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Why pay attention to paths in the practice of environmental modelling?

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ABSTRACT

Taking the 'path perspective' helps to understand and improve the practice of environmental modelling and decision making. A path is the sequence of steps taken in a modelling project. The problem solving team faces several forks where alternative choices can be made. These choices determine the path, together with the impact of uncertainties and exogenous effects. This paper discusses phenomena that influence the problem solvers' choices at the forks. Situations are described where it can be desirable to re-direct the path or backtrack on it. Phenomena are identified that can cause the modelling project to get stuck on a poor path. The concept of a path draws attention to the interplay of behavioral phenomena and the sequential nature of modelling processes. This helps understand the overall effect of the behavioral phenomena. A path checklist is developed to help practitioners detect forks and reflect on the path of the modelling project.

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1. Introduction

This paper aims to show that the idea of paths in modelling is an important perspective for people working with model supported problem solving, planning, policy development, management, and decision making. The literature on environmental modelling has discussed *processes* and *best practices*. There is, however, a key difference compared to a *path*, which is defined as the sequence of steps taken in a problem solving case (Hämäläinen and Lahtinen, 2016). Process descriptions and best practices describe what is intended to be done, whereas a path describes what consequently actually occurs. When the term *process* is used, it does not necessarily become clear that a given process might manifest itself in different ways, which generate different paths that can lead to different outcomes (Hämäläinen et al., 2013). That is, there can be *path dependence* in modelling (Hämäläinen and Lahtinen, 2016; Lahtinen and Hämäläinen, 2016).

Reflecting on paths is particularly important in environmental modelling (Hämäläinen, 2015), where the problems are often complex, participatory, and include multiple sources of uncertainties. In such contexts we can easily end up following different paths. Taking the path perspective means awareness of the fact that the choice of the modelling path can matter. Even if we cannot assume that there is a perfect path or that we could find it, a poor path or possibilities to improve a planned path can often be identified.

The concept of path discussed here differs from the pathway concepts considered in the environmental literature. The term *adaptive policy pathway* relates to policy processes under deep uncertainties regarding the system under study (see, e.g. Haasnoot et al., 2013). Gregory et al. (1997) use the term *decision pathway* to describe possible chains of reasoning when people construct their opinions regarding an environmental policy problem.

The message and the conclusions in this paper resonate with the recently proposed socio-environmental modelling agenda by Voinov et al. (2014) that emphasizes subjectivity in the practice of modelling. Our starting point is different but consonant. It is a fact that modelers, like all people, are social, can be biased, make mistakes, and may sometimes act in self-interest.

What does a path look like? During a modelling project, the problem solving team faces several *forks* with alternative plausible and justifiable next steps or directions to be pursued. The choices and omissions made at these forks can have a strong influence on the path (see, e.g. Linkov and Burmistrov, 2003). Forks cover the

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breadth of the project; ranging from the choice of people invited to the problem solving team, to the choice of software and methods used, as well as to transferring the modelling results into practice. Sometimes the problem solvers are not aware they have passed a fork, e.g. when collecting data, or when they adopt a particular problem framing because they have always done so. Forks in the statistical analysis of data are notably discussed by Gelman and Loken (2014).

The following narratives characterize ‘ideal’ and ‘worst-case’ paths:

Ideal path: The path is formed by well-justified choices by the problem solving team with consideration given to the well-understood preferences of the stakeholders. The approaches used and procedures followed are suitable for taking into account the essential characteristics of the problem at hand. The path is navigated in a reflective mode, which can benefit from the modelers' experience in different situations. The path is reconsidered and redirected if needed, for example, due to changes in the problem environment.

Worst-case path: The path is determined by narrow-sighted problem framing and affected by hidden strategic motives. Inadequate judgment and procedures drive the analysis. Biased reasoning dominates thinking. The steps which are already taken are never reconsidered or backtracked. The problem and its environment are assumed to stay unchanged over time.

In systems terminology, a path can be described as the trajectory of the system of problem solving. Franco and Hämäläinen (2016) describe the system of modelling that consists of *actors, methods,* and *context* whose interaction forms the *praxis* leading to *modelling outcomes*. The path perspective encourages and helps consider the dynamics present in this system. For instance, sometimes backtracking is not an option so the choices made in the first steps can make certain outcomes unreachable in the sequential modelling process.

To be specific, we believe the path perspective holds promise in at least three ways:

1) The perspective helps practitioners plan and manage modelling projects more successfully. It challenges modelers to identify critical forks in their projects, and consider the options more widely at these forks. Awareness of path dependence encourages modelers to follow adaptive modelling practices (Hämäläinen and Lahtinen, 2016).
2) The term path is useful when communicating about models. It evokes the importance of modelers' choices at forks. It is useful to acknowledge that behavioral aspects and subjectivity are inherent in model-supported problem solving (see, e.g. Hämäläinen et al., 2013; Voinov et al., 2014). When interpreting modelling outcomes, the path metaphor is a reminder that other paths could also have been followed. The implementation of a set of best practice procedures depends on the people involved – the best possible result is not necessarily guaranteed.
3) The concept of a path offers a systemic and integrative perspective, which helps to understand the overall effect of behavioral phenomena as well as cognitive and motivational biases in modelling. These phenomena do not occur only at isolated steps – they take place within the sequence of interrelated steps over the whole modelling project.

Fig. 1 introduces the path framework used in this paper with a mountain hiking related metaphor. It highlights phenomena and recommendations discussed in the following sections, regarding choices at forks (Sections 2 and 3), redirecting the path (Sections 4 and 5), getting stuck on a poor path (Sections 6 and 7), along with the factors involved in each case. In Section 8, the path related phenomena are placed within the framework (Table 1) and a checklist is provided (Table 2).

2. Phenomena that influence choices at forks

The choices at forks together with exogenous impacts determine the path followed in a modelling project. This section discusses phenomena influencing these choices. These phenomena can: affect the evaluation of alternative courses of action, cause the problem solving team to find or overlook an alternative, or cause the team to miss the opportunity to make a choice altogether.

Focused thinking refers to deliberately directing one's thinking, e.g. by the choice of focal issues, or by intentionally taking a certain perspective. A broad scope is needed in policy problems, where the goal is to provide transparent policy recommendations. Ideally, such recommendations are based on a comprehensive analysis of the problem, but in turn depend on focused tasks concerning, for example, stakeholder engagement, technical feasibility, or analysis of risks. Framing can also reveal synergies. For instance, McCollum et al. (2013) show that it is less expensive to address global problems related to energy, air-pollution, and global warming as a whole rather than separately solving each of the problems. Following a path determined by a narrow scope can be justified in other circumstances, such as when the goal is to generate specific new insights to advance basic science. The choice of focus matters especially in the early stages of the modelling project, for example when the problem solvers define the scope of the project and set the objectives.

Narrow thinking can limit the number of alternative paths perceived to be available at a fork. Ignorance or unintentional disregard of important aspects related to the overall problem can lead to a *myopic problem representation* with missing policy alternatives, objectives, or scenarios (Montibeller and von Winterfeldt, 2015). The problem solving team may omit an important perspective, for example, if they are not familiar with the relevant information, concepts, or models. Sometimes a person's ignorance of facts, perspectives, or possible paths to be followed can be, *deliberate ignorance* (Hertwig and Engel, 2016), i.e. a self-interested and possibly strategic choice.

The approaches used influence mental models and thinking. This can naturally happen as models are often used as tools for thinking. The mental models, i.e. internal representations of the world, held by the problem solvers are likely to be influenced by the approaches they have adopted in the past. For example, a cost-benefit analysis can lead to the view that all environmental impacts can be quantified in monetary terms. The mental models held by the problem solvers and the way they think naturally have an effect on their choices at forks (see, e.g. Jones et al., 2011). In preference elicitation, the results can depend on the elicitation technique (see, e.g. Pöyhönen and Hämäläinen, 2001). The choice of results to be used creates a fork in the path. The problem context and the availability of data impact the choice of approaches, and the approaches used influence the data requirements (see, e.g. French and Geldermann, 2005; Kelly et al., 2013).

Expressed preferences and hidden motives influence choices at forks. Preferences and motives determine the desired destination of the path. It is common that stakeholder preferences are assessed in a problem solving project. Ideally, clearly stated objectives would guide the choices at forks. However, all motives rarely become explicit and the problem solvers can strategically or unintentionally bring in their own interests (see, e.g. Kunda, 1990; Huesemann, 2002). Such interests can include minimizing one's workload and career advancement related risks. For example, an important decision may be postponed to escape responsibility (Gregory et al., 2006). This may cause some desirable paths to become unavailable.

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