier et al., 2016), optimisation (Szemis et al., 2014; Tsoukalas and Makropoulos, 2015), or development of system understanding or social learning (El Sawah et al., 2015; Giordano et al., 2007; Lund and Palmer, 1997; Van der Wal et al., 2016; Videira et al., 2009). Often these models are not intended or designed for use on a routine or regular basis by individuals or organisations. In such cases a narrow definition of success will understate the potential benefits gained from a modelling project, for example, individual or group learnings, or enhanced collaborations and networks gained during the development process. Alternatively the intended routine use may not be achieved but the latter measures of success might be realized.

In the next section we provide a brief overview of methodological approaches used in the environmental modelling, operations research and information systems fields to draw insight into the determinants of project success. We then present a synthesis of factors influencing success of environmental modelling projects. The 33 factors identified form the basis of a structured reflection of 15 water resource modelling projects, for which the survey design and evaluation methods are presented in Section 3. The results in Section 4 rank the general importance of the 33 success factors before relating achievement (or not) of the factors to the respondents' views on the client and research outcomes of the 15 projects. Key results are discussed in Section 5, drawing on any identified barriers and enablers to realizing each factor and relating findings back to the modelling literature.

2. Determinants of successful modelling projects

2.1. Overview of methodological approaches to identifying 'success' factors

In the fields of integrated assessment and environmental modelling, several collaborative papers have looked at what had been developed in the past, trying to gain insight into why different model-based tools had, or had not been used, and to derive lessons on key modelling challenges and best model practices (e.g. McIntosh et al., 2011; McIntosh et al., 2008). Other papers have provided in-depth insight into particular case studies or modelling tools (El Sawah et al., 2015; Liu et al., 2008; Maciag and Hepting, 2008; Poch et al., 2004; Ticehurst, 2008; Uran and Janssen, 2003; Welp, 2001). These case study papers are often retrospective and reflective, although formal elicitation processes and workshops have been used to evaluate outcomes and seek feedback from participants throughout the life of a project (Giupponi, 2007; Inman et al., 2011; Matthews et al., 2011). Evaluation approaches have included elicitation from model developers or users using formal structured interviews (Giupponi, 2007; Matthews et al., 2011; Robinson and Pidd, 1998), group discussions including facilitated workshops (Matthews et al., 2011; Sieber et al., 2013), and technical evaluations of (for example) functionality and usability of modelling tools (Uran and Janssen, 2003).

Outside the environmental field, there are valuable studies that have comprehensively assessed factors influencing the failure and success of modelling projects. Tilanus (1985) reviewed 58 different cases across a range of project types (e.g. client-oriented, operational-oriented) and sectors (e.g. agriculture, manufacturing, education). The authors interpreted written reports that they had elicited from sector representatives where they self-evaluated the reasons for success and failure for various projects in which they had been involved. Robinson and Pidd (1998) conducted formal interviews with 20 modellers and customers to explore the varied measures of success and how the level of success can vary throughout a project. Monks et al. (2014) undertook an experimental study to examine the effects of different degrees of stakeholder involvement on the learning outcomes and perceived credibility of the modelling process. To gain insights for the environmental field, Díez and McIntosh (2009) reviewed the non-environment information systems (IS) literature to characterise organisational outcomes of nine IS life cycle processes – design, diffusion, adoption, implementation, acceptance, use, evaluation, assessment and continued use – which they grouped into pre-implementation, implementation and post-implementation phases. The authors identified over 250 factors that could influence these processes and attempted to quantitatively assess the influence of each factor.

2.2. Synthesis of 'success' factors from environmental modelling literature

For the subsequent analyses in this paper, factors or criteria identified as important for maximising the effectiveness of environmental modelling outputs in supporting activities of policy makers and managers were identified from pertinent journal articles, conference papers, and book chapters. To do this, the Google Scholar database was invoked and searched using combinations of the keywords: "critical success factor", "success", "integrated assessment", "integrated model", and "decision support system." Those documents that related to the field of environmental modelling and that included either informal or empirical evidence about success factors were then considered. An initial list of 37 factors was identified from the environmental literature; this was subsequently reduced to 33 factors as four were considered to overlap in their interpretation with other factors. The 33 factors appear in Table 1, classed into seven groups: project management (PM; 7 factors), project actors (PA; 5 factors), stakeholder engagement (SE; 5 factors), model development (MD; 7 factors), model evaluation (ME; 1 factor), contextual factors (CF; 3 factors) and model use (MU; 3 factors).

3. Methods

This section describes the survey-based instrument used, firstly to elicit perceived relative importance of the 'success' factors from the environmental literature, and secondly to retrospectively evaluate 15 water resource modelling projects against the factors. Eleven (the authors of this paper) of the 13 people who were identified as part of the development team of these modelling projects undertook the survey with 1–5 respondents per project. Given the time that had elapsed since completion of some projects and personnel changes within some key partner organisations, it was not considered practicable to conduct an equivalent survey with clients and model users for the 15 projects.

3.1. Survey design

The survey was developed in two parts (Table 2). Part 1 collected information on the role of each respondent for all projects relevant to them. It also aimed to elicit an overall assessment by the respondents of how well research outcomes were met for each project and their perceptions on how well the expectations of