Chapter 5
Planning

5.1 Introduction

Choosing the planning domain to study organizational innovation from a knowledge perspective was triggered in three ways. Firstly, the domain of planning is highly cognitive [e.g. Mietus 1994], as this chapter will show. Secondly, the process of planning has been shown to be an important influence on innovation [e.g. O’Connor 1998; Castrogiovani 1996; Avlonitis, Kovremenous, & Tzokas, 1994]. Although the first point is of more direct concern to the present study the second point underlines the power that comes with the planning domain. The third trigger, finally, concerns a practical reason; at the faculty of Economics and Business we developed knowledge and experience on planning and planning support, e.g. the planning support software ZKR. This was developed between 1989 and 1995 at the university of Groningen and became a commercial software product in 1996.

The aim of this chapter is to show some aspects of the rich and complex domain of planning. We therefore start with discussing the planning domain in general, focusing on its practical value and the differences between everyday planning and organizational planning [5.1]. We will then show the great complexity of the planning domain, in particular planning as a scheduling task [5.2]. Section 5.3 discusses the main subtasks of planning that are of interest to us for the purpose of our study on knowledge dynamics. The subtasks are ‘gathering information’, ‘negotiating’, and actual scheduling [5.3]. And finally the last section [5.4] is on the use of computer support for planning, in particular the use of ZKR to make the duty roster.

5.2 The knowledge domain of planning

5.2.1 Planning in everyday life

We use planning in organizing our everyday life [Woll 2002], especially when we want to achieve something which requires several parallel and serial actions, for instance the planning of a vacation or the running of errands [Hayes-Roth & Hayes-Roth 1979]. In planning a vacation we come across a number of practical
decisions. For instance, when we choose a destination we need to consider the following:

- The type of vacation, for instance do we want an active vacation, do we want to see many things and educate ourselves at the same time or do we just want to lie on the beach. This decision relates to the goal of our vacation, which is seldom precisely defined or clear-cut.
- What facilities are available at the place of destination? This decision relates to the availability of information, which seldom is certain and complete.
- Valuing the available information about our destination. This decision relates to the reliability of the sources of information.
- How to get to the place of destination
- Considering alternative destinations

These are some aspects to consider, but there are probably more. And then there is a difference in planning for yourself and planning for others; just think about picking a travel destination for a group of friends. So, planning involves many aspects and actions such as in the vacation-example. However, we surprisingly often seem to plan without thinking, combining the different aspects of planning in a natural way.

Probably because of its complexity, within the academic world different aspects of planning have been studied by a variety of disciplines ranging from economics, management and organization, operations research to mathematics, artificial intelligence and cognitive psychology [Kiewiet, Jorna, & van Wezel 2005]. Taking on different perspectives, these disciplines all deal with attuning and coordinating objects, activities and actions in time and space. To illustrate the impact that planning can have we will discuss the example of the seven bridges and the bridge masters taken from Jorna, Gazendam, Heesen, and van Wezel [1996].

### 5.2.2 The bridge masters example

The following example illustrates the difference a planning can make. Before the planning was introduced the situation was as follows. A busy part of an important waterway had seven bridges across. Each bridge was operated by a single [different] bridge master. The seven bridge masters all lived in their own bridge
master house as part of their own bridge. During the night all the seven bridge masters were asleep and consequently each of the seven bridges was closed. During vacation periods all of the seven bridge masters had to find their own replacement. All seven bridges were operated independently without a planning schedule; the seven bridge masters all planned for themselves.

The introduction of modern technology made it possible for one bridge master to operate all seven bridges, which resulted in radical changes. First of all, every day was divided into different parts; each day now contained three shifts [early shift, late shift, and night shift]. And instead of seven bridge masters all operating individually and at the same time, each shift now only required one bridge master to operate all seven bridges [plus one bridge master as a sub in case of emergency]. Then, the bridges were now also operated during the night. As a result of this new approach only six bridge masters are needed instead of the former seven. The six bridge masters all work 38 hours a week and they all have a four-week period of vacation each year.

The bridge masters example shows that planning can have a great impact on required capacity and services. The example shows, furthermore, that planning calls for the uniting of different independent organizational units [the seven bridge masters] into one bigger unit [six bridge masters working together]. So the consequences of planning are often more far reaching than one might expect at first and organizational planning is no exception. For example, limited capacity of personnel calls for a highly qualitative duty roster [Jorna et al. 1996].

5.2.3 Comparing everyday planning to organization related planning

As the above examples of planning a vacation and the bridge masters show, there are some differences between everyday planning and professional planning in organizations. Whereas everyday life planning often goes by tacitly, organizational planning is much more explicit. Typical for everyday planning is that many different goals arise simultaneously and planning opportunistically seems to be a strategy to cope with these simultaneous goals and keep focus [Hayes-Roth & Hayes Roth 1979; Patalano & Seifert 1997]. Planning within organizations is a coordinating activity aiming to improve the performance of the organization, as with most organizational activities [Mietus 1994: 18].

In general we can distinguish three types of organizational planning, namely strategic planning, tactical planning and operational planning [Mietus 1994]. Strategic planning focuses on organizational policy and organizational goals.
Tactical planning focuses on acquisition and use of organizational resources. Anthony [1965] uses the term of management control rather than tactical planning and emphasizes the information handling aspect of organizational planning. And thirdly, operation planning assigns operational tasks that should be carried out immediately [Mietus 1994: 18]. It is very difficult to make clear-cut distinctions here, and therefore our focus of attention is on tactical planning and especially operational planning.

5.3 Planning as a problem solving task, the knowledge to make a duty roster

In defining the concept of task, literature on this subject emphasizes aspects such as ‘a complex situation capable of eliciting goal directed behavior’ [Farina and Heaton 1973 in Lamain 2000]. Other emphasized aspects are [human] actions [Drury, Pramore, Van Cott, Grey, & Corlett 1987 in Lamain 2000; Hacker 1986], [associated] goals [Hacker 1986 in Lamain 2000; Filkes 1982 in Wærn 1989] and achieving these goals [Filkes 1982 in Wærn 1989]. Generally speaking, people perform tasks in order to achieve goals [Lamain 2000]. Thus, a task involves setting goals and accomplishing them through behavior that is required to perform the task.

Several types of planning tasks can be distinguished, such as production planning, transport planning and planning of personnel, but there are more. These tasks essentially attune different types of entities, for example persons, vehicles, locations, machines et cetera, while taking into account a number of constraints. The aim is either minimizing or maximizing different goal functions [Jorna et al. 1996]. In this way, planning as a task can be viewed as a form of problem solving [Hayes-Roth & Hayes-Roth 1979]. In the following we further elaborate on the task planning of personnel, the focus of the present study.

Manpower planning to make a duty roster is very complex. Figure 5.1 shows a conceptual model of planning as a task for the domain of nurse scheduling [Mietus 1994]. The figure shows that the planning task involves many entities of different caliber; this is precisely what makes planning such a highly cognitive task, putting a great strain on the planner. We will discuss the five knowledge clusters for making the duty roster as put forward in figure 5.1.
5.3.1 Knowledge of the schedule itself

The planner needs to have knowledge about the schedule itself. This knowledge implies that the planner can place the planning periods, the shifts, and the personnel in the empty framework of a schedule.

5.3.2 Knowledge of shift

A second knowledge domain concerns the three shifts, which are day, evening, and night. Each of these three shifts has its own demands in terms of quality and quantity of staffing. For instance, a planner has to consider the irregular working hours, that result in obligatory resting hours for recuperation from work. But also the mandatory days off and the compensation days around the vacation periods, such as Christmas, are important. And then there are all kinds of variations on this three-split in shifts caused by the contractual hours and labor agreements, for instance resulting in 7.2 hour-shifts.

5.3.3 Knowledge of personnel

The third knowledge domain is concerned with the personnel to be scheduled, a complicated domain. This knowledge entails the personal data related to individual staff members, for example function, the degree of experience, contractual hours and labor contracts. Knowledge about the labor contracts is important as it puts different restraints on the assignment of shifts. For example, personnel with particular part time contracts can work only in the evenings or at nights.

Knowledge of personnel also concerns established data, such as courses and vacations. Courses are considered official working time and should therefore be taken into account in the duty roster. Historical data concern the historical progression of scheduled shifts for each colleague that is scheduled. This data needs to be considered over an entire year and needs continuous updating.

And finally there are the personnel’s wishes. These preferences for specific shifts or dislikes to a specific combination of shifts are often considered to be an acquired right for the employee and should therefore be handled delicately.

5.3.4 Knowledge of constraints

The fourth knowledge domain is concerned with the constraints that are put on the duty roster, which contain labor agreements, quantity of staffing and quality of
staffing. Labor agreements include many precise rules about hours of rest. For instance, the completion of a night shift sequence should be followed by a period of two days off, which implies that an employee cannot be assigned to a shift in the schedule for the two following days. Quantity and quality of staffing involves the number of staffing required in combination with a balanced combination of qualified staffing.

Figure 5.1: Conceptual model of the task domain in nurse scheduling [Mietus 2004: 68]

Clusters of domain entities [Mietus 1994: 87]
5.3.5 Knowledge of goals

And fifthly, in order to make the duty roster the planner needs to be aware of the goals involved for making the duty roster. This knowledge domain concerns honoring the wishes of personnel, assuring the quality and quantity of staffing, continuity over days and the balance between work days and days of. But there are also more complex aspects, even to experienced planners. These concern continuity between days and the distribution of shifts, per employee as well as among employees.

The above elaboration on the knowledge domains of planning shows that making the duty roster is a complex task with many different aspects. To study the dynamics of making the duty roster it is more suitable to take on a task performance view, as this allows linking the knowledge to specific actions. The next section elaborates on the subtasks involved in planning.

5.4 Subtasks of planning

5.4.1 Planning as a task

Planning is considered to be a synthetic task [see Clancey 1985 or Schreiber, Wielinga, & Breuker 1993 in Jorna et al.1996: 66 for more details]. In contrast to an analytic task, such as diagnosis, where decomposition is important, in the planning task various activities or entities have to be merged or integrated. Furthermore, planning is considered to be a generic task, meaning that despite strong domain differences similar subtasks and similar reasoning patterns between planners in different domains can be discerned. Mietus ([1994: 93] distinguishes three clusters of subtasks, namely administration, problem solving and evaluation. The first cluster of administration within planning involves processing of personal data, determining fixed data, determining historical data, and determining wishes for the planning period. The second cluster of problem solving involves scheduling a shift, scheduling personnel, scheduling part of a planning period, counting the quantity of staffing and counting the number of assigned shifts. And all this to see whether the goals are met. And finally the third cluster involves weighing the schedule goals, checking the constraints, counting the quantity of staffing and counting the number of assigned shifts. For practical reasons we renamed the task clusters and fine-tuned their content to fit the empirical setting of our study. We renamed the three subtasks of planning into gathering information [part of the administration cluster], scheduling [part of the problem solving cluster], and
negotiating [relevant for problem solving]. They cover the most important aspects of making the duty roster. This reshuffling implies that we have left out both the subtasks of counting and evaluating; the weight of the subtask of counting decreases enormously with the introduction of DSS and the subtask of evaluating has more or less been put together with the subtask of negotiating.

Redefining the planning task in terms of the three subtasks of gathering information, scheduling and negotiating allows us to bridge the knowledge types and the knowledge dynamics to actual activities. Furthermore, it allows us to differentiate between the knowledge dynamics of the different activities involved in the innovation process.

5.4.2 Gathering information

The process of gathering information involves the selection, integration, and retrieval of data from diverse information sources, distributed as well as heterogeneous [e.g. Knoblock 1995]. Information gathering can be ascribed a key role in the planning process. Le Breton and Henning [1961] even state that a successful plan can be no better than the information made available and the judgment exercised with this information. The gathered information concerns all information required to plan, varying from constraints to practical information such as availability of resources. Information can be gathered in a number of ways, but most important is to do so in the light of its expected use [Le Breton & Henning 1961].

Le Breton and Henning [1961] remark that the significance of certain data does not lie in their total quantity; making up only a relatively small part of all necessary information, it can nevertheless have a key role in the final duty roster.

We distinguish five types of data to be gathered, namely personal data, wishes, established data, historical data and constraints [Mietus 1994]. In this way gathering information can be considered to rely heavily on coded knowledge. However, the information used for making a planning is not always gathered explicitly. Situations that provide a great deal of information for some planners may not provide any information for other planners.

5.4.3 Scheduling

Once all the data has been gathered the actual puzzling to fit all the required data into the roster can begin, the subtask of scheduling. Generally speaking scheduling consists of three major parts, attuning, adjusting and valuing. Attuning refers to
fitting the instances of object types. This is the real puzzling, it deals with reasoning, weighing of alternatives and choosing what entities to combine, to attune or put together. Justifying the final duty roster is an important goal, so theoretical knowledge is expected to play an important role in this subtask.

Adjusting is different from attuning in that it normally is done after the duty roster is finished. Adjustment is required in case of changing circumstances, for instance due to illness or in case the duty roster is unacceptable to the personnel who have been scheduled, but also when the scheduled people are dissatisfied with the roster. Valuing is mostly done when the duty roster is more or less finished; the planner evaluates to see whether adjustments can be made for improvement. In other words, this part of scheduling weighs alternatives. Most of the time this is done implicitly [Mietus 1994].

5.4.4 Negotiating

Negotiating can be considered part of the adjustment process, when the draft version of the duty roster is finished. Although negotiating is often associated with great conflicts such as peace negotiations between countries at war, negotiating is used in many other situations as well, such as everyday life situations in traffic or standing in line at the grocery store [Lewicki, Saunders, & Minton 1998]. The aim of negotiating is agreement and this implies compromise [Morley & Stephenson 1977]. According to Lewicki, Saunders, and Minton [1997] negotiating situations have the following in common:

- Two or more parties are involved
- There is a conflict of interest between the two or more parties
- It is a voluntary process; the parties involved think that they can influence each other
- The parties prefer to search for agreement, rather than fight openly
- It is expected that the involved parties both give and take
- Successful negotiation involves the management of the intangibles as well as the resolution of the tangibles

Furthermore, negotiating is characterized by joint decision making and talking about the relationship. This last characteristic distinguishes negotiating from bargaining – in research literature – as bargaining does not necessarily involve
verbal expression; bargaining could be denoted as the manner in which agreement is negotiated [Morley & Stephenson 1977]. Diplomacy can also be considered a form of negotiating as making compromises in international political matters [Neal 1964 in Morley & Stephenson 1977].

In the case of making the duty roster, the preliminary duty roster often creates a situation for negotiation, as most of the time at least some people are dissatisfied with the preliminary duty roster. So, negotiating as part of planning implies that the roster is not finished yet and that certain aspects of the roster need to be changed, which calls for fine tuning and calibrating, negotiating. For instance, it might be impossible to grant all wishes concerning weekend shifts or night shifts. Then, decisions need to be made as to who gets his or her wish granted and who does not. Much depends on the constraints concerning these special shifts in combination with the grounds of the wish. We therefore expect the subtask of negotiating to involve a substantial part of sensory knowledge.

5.5 Planning with decision support software

5.5.1 Computer supported tasks

The use of computer support to perform a task such as staff planning or manpower planning becomes more and more popular. In the first place, this increase in popularity can be explained by the possibilities that this computer support offers to improve the quality of the duty roster, in process as well as in outcome. As the above showed, planning puts a strain on cognitive capacity while decision support can remove some of this strain. A second explanation relates to administrative aspects, such as manipulating the data. For instance, as the data can be processed uniformly, using these data for other purposes becomes incredibly easy: that is, analyzing the data or linking them to other, for example financial, data.

The use of computer support does have a threshold; working with a computer program is something you need to learn. Especially, people who are unfamiliar with computers are not particularly fond of computer support. Wærn [1989] notes that learning a computer task will not be facilitated when performed under stress, such as time pressure or noisy environments. Other dismays include getting headaches from looking at the computer screen, not having the overview, which planners do have when using pen and paper, or not being able to scratch a few notes on the paper copy. But also restrictions in terms of having to work indoors and having to work with access codes can be considered a disadvantage.
to computer support. Furthermore, people who have much experience in planning [experts] and who will now have to learn to work with computer support do so only to continue their expertise at their main task of planning; experts may not particularly be interested in understanding the computer support itself, compared to novices.

So, the use of computer support affects the execution of a task in different ways. New skills need to be learned, such as using a new software tool; some people might even need to get used to working with a computer in general. Side effects can be that the new way of performing the task becomes time consuming. Thus, the introduction of computer support is considered an organizational innovation, from outside coming into the organization [Leonard-Barton 1995].

To get an idea of the impact that starting to work with DSS has, we will discuss the decision support system ZKR, a computer software program to support planners in making the duty roster [Jorna et al. 1996]. This software program was also introduced in Bartiméus [see chapter 7].

5.5.2 ZKR: Planning in health care

Introduction

ZKR is a software program for planning support. ZKR stands for ZieKenhuis-Rooster-systeem, meaning duty roster for hospitals. It was designed and developed at the university of Groningen [van Wezel, Jorna, & Mietus 1996] and was commercially explored by IKS and it was a widely used product between 1998 and 2003. In 2004 it was integrated with ‘Harmony’ [ORTEC], another DSS. No commercial or organizational connection between IKS, ORTEC and the university of Groningen has existed since 1994. ZKR was specifically designed to function as a personal support for the planner; it helps in structuring data, it ‘makes various schedule proposals, in conjunction with the user, for the different shifts which have to be scheduled’ [Numan 1998: 74]. Starting point in the design process was to stick to scheduling by hand as closely as possible. So, the aim of ZKR was to make the duty roster look as similar as possible on the computer to the manual duty roster. Figure 5.2a [on bookmark] shows a ZKR duty roster. The personnel are listed in rows at the left hand side. The days to be scheduled are represented by the columns; the different colors indicate different types of shifts. At the right hand side as well as at the bottom are the [automatic] calculations of hours are represented per person and per day respectively. Figure 5.2b [on bookmark] shows how a type of shift can be selected through a pop-up menu.
Thus, the computer software functions as a means to support the planner. It does not function as a tool to replace the planner. That is, the planner will always be the vital link in making the duty roster. ZKR neither functions as a tool that corrects on-line, for instance in the way that ‘Word’ provides the ‘AutoCorrect’ tool. New software programs such as Harmony do provide this functionality, but it is up to the planner to decide to use it or not. Programs such as ZKR and later Harmony provide functionalities in that they generate all kinds of overviews. These types of programs are therefore also especially interesting for management purposes as they provide the functionality to combine information.

The primary focus of ZKR is that it supports the subtasks of gathering information and scheduling, which are subject to the present study; it does not support the subtask of negotiating. Although ZKR does not support the subtask of negotiating in the same way that it supports both gathering information and scheduling, we do expect the subtask of negotiating to be influenced by computer support. Hence, planners will have a great amount of information at his/their disposal. So it becomes easier to take different points of view, as ZKR generates proposals. For instance, ZKR clearly points out the restrictions and constraints of changing the duty roster. In this sense planners can use ZKR to back up their argument.

The SEC-model

ZKR takes the SEC-model – Scheduling Expertise Concept – as a starting point, distinguishing two dimensions in computer support in planning [Jorna et al. 1996]. The first dimension consists of two modes, planning-by-hand [computer supported] and automatic planning by the computer. The planning-by-hand mode involves everything that a planner normally does when planning without a computer, using pen and paper et cetera. In other words, the computer provides an electric pen and paper. On top of that the computer provides easy access to information, it does the counting and everything is available at the same time. This mode also enables checking and evaluating preliminary plans. In contrast, using the mode of automatic planning the planner commands the computer to generate a possible duty roster, although the planner still provides the starting point in supplying the data. The automatic planning mode still entails a planning-by-hand aspect as the planner can make some adjustments [or of course reject the roster completely].

The distinction between planning-by-hand and automatic planning can be made more fine-grained by distinguishing four cumulating forms of support: 1] offering and requesting information [editor], 2] checking criteria [inspector], 3] evaluating
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goal functions [evaluator], and generating planning solutions [generator]. The editor provides the simplest form of support; in addition to the same options as when planning by hand the planner has the possibility of automatic counting and easy access to information. The second form of support, provided by the inspector, offers a much more advanced type of support. Additional to the possibilities of the editor mode, the inspector offers the option of having the computer automatically check the constraints that were set up front by the planner in creating the duty roster. When the computer signals a violation of the constraints the planner can choose whether or not to adjust the duty roster. An example often encountered is the constraint of forward rotation. This constraint, based on physiological research, dictates that a person may not take an early shift following a late shift. In practice this constraint will often be violated as it implies ‘sacrificing’ days off.

At the third level of support, provided by the evaluator, goal functions are used and evaluated in terms of minimizing and maximizing these goal functions [see figure 5.2c on bookmark]. This level of support can be viewed as an extension of the inspector level; when a constraint has been violated the planner will try to minimize this violation in changing this constraint into a goal function. Whereas the inspector formulates the constraints very strictly, such as either a maximum of two nightshifts or not [a dichotomous choice: yes or no], the evaluator formulates the goal functions in terms of percentages [weighing of the goal functions, see the green beams in the pop-up menu of figure 5.2d on bookmark]. For example, using percentages a planner can see how to value a certain goal function, for example a planner is satisfied if 60 percent continuity is met during day shifts.

The generator offers the fourth form of support; the computer generates a few partial alternative duty rosters. The program will show a number of solutions among which the optimal solution, in meeting all constraints and goal functions as best as possible. Through a pop-up menu the planner can select the type of shift for which a solution is requested and the week in which this shift should take place. After the information is put in the computer ZKR will generate a solution [see figure 5.2e on bookmark]. The planners can now decide either to take the generated solution or to try another option.

5.5.3 Differences between manual planning and supported planning

The change from planning manually to planning with decision support implies that the execution of the planning task will change [Roth & Woods 1989 in Mietus 1994], for instance improvement of performance and increase of possible
solutions for a specific problem. Mietus [1994] more specifically studied the difference between planning manually and planning with the decision support of ZKR. She concludes the following. First of all, decision support to make a duty roster takes over some of the time consuming activities, such as counting. But it also guards the constraints. As a consequence, the planner will have less cognitive limitations, which allows a different allocation of cognitive resources. In particular, she found that the domain knowledge was used to weigh alternative possible rosters generated by ZKR; an activity seldom undertaken in the manual situation, as this required too much additional counting. Secondly, the ZKR structures the planning task, which makes it easier to focus on one particular aspect of the duty roster. Mietus also studied the differences between novices and expert planners and found these to be bigger in the manual situation than in the supported situation.

5.5.4 In conclusion

We expect the coded knowledge to increase in the new and more standardized situation. As the new situation with ZKR opened up the possibility to weigh alternative rosters, we expect this to influence the theoretical knowledge of planners. Furthermore, we expect more knowledge dynamics for novices than for experienced planners.

Now that we have studied the theoretical issues underlying our research question the following chapter will reformulate the research question formulated in chapter 1. We will present our conceptual model and draw hypotheses from it.