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Decision Support

An empirical investigation into the learning effects of management flight simulators: A mental models approach

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A B S T R A C T

There are many claims about the learning effects of Management Flight Simulators (MFS) as a public education and communication tool in water resource management. However, there is still lack of empirical evidence to support this claim. To address this issue, an exploratory experimental study was conducted to examine the learning effects a series of MFS had on the mental model of water users in the Australian Capital Territory (ACT). Participants' mental models of the causal relationships that influence water availability were elicited before and after interacting with a series of increasingly complex MFS, and compared to the reference model structure underpinning the MFS. Results showed that the MFS experience improved participants' causal knowledge of the model structure and generated Critical Learning Incidents. The findings are interpreted in light of the study limitations along with future research directions.

1. Introduction

An active and well-informed participation by the public is widely acknowledged as a crucial pillar and goal for sustainable management of natural resources, including water resources management (Kuruppu,and Liverman, 2011). Public participation plays a significant role in water resource management both directly through water use decisions (e.g. length and frequency of showers) and indirectly through supporting particular political views that shape public policies. Despite recognition of the public role, the challenge to bring the public on-board remains, especially when communicating the complexity of water resource issues which can overwhelm both experts and policy makers (Cockerill, 2010; Hjorth & Bagheri, 2006). The combination of systems thinking and modeling techniques has been argued to be a promising approach to improve learning and communication about complex water management issues (Stave, 2002).

The present article is part of a broader case study-based research project to develop, use, and evaluate a suite of systems thinking and dynamic modeling techniques to deliver a methodology that enables public participation through learning about present and future complex water challenges. The project uses water resources management in the Australian Capital Territory (ACT) as a case study to develop and trial the methodology, and produce learning tools. Fig. 1 shows the research methodology undertaken in the project, and locates the present article in the broader context of the project.

The previous project stages have resulted in two main outcomes on which the present article builds on. First is identifying the misperceptions and information gaps that may inhibit informed understanding and engagement in water management were identified (Elsawah, McLucas, & Mazanov, 2013). The identified mental model flaws were consistent with other findings about misperceptions in the water management literature (e.g. Stave, 2003) including:

- Simplistic and erroneous inferences about the dynamic relationships among hydro-climate variables and water availability.
- Poor understanding of the key variables that influence water use, such as the effects of population growth and environmental releases policy.
- Poor judgments about the use of various sectors (e.g. business, household).
- Poor judgments about the collective outcomes of water use behavior and effectiveness of various water efficiency measures.

The second outcome from the previous project phases is the development of a Management Flight Simulator (MFS), a System Dynamics- based interactive simulator, as a tool for learning about

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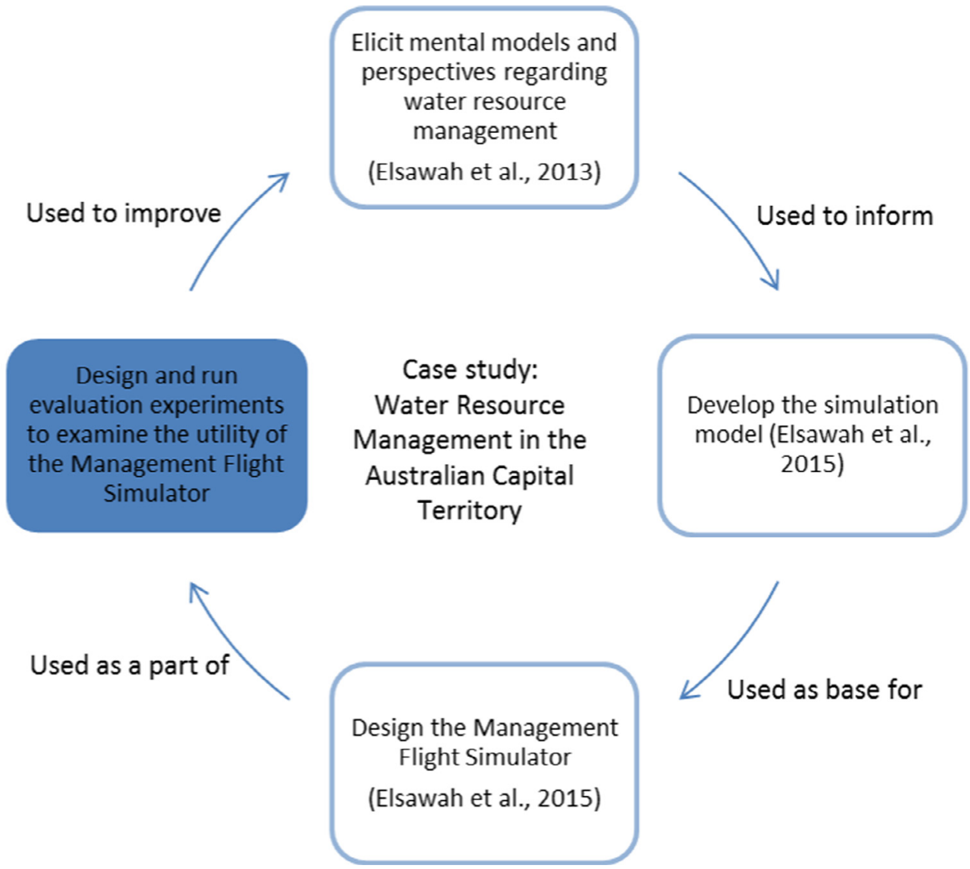

Fig. 1. The research methodology undertaken in the project and where this paper fits into the broader project context (shaded box).

the variables and complex interactions that influence water availability in the ACT (Elsawah, McLucas, & Mazanov, 2015).

There are many claims made about the learning effects arising from the use of MFS to improve decision-maker understanding of complex systems (Sterman, 2000). However, the empirical evidence on the utility of MFS, both generally and for water resource management specifically, is still limited. This knowledge gap is where the final phase of the project and the present article makes a contribution. This article examines the research question of whether the use of a sequence of progressively more dynamically complex MFS improves user understanding of the causal relationships represented in a system dynamics model of water availability in the ACT.

To address the research question, an exploratory experimental study was conducted with 10 urban water users to examine what, if any effects on learning could be attributed to their interaction with the MFS. Given the potential challenge of building domain knowledge while understanding the model's causal structure (van Borkulo, van Joolingen, Savelsbergh, & Jong, 2012), the experiment was designed around a series of simple-to-complex tasks. Each task was focused on building causal knowledge of a particular part of the model structure. A knowledge test specific to the underlying SD model was designed to collect data about the participants' mental models before and after interacting with the MFS.

Results indicated that interaction with the MFS improved the mental models of participants. That is, they developed a better understanding of the SD model underlying the MFS. Moreover, participants demonstrated some Critical Learning Incidents (Thompson, Howick, & Belton, 2016), suggesting participants' mental models underwent major shifts in understanding as they progressed through the MFS experiment.

The paper is organized as follows: in Section 2, the background of the current research is presented, and the study's objective in this context is argued. Section 3 presents the design principles and methods underpinning the research approach used in the study. The research hypothesis and approach is explained in Section 4. Section 5 presents the results and their implications, followed by the study limitations and suggestions for future research in Section 6.

2. Research background and objectives

The purpose of Section 2 is to present the research background and outline the study objective in this context, starting with the role of mental models in SD. Some of the misperceptions and flaws of mental models about water resource management are identified, followed by the case that MFS have significant potential to be a useful tool to help overcome some of these misperceptions. The Section concludes with the research objectives extending from the evidence and argument.

2.1. Mental models

Human decision making is predicated upon internal representations of the problem at hand, including the reciprocal influence of causes, effects, and how the actions of the decision-maker as well as the decisions of others' influence the problem. These internal representations have various names: mental models (Doyle & Ford, 1998), mental frames (Isendahl et al., 2009), and mental schemas (Mohammed, Klimoski, & Rentsch, 2000). The concept of