

COGNITIVE SKILLS TO DEAL WITH THE CHALLENGE OF COMPLEXITY IN PLANNING

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Abstract

Complex problems represent a serious challenge in planning. Planners must make use of incomplete and potentially contradictory information to reach diverse, at times conflicting goals. Nobody can apprehend all of the different variables involved at a glance. Nor is it possible to predict with certainty how they are likely to change in the future. The mental models (i.e. representations of our environment) with which planners operate are therefore prone to errors that inhere in the very process of cognition itself, which only compounds the difficulty that planners face when dealing with complexity. Drawing on foundational insights from planning theory and practice, as well as from cognitive psychology and the interdisciplinary field of complexity theory, this paper seeks to develop and define some key cognitive skills designed to make dealing with complex planning problems easier.

Planning in a complex world with an unpredictable future forces us to confront the limits of our ability to control socio-spatial systems. Yet we still make plans, not with the mistaken hope to fully determine the future, but rather with the intention to influence the development of complex socio-spatial systems, remaining attentive to their evolution over time. That said, how can we ensure that our modest ambitions are grounded in substantive knowledge about the planning situation at hand?

In order to comprehend a situation and to come up with proposals for how to act, planners use so-called ‘mental models’. Being mental representations of our environment and the range of options available to change it, mental models consist of concepts (or terms, such as ‘city’ or ‘traffic’) that are connected by way of relations to form propositions. They depict our understanding of a given system’s various causal relationships, which determine a planning situation. If a system is to be modified by the intervention of

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planners, then mental models are used to predict the behaviour of the system and to suggest possible procedures (see, for example, Eysenck and Keane 1998; Gentner and Stevens 1983; Johnson-Laird 1983; Reason 1994).

It stands to reason that the more well founded our mental models (that is to say our concepts and propositions) are, the more secure the knowledge that underlies our plans will be. It is with this goal in mind that this paper outlines some key cognitive skills on which planners can rely to help them generate the substantive and coherent knowledge (couched in mental models) required to design plans and make strategic recommendations in the face of complexity.

The cognitive skills in this paper have been developed for planners who work on tasks such as complex, strategic problems in the field of planning, especially in spatial planning. As a general rule, complex problems can be characterized as follows: i) they consist of many parts that are ii) mutually imbricated and iii) co-dynamic (which is to say they are interconnected and are able to change absent any influences from outside the system itself), as well as being iv) both novel and obscure from the planner's perspective, and v) characterized by a plurality of possible goals and courses of action (see, for example, Doerner 1989/2009,58f; von der Weth 2001,10ff).

Empirical findings from cognitive psychology show that planning, just like any other cognitive task, is infused with a whole range of unconscious, innate cognitive tendencies (i.e., fallacies or biases), especially when dealing with complexity. For example, we tend to assign a single cause to a multiplicity of effects rather than looking for a complex network of causal relations. Or, we tend to assume that current trends will extend into the future in a more or less linear fashion without proof this is indeed the case. These and other cognitive traps are mirrored in the errors we make when planning (see, for example, Doerner 1989/2009; Reason 1994; Schoenwandt 2008 and 1986; Strohschneider and von der Weth 2002; von der Weth 2001). The cognitive skills that are discussed below are intended to counteract the negative effects of these cognitive traps.

This paper will focus on the process by which new knowledge is acquired about a complex planning problem: how we go about constructing and transforming mental models for planning purposes. As such, the scope of this paper excludes decision-making processes as well as many of the overtly communicative

aspects of planning (Who s should be included? How is the process of communication to be organized? How is it to be moderated? According to what rules are decisions to be reached? What role do the power dynamics of the various participants play?, etc.). However, this should not be taken to imply that we view these aspects of the planning process and the skills they require to be of only of minor importance.

3-Phase Model (after Lewin)

People exhibit a general tendency to employ cognitive strategies that make it difficult to deal with complex situations. The question thus naturally arises: what kinds of key cognitive skills do planners require to reliably construct adequate mental models of their environment and predict the effect of their own actions in that environment as precisely as possible? For one thing, it is clear that when faced with novel, complex challenges planners must be willing to abandon or in the very least modify well worn thought patterns and routine procedures. Established mental models must be subject to change if new epistemic structures are to be generated and appropriate planning processes established.

The early 20th century psychologist Kurt Lewin identified stages of change that are still the basis of many approaches today (see, for example, Lewin 1953/1975). Inspired by Lewin's approach, we distinguish three phases in the evolution of mental models:

1. Unfreezing

It is always the case that people only alter their mental models when they are perplexed either by some new and obscure phenomenon or by information that is inconsistent with a previous theory or expectation. This is certainly true in the case of complex planning problems. However, obscure phenomena or information that challenges our preconceptions do not suffice to force a change in mental models, as they can be ignored or dismissed as irrelevant. Moreover, when a plan meets with undesired results, these can be blamed on the mistakes of other people, on fate, or simply denied really to have taken place. Although it may appear irrational, this kind of behaviour is widespread and common, perhaps because people prefer it to a leap into the unknown or the loss of self-confidence that comes with admitting a mistake or a gap in our understanding (see also Doerner 1989/2009). However, if we ignore new information we only maintain worn out routines and oversimplify complex situations in ways that tend to be unreliable. To allow for the possibility of genuine change, which is essential to be able to cope with complex problems, we must face obscure phenomena and perplexing information head on, realizing that by refusing to alter our thinking we make it

impossible to solve many problems or reach goals we have set (see Schein 2010). For this reason, we must be willing to ‘unfreeze’ cherished assumptions or risk being unable to deal adequately with novel complex problems.

2. Change (Transition)

Once we have ‘unfrozen’ our cherished assumptions and are motivated to change, it becomes possible to re-define and rework old mental models. This process usually begins by broadening our cognitive horizon and opening ourselves up to take in new information. For example, we might consider if an established concept can be interpreted much more broadly than we had previously thought; or, we might find that the set of presuppositions we use when making judgements and drawing comparisons are not appropriate or helpful, and that if we adopt different presuppositions the scope of our judgements and the nature of our planning will shift (see Schein 2010).

3. Refreezing

The aim and purpose of broadening our horizon to take in new information is that doing so allows us to modify existing mental models or build up new ones. These aim to represent the many, mutually imbricated elements of our environment in a way that is both relatively simple but essentially accurate, thus making it possible to take the relevant variables of a planning process into account. Once we are truly satisfied this task has been accomplished, we can, so to speak, ‘refreeze’ our new mental models and gain a new perspective on our environment.

Lewins’ 3-Phase Model and the Key Cognitive Skills in Planning

Each of Lewins’ three phases of change roughly correspond to one of the basic steps in planning. As a rule, they generally cannot be completely divorced from one another, and we tend to cycle through them repeatedly as we engage in complex cognitive processes such as planners often face. Despite the fact that each step in the process cannot be neatly separated out from the rest, Lewins’ schema nonetheless provides the underlying structure for what we have termed key cognitive skills in planning. In what follows we will outline a rough sketch of these skills (see also fig. 1). The rest of the paper will then provide a more detailed and precise elaboration of each in turn.

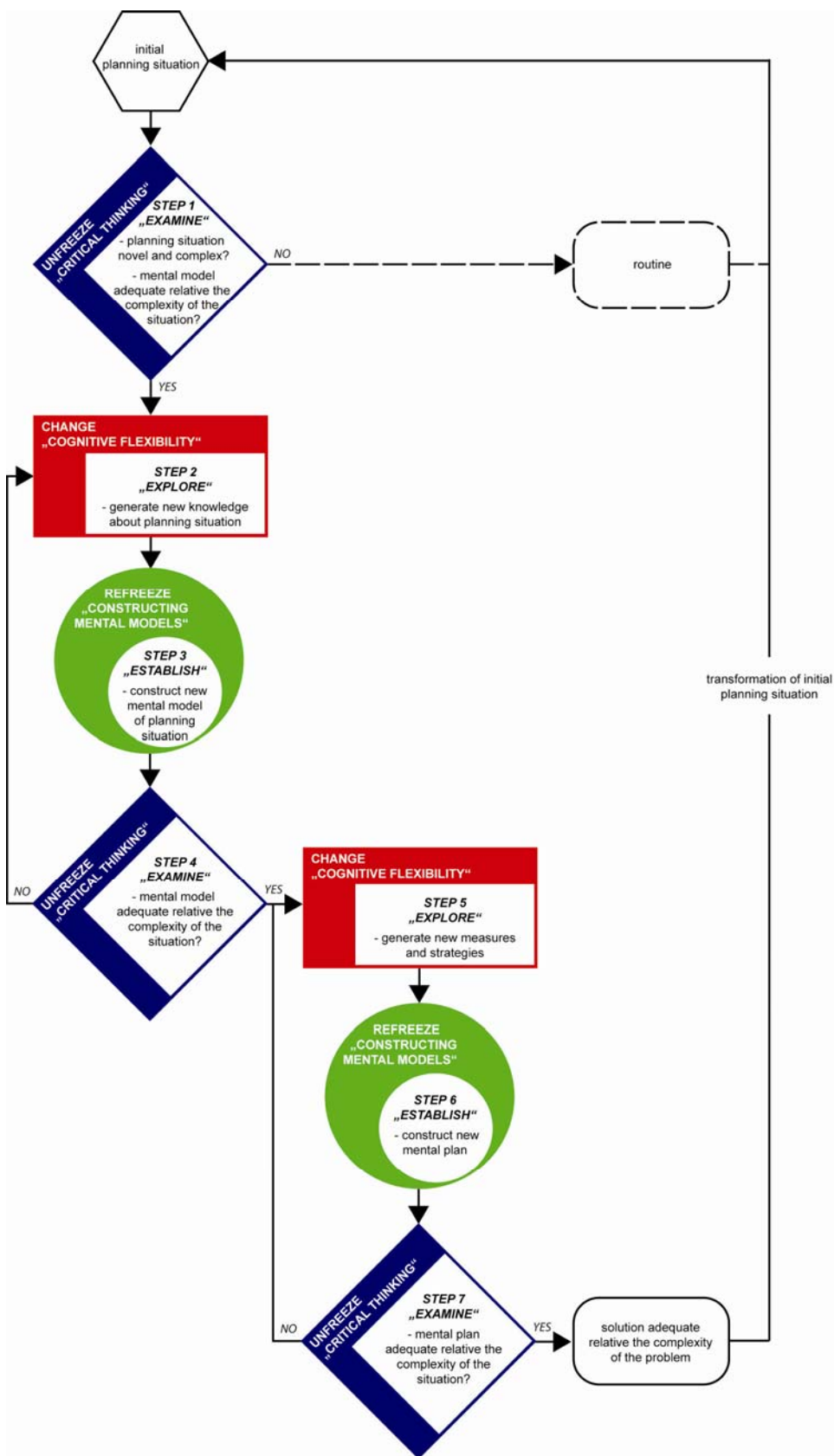


Figure 1: The 3-Phase Model (after Lewin), Key Cognitive Skills and some Basic Steps in Planning (by the authors)

Step 1 (in fig. 1)

Planners face a complex set of initial conditions when solving a problem. If they recognize that the situation is novel, opaque, and generally complex, they depart from the basic assumption that they should initiate an appropriate and open-ended planning process. In contrast, if they do not recognize the complexity of the problem, or if they wish to maintain an erroneous sense of mastery over it, they will rely on well worn thought patterns: instead of an active, critical mental representation, they will call upon procedures, methods, and instruments that have been proven to work for routine assignments in the past but that do not necessarily fit the specific problem at hand. The ability to question established patterns of thought and actions, to abandon old mental models and recognize novel situations for what they are corresponds to the Lewin's 'unfreezing' phase. In the context of planning, we can describe this skill as *Critical thinking* because doing so necessitates a capacity for self-reflection (on which more below).

Step 2 (in fig. 1)

Once the complexity of the planning situation and the limited utility of existing mental models (or patterns of thought) have been recognized, planners must acquire new knowledge that will allow them to modify their old models. The ability to generate new knowledge—e.g., to recognize new connections between elements (or variables) of a system—corresponds to Lewin's 'change' phase. In what follows, we will describe this skill as *Cognitive flexibility* in accommodating mental models (on which more below).

Step 3 (in fig. 1)

Based on the knowledge acquired in step 2, new mental models (i.e., simplified representations of situation designed to guide our actions) can be generated. The ability to integrate new information and construct new representations corresponds to Lewin's 'refreezing' phase and constitutes our third key cognitive skill, which we can designate as *Constructing mental models* (on which more below).

It is important to recognize that the each phase of planning process need not necessarily follow one from another precisely; rather, planners tend to cycle through all of the phases in an iterative fashion.

Steps 4-7 (in fig. 1)

The usefulness and adequacy of new mental models must continuously be tested anew (step 4, a renewed ‘unfreeze’ phase, which again requires the cognitive skill of *critical thinking*). Should the new mental model prove inadequate to the task at hand, we proceed again to step 2. Otherwise, a range of possible measures are developed based on the mental model in question, each of which seeks to eliminate the problem or achieve a predetermined goal. As a rule, planners will propose a variety of possible measures and compare their predicted outcomes (step 5, a renewed ‘change’ phase, which draws on the key skill of *cognitive flexibility*). Finally, the planner then selects the measures he judges to be the most appropriate. As a mental plan, these will then constitute the proposed real plan or, more generally, recommended action (step 6, a renewed ‘refreezing’ phase, which requires *constructing mental models* (respectively constructing mental plans to guide our actions). Should the mental plan be judged insufficient for tackling the problem at hand the planner will return once again to step 5.

Key Cognitive Skills for Dealing with Complex Planning Problems

In what follows, we decompose the still somewhat vague notions of *critical thinking*, *cognitive flexibility*, and *constructing mental models* into their constituent elements, thus defining the key cognitive skills required in planning more precisely. By invoking series of real-world examples we can demonstrate how these key skills are operationalized to be of use in concrete planning tasks. In addition, examples show how the key skills contribute to a planner’s ability to deal with the aforementioned features of complex problems as well as the cognitive traps into which we so often fall when attempting to solve a complex problem. Table 1 provides an overview of the key cognitive skills (see below).

1. Critical thinking (the capacity for self-reflection)

The key skill of *Critical thinking* can be decomposed into three sub-components:

Subcomponent 1a): Reflecting on Information

By *Reflecting on information* we mean the skill of taking statements about what a plan entails and critically questioning their underlying assumptions as well as their empirical validity. This requires recognizing the fact that seemingly ‘objective’ or ‘factual’ statements and/or assumptions are never true in themselves and only have meaning relative to the context in which they are expressed. For example, we might question the

validity or applicability of forecasts about a problem. At the same time, it is important to cultivate a critical approach not only in relation to externally generated information but also in relation to statements we have generated ourselves. For example, planners are well advised to question their own basic assumptions about, e.g., the causal connections that obtain in a complex system or what the likely outcomes of their proposed measures will be. Among other things, doing so requires confronting the negative downstream or side effects of any measures we may propose. Thus Maurer (2005, 761) admonishes us that "... opinions about causal mechanisms should not be taken as truths."

Strengthening this key skill can help alleviate the impact of a cognitive trap that planners typically face, the so called 'Affirmative behaviour'. This is a trap into which planners fall when they refuse to acknowledge information that is not consistent with their own expectations (see also Bazerman and Watkins 2004; Schoenwandt 2008 and 1986).

Subcomponent 1b): Reflecting on methods

By *Reflecting on methods* we mean the skill of always reflecting on and questioning the adequacy of the methods and procedures we use: are the methods, theories and approaches we apply appropriate for the problem at hand or would it be better to choose another, different set of procedures and methods?

This key skill is applicable to another cognitive trap into which planners commonly fall, which is perhaps best described as the excessive allegiance to a particular methodology (see, for example, Doerner 2008). This happens when planners apply some method uncritically because it has proven itself to work well in the past but which need not be adequate to the new, complex problem at hand.

Subcomponent 1c): Reflecting on one's own point of view

Paradigmatic patterns of thought (see, for example Kuhn 1962/1981 and Bunge 1996) or initial planning approaches that underlie the basic foundation of all planning play an important role in the planning process. Initial planning approaches include everything from how we frame a problem and how we articulate our goals to the methods and background knowledge we bring to each new task. Each of these four components influence and interact with one another to determine a planner's basic approach. They are like a pair of glasses in that they determine how a planner will see a problem, which has direct implications for the kinds of solutions he is likely to propose. For this reason, the way in which we initially approach a problem is not dictated by the nature of things 'in themselves'. Rather, there are always a variety of remarkably different approaches from which a planner could, in theory, choose (see also Schoenwandt and Voigt 2005).

By *Reflecting on one's own point of view* we thus mean the capacity to critically examine our own basic assumptions and ethical values, questioning their adequacy to the problem at hand and asking if they do not unduly restrict range of possible solutions available to us. As such, this key cognitive skill presupposes that we recognize the situatedness of our own knowledge, understanding that our basic assumptions are always provisional and up for discussion. For example, our values play a role in planning because they form a standard against which a given situation can be judged deficient in some respect. Hence, it is only relative to our values that some aspect of a situation can be treated as a problem in need of a solution to begin with. In fact, one or more people involved in the planning process tend to regard at least some aspects of the same situation as positive because they are working with their own, different set of values and ethical commitments. Self-reflective planners must therefore be capable of acknowledging and recognizing the positive aspects of a given situation even though they may have deemed it to be problematic in some other respects. As such, they can accommodate information even though it may conflict with their own view, which requires being able to question their basic assumptions.

All of the three sub-components discussed above primarily emphasize the ability to *acknowledge* the relative, situated nature of information, points of view, methods, and ways of proceeding.

The ability to *generate* and *ascertain* new, alternative information, methods, or ways of proceeding all belong to the key skill of *Cognitive flexibility*.

2. Cognitive flexibility in accommodating mental models

The key skill of *Cognitive flexibility* can be decomposed into four sub-components.

Subcomponent 2a): Flexibility in exploring relations

By *Flexibility in exploring relations* we mean the skill of being able to think through relational chains or networks in order to recognize the causal, temporal, or spatial relations that may obtain between a number of individual variables of complex systems (for a sampling of different kinds of relations, see Schoenwandt 2008, 77f). This is important because planners, for example, must ascertain causes of a given problem before they can generate reliable measures to solve it effectively. Doing so allows planners to generate new

knowledge about some problematic situation. Other avenues to achieve this latter goal include various aids to creative thinking, such as brainstorming, etc.

Planners who can think creatively and flexibly in this way are less liable to fall into the so-called cognitive trap of ‘Reductionism’, in which a variety of effects are all thought to follow from a very few causes (see, for example, Doerner 2008, Schoenwandt 2008 and 1986). (Note that reductive, monocausal hypotheses need not always be erroneous, but they are almost always incomplete and therefore misleading.)

Subcomponent 2b): Varying levels of abstraction

By *Varying levels of abstraction* we mean the ability to regulate how fine-grained the information we take in, work with, or use to generate, e.g., new measures to solve some problem, is. We thus vary or ‘calibrate’ the scope of our concepts (general or specific concepts, i.e., individual features) as well as the background knowledge they presuppose depending on the problem at hand. (By which we do not mean an actual calibration, but rather just the ability to work with variables at diverse levels of abstraction.) For example, suppose an infrastructure planner surveys a region to determine whether it contains enough schools to guarantee a given level of education. In this context, the planner can safely assume that ‘learning’ is the primary educational mechanism of schools. However, if a planner has been commissioned to build an individual school, he will want to distinguish between various ways in which learning can take place, e.g., lectures, individual projects, group work, etc. This is important because each distinct kind of learning requires different demands to be placed upon the space of the school. Alternatively, a psychologist who investigates the various degrees of retention that can be achieved different kinds of learning will want to distinguish between different forms of learning in an even more detailed way. He may, for example, distinguish classical conditioning, operant conditioning, visual learning, linguistic learning, concept formation, problem solving, etc. That said, it is important to recognize that from the point of view of an infrastructure planner who wants to assess how many schools to build in some region, the resolution of the psychologists different concepts of learning is too fine grained to be of any use in his work (see Bredenkamp and Bredenkamp 1974,610; Schoenwandt 2008,85).

Subcomponent 2c): Flexibility with regard to diverse points of view

By *Flexibility with regard to diverse points of view* we mean the ability to provisionally adopt a variety of different viewpoints and values to see what kinds of actions each would dictate in the planning process. This kind of flexibility ensures planners avoid tunnel vision, and it helps them to integrate new perspectives as well as to explore new, previously hidden areas of the solution space. In addition, by including different

approaches and points of view in the planning process, we are better able to understand, moderate, and account for the ideas and actions of stakeholders who will be effected by the plan. This, in turn, increases the likelihood that the final plan is widely accepted and seen to be legitimate.

Subcomponent 2d): Variable executions of methods and procedures

By *Variable executions of methods and procedures* we mean flexibility in our behaviour as planners. Maurer (2005, 763) has written, “It will not do to count on the false sense of security provided by familiar forms, methods, or even narrow ideologies.” Variable executions of planning procedures might include not forcing ourselves to work out each individual phase of a planning process—define a problem, elaborate a goal, predict the outcome of an action, etc.—in a strictly ordered way. Rather, we might cycle through each phase of the process several times in an iterative fashion. Flexibility of this kind is especially important if new and relevant information continually comes to light in the middle of a planning process. A willingness to vary our planning methods and the sequential ordering of planning steps is also necessary because people have a limited capacity to process information and thus never really have complete oversight of a complex system’s many relevant features (see, for example, Fodor 1979). As a rule, it is only by actually working through the planning process that people acquire the necessary knowledge and understanding required to execute the parts of the planning process successfully.

3. Constructing Mental Models to Guide our Actions (Mental Plan Construction)

The key skill of *Constructing mental models* can be decomposed into three sub-components.

Subcomponent 3a): Systemic thinking

Planners need to think systemically, that is, they need to integrate the relevant features of a complex situation in their mental models and then decide on a course of actions that takes into account the context of that situation (e.g., the long-term effect of their actions). In order to produce genuine understanding, a mental model must abstract away from and thus simplify the complexity of the system it represents. However, if the model is to guide our actions effectively, it must also capture all the essential features of that system, such as, for example, the causal connections that obtain therein. As Maurer (2005, 762) wrote: “Representations of reality should build bridges between abstractions, which are required for strategic contemplation, and concrete actions.” Since complex planning problems usually contain a large number of diverse elements, each of which must be taken into account, planners should have the capacity to incorporate as many different

relevant variables into their mental models as possible. For example, these may include downstream and side effects of their actions, financial and technical aspects of planning, or, whether other people involved in the planning process are likely to accept a planner's recommendations. (Of course, it is only in the context of a concrete planning assignment that we can say which variables are relevant and must be taken into account.)

Subcomponent 3b): Rigorous thinking

The subcomponent *Rigorous thinking* subsumes both the ability to use formal logic and the more general capacity for thinking through a problem systematically, such as, for example, when we are in a position in which we must relate the different stages of a planning process to one another, or when we infer which measures are likely to solve a problem from its root causes. This is especially true in spatial planning, which tends to present a long temporal horizon because the effects of our planning measures can only be evaluated far down the line ('A Breakdown of Control', see Doerner 2008). Given the complexity of so many planning tasks, Maurer (2005, 760) wrote, "Ignorance and risks are unavoidable. We must deal with credible information in a consequential way. We can do so using the logic of decision making and the mathematical theory of estimation as a foundation."

Subcomponent 3c): Flexibility of mental plans

An important skill in planning and problem solving is the ability to build mental plans that can handle the dynamic evolution of complex systems, which cannot be accurately predicted in advance. Planners must design flexible models that can react to unexpected events or previously unrecognized features of a complex system. As such, planners must be able to fashion their plans in a way that makes it possible to modify, adapt, or overhaul them entirely. This can be accomplished in a number of ways, such as by building resource reserves (e.g., space, money, time, personnel, etc.) into the plans, by developing alternative plans early, or by planning measures that can be altered or even abandoned should the situation change at some point in the future (see, for example, Grapengiesser 2009). In general, it is important to react to changes in a system and do justice to the shifting requirements that are placed upon it. An example of such shifting requirements is the extreme changes in how much traffic occupies a city's arterial roads in the morning and evening. A correspondingly adaptive plan would be, for example, to have three lanes on a four-lane highway feed into a city during the morning hours and then switching two of the lanes such that three lanes feed out of the city in the evening (see, for example, Ackoff 1999, 108 and 110). Flexible mental models and plans allow us to avoid the cognitive trap of 'Ballistic action', which Doerner (2008, 110) describes in the following way: "Actors ... shoot their measures off like so many cannon balls, which cannot be controlled once they have been fired."

<p>CRITICAL THINKING (the capacity for self-reflection)</p> <p>// Reflecting on information // Reflecting on methods // Reflecting on one`s own point of view</p>
<p>COGNITIVE FLEXIBILITY in accommodating mental models</p> <p>// Flexibility in exploring relations // Varying levels of abstraction // Flexibility with regard to diverse points of view // Variable executions of methods and procedures</p>
<p>CONSTRUCTING MENTAL MODELS to guide our actions (mental plan construction)</p> <p>// Systemic thinking // Rigorous thinking // Flexibility of mental plans</p>

Table 1: Key Cognitive Skills in Planning

Outlook

The key skills discussed in this paper are intended, among other things, to help steer the future course of educational curricula for planners. For example, on the basis of these key skills, targeted methods can be developed that will not only strengthen the skills themselves but will help advance the search for solutions to complex problems. The development of precise criteria to build on these key skills can furthermore be of use as a preliminary evaluation of future research into how well certain basic skills have been transmitted that are needed to work out complex planning problems.

Note

This paper, especially the development and description of the key cognitive skills in planning, is primarily based on the as yet unpublished dissertations of Christoph Hemberger and Rinat Saifoulline (see Hemberger (forthcoming) and Saifoulline (forthcoming)).

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