Chapter 17

THE INTERPLAY OF INTERNAL AND EXTERNAL SCRIPTS

A Distributed Cognition Perspective

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Abstract: This chapter describes different script types that are involved when a person X is accomplishing a particular task Y. We refer to concepts and ideas from distributed cognition theories. It is assumed that individuals are holding internal scripts that guide them in the way they process tasks they are faced with, and these internal scripts are standing in a complex relationship to the external scripts provided by an artifact or by other persons. Three factors are regarded as crucial in order to describe the accomplishment of a task, namely (a) the actual activity, (b) knowledge underlying the activity, and (c) the executive function, a (meta-)cognitive instance that is setting the goals for the task and controls the system's task accomplishment. For each of these three main factors, several sub-categories are introduced, on which two script approaches are compared. The first approach represents the socio-technical environment Memory Aiding Prompting System (MAPS) designed to support individuals with cognitive disabilities in accomplishing everyday tasks with a focus on "tools for living". The second approach, the so-called collaborative argumentation script, represents a computer-supported collaborative inquiry learning environment to facilitate students' collaborative argumentation with a focus on "tools for learning". Implications of the comparison for the design of external scripts are derived and directions for future research are discussed.

1. INTRODUCTION

Research on scaffolding tools has often adopted a technology-centered approach. Typically, individuals are provided with a technological tool and asked to perform a specific task, followed by measuring task performance as a function of using the tool or not (Pea, 2004). The personal development of the individual as well as changes of the context as a function of the interactions between the individual and the tool (i.e., an individual facing a new situation after having used a tool) are rarely subject to theorizing and research. Salomon (1990) described the latter instance as the *effects with* tools

which stand in contrast to *effects of* tools, meaning the cognitive residuals that an individual holds after having interacted with a tool. These cognitive residuals then describe "learning" in a deeper sense. The aims of developing a technological tool that can support an individual's accomplishment of a task can be both to invoke effects of and effects with. To understand how an individual accomplishes a task, it is necessary to take into account the different factors that contribute to task accomplishment. These factors are comprised of the technological device, the target individual herself, as well as the context in which the individual uses a particular technology (cf. Stahl, 2002). To conceptualize the complex interplay between these factors, we refer to the term *script* since it has been used in all three disciplines that can contribute to solving this problem, namely psychology (Schank & Abelson, 1977), education (O'Donnell, 1999), and computer science (Ayala, this volume; Miao, Hoeksema, Hoppe, & Harrer, this volume). Although scripts are conceptualized differently in the three domains (see F. Fischer, Kollar, Mandl, & Haake, this volume), they share in common being seen as structures guiding sequences of activities. In other contexts, scripts are referred to as *checklists* (G. Fischer, Lemke, Mastaglio, & Morch, 1991). How these approaches differ is in the question of where this guiding structure resides (in the mind of an individual vs. in the mind of the designer of an externally provided script vs. in the design of an artifact). The basic aim of this article is to articulate a perspective of an individual accomplishing a particular task as being guided by (a) the *internal* scripts individuals are holding with respect to the target activity, (b) the *external* scripts that are provided in the external surround of the actor(s), and (c) an interplay between those internal and external scripts. We are analyzing two scenarios:

- In the first scenario, individuals with cognitive disabilities are provided with a Personal Digitial Assistant (PDA) prompting them in executing everyday tasks like taking the bus, which they would be unable to execute without the tool (Carmien, 2006b).
- In the second scenario, dyads of learners collaborating in a web-based inquiry learning environment are provided with a collaboration script guiding them in how to engage in argumentation (Kollar, F. Fischer, & Slotta, 2005), thereby getting learners to internalize parts of the collaboration script so that they can use the imposed strategy even when the collaboration script is not present.

The chosen scenarios point to a distinction between *tools for living* and *tools for learning* (Carmien, 2005). Tools for living are external artifacts that empower human beings to do things that they could not do by themselves without that individuals are required to internalize the knowledge residing in these artifacts (Engelbart, 1995; Norman, 1993); they support distributed cognition or distributed intelligence (Pea, 1993), i.e., they serve as artifacts

that augment a person's capabilities within a specific task for which an internalization is not required or aimed at (e.g., a hand-held calculator). Tools for living can be tailored to specific tasks and to specific individuals. Tools for living do not change over time, remain a constant factor during task accomplishment and are rarely abandoned (Carmien, 2005). In contrast, tools for learning support people in learning a new skill or strategy with the objective that they will eventually become independent of the tool. Tools for learning often serve a *scaffolding* function (Pea, 2004) meaning that the strategy that is represented in the tool should be gradually internalized by the learners.

2. SCRIPTS FROM A DISTRIBUTED COGNITION PERSPECTIVE

In most traditional approaches, cognition has been seen as existing solely inside a person's head, and studies on cognition have often disregarded the physical and social surroundings in which cognition takes place. Gregory Bateson remarked that memory is half in the head and half in the world (Bateson, 1972). We live in a world of *distributed cognition* (Salomon, 1993; Hollan, Hutchins, & Kirsch, 2001; G. Fischer, 2003; Pea, 2004): the shopping list that "remembers" for us, the speedometer on our car, the position of the toggle on our light switch.

In his *person-plus-surround* conception, Perkins (1993) adopts a systemic view on cognition that goes beyond the individual actor: A system engaging in cognition usually consists of an individual (person-solo) and his immediate physical and social surround. This surround might include tools (such as hand-held calculators, spelling correctors, prompting systems, Mathematica software) as well as other persons (person-plus-surround), and the person-solo and its surround are standing in a complex interplay. To perform a task, it matters less *where* the needed knowledge is represented – what counts are the *access characteristics* of that knowledge, i.e., how easily the system consisting of a learner and the immediate social and artifactual surround can access the relevant knowledge. For example, a person might consider a hand-held calculator as harboring the necessary knowledge to compute 3532*32131, and estimate that using the hand calculator requires less effort than calculating mentally. A system can further be characterized as dependent on which of its components has the *executive function* with respect to the task being accomplished. By executive function, Perkins (1993) means the (meta-)cognitive control over the system's actions. For example, a French language book can take over the executive function for the system consisting of an individual learner and the book when it includes

orders like "conjugate 'aller'". According to Perkins, transferring knowledge to an external tool is adequate if the tool only performs routine tasks that cost too much to internalize (e.g., some mathematical calculations). *Higher-order knowledge* (e.g., knowledge about argumentation), as opposed to knowledge about routine tasks, should however reside in the person-solo (or be internalized by the person-solo), and not be transferred to the surround in order to give the individual the opportunity to internalize this knowledge and to be able to transfer this knowledge to different upcoming situations. The person-solo should be able to access this knowledge in situations in which an external tool is not present, i.e., to hold accessibility of the relevant knowledge as high as possible for different situations.

To describe situations in which an individual together with an external artifact accomplishes a particular task, scripts in various forms come into play. Instructional psychology (e.g., O'Donnell & Dansereau, 1992) uses the term script to describe instructions providing individuals (mostly members of a group) with procedural information with respect to performing a specific task (e.g., a manual for creating a table in WORD). These scripts can for example be represented graphically in a computer-based learning environment or can be given by a teacher's oral instructions. Scripts are – at least when they are presented for the first time – located in the *external surround* of the individual, aiming at improving an individual's (or a group's) performance with respect to a specific task. Considering the term as used in cognitive psychology (Schank & Abelson, 1977), scripts can be seen from a *person-solo* perspective as well: Most people already possess knowledge guiding them how to act in specific situations and in performing a specific task before actually performing it. For example, to use a PDA properly, one needs to have prior experiences concerning how to scroll down a menu, open files, etc. In the following, we elaborate in depth the importance of scripts for an individual performing a particular task, first talking about scripts residing in the person-solo (internal scripts), then about scripts residing in the person-solo's surround (external scripts) and finally provide thoughts about their interplay.

2.1 Scripts residing in the person-solo: Internal scripts

From a person-solo perspective, the term script describes the knowledge and strategies that an individual possesses and which guides actions and understanding in a specific situation (see Kolodner, this volume). In cognitive psychology, "a script is a structure that describes appropriate sequences of events in a particular context. A script is made up of slots and requirements about what can fill those slots. The structure is an interconnected whole, and what is in one slot affects what can be in another" (Schank & Abelson, 1977,

p. 41). Schank and Abelson (as well as Schank, 1999) use the term predominately with respect to rather well-defined situations, the knowledge about which is acquired through repeated experiences with similar situations and which can be assumed as being culturally shared to a certain extent (e.g., a "restaurant script"). However, they also introduced *personal scripts*, meaning personal knowledge and strategies that guide an actor in acting in a situation that perhaps only herself interprets in this specific way and which is not culturally shared. For example, person A might possess knowledge of how to attack other arguments by creating counterarguments, whereas person B holds knowledge guiding her in finding an integration of different viewpoints. Such personal scripts can be highly flexible – experiencing an impasse can quickly trigger a change in the sequence of the personal script so that a different sequence gets instantiated.

Referring to Schank and Abelson's (1977) notion of personal scripts, individuals may hold scripts for many situations they have experienced before. In our view, a script can be more or less flexible, well- or ill-defined depending on at least three conditions: (a) the stability of the previous experiences collected in similar previous situations, (b) the individual's abilities to abstract and generalize from these specific situations to similar new ones, and (c) the degree of structuredness or openness of the particular situation to rather situated actions and reactions. There can occur problems with an individual's internal scripts. First, internal scripts might not yet be well developed because the individual did not go through a specific situation often enough to develop an internal script already solid enough to prescribe a definite sequence of activities. This might be true for a middle school student who just started to learn algebra and has not yet developed an internal script concerning how to solve equations with two unknowns. Second, an internal script might not be adequately activated, perhaps because a person is performing two tasks simultaneously ending up with two scripts competing for too limited cognitive capacity. A third problem occurs when internal scripts are inaccessible or no longer accessible at all, as might be the case for people having had an accident that resulted in severe brain injury. In that case, internal scripts, for example for using public transportation, might not be accessible any more and can provide an opportunity for an external device designed to support an accomplishment of this task. A fourth problem could be that an internal script can be activated that does not fit current realities, for example a person with cognitive disabilities having activated the "board the express bus"-script but arriving at a bus stop that serves only local busses or a student creating a summary of a text when the actual task is to discuss strengths and weaknesses of the text. Fifth, in a collaborative learning scenario, collaborators might have activated inadequate or maybe too heterogeneous internal scripts which hamper interaction, collaboration, and in the end

learning. For example, when learners have the task of understanding the concepts of velocity and gravity by manipulating a computer model of a ball (similar to the task that was used by Roschelle & Teasley, 1996), one learner might have activated a trial-and-error-like internal script, whereas the other learner might have activated an internal script that guides her in thinking about the concepts in a more theoretical sense.

Depending on the nature of the misfit of an internal script with respect to the external task, whatever of the five problems just described might have caused it, technology can help to provide external scripts to complement those deficient or inadequate internal ones.

2.2 Scripts residing in an individual's surround: External scripts

In contrast to cognitive psychology (Schank & Abelson, 1977), instructional psychology (O'Donnell & Dansereau, 1992) as well as computer science (Ayala, this volume; Carmien, 2006b) use the term script to describe guidelines in the surround of an individual or a group of individuals that provide procedural support for accomplishing a specific task or a class of tasks. *External* scripts can take on very different forms, i.e., they can be represented in very different styles and provide affordances for desired actions and constraints for undesired actions, and they can do so in an explicit or a more implicit manner (see Kollar, F. Fischer, & Hesse, in press). This broad definition allows us to discuss very different kinds of external scripts. We differentiate between scripts that are tools for living, i.e., scripts that were developed to help people in accomplishing everyday tasks like "riding a train", and scripts that are tools for learning that aim at encouraging learning processes on behalf of the users (Carmien, 2005). Using Perkins' (1993) terms, the main difference between these two approaches can be seen in the question whether the knowledge under consideration in these scripts is to be internalized by the learners or not. If this is the case, we are talking about a tool for learning, if not, the tool under consideration represents a tool for living.

In instructional psychology, much effort has been taken to develop scripts that are tools for learning. There, external scripts often provide rather clear procedural guidance. In the classical approach from O'Donnell and Dansereau (1992), for example, the script specifies that at first collaborators have to study a text individually, then one learning partner is playing the recaller while the other one adopts the role of a monitor pointing to omissions and mistakes in the recaller's summary, etc. Scripts can be viewed as inducing specific activities, which are to be shown in a certain sequence and which can be bound to certain roles. External scripts do not always have to

be as constraint-based or prescriptive as the script developed by O'Donnell and Dansereau (1992). Other scripts rather provide *affordances* (Norman, 1993) for particular activities to be carried out by an individual without explicitly stating "Now do X", thereby being more permissive in nature. For example, scripts in inquiry-based learning environments tend to be rather open in that they afford very different activities to be conducted by the learners. Learners can engage in exploring information, in conducting experiments, in manipulating simulations, etc. What activities and what sequences of activities a learner is realizing depends on the structure of his internal script. It is this interplay between externally present or induced scripts and the individuals' internal scripts that is of interest in the next section.

2.3 Scripts in the person-plus-surround system: Interaction between internal and external scripts

We claim (1) that the design of an external script must take into account the internal scripts of the individuals that will be utilized to accomplish a specific task and (2) that it is not adequate to regard the interplay of internal and external scripts as a static relationship. Different individuals hold different internal scripts that can be complemented only by different external scripts, and in the case of scripts that are tools for learning, portions of the external script become more and more internalized by individuals, becoming encoded in their internal script with respect to perform a specific task. In the case of individuals with cognitive disabilities the internal scripts (innate abilities and skills) differ from the internal scripts of non-handicapped individuals in both content detail and in how to be best triggered externally. In the second, collaborative argumentation scenario we present later, two learners holding low-level internal scripts about how to engage in collaborative argumentation are guided by an external collaboration script to debate about the contents of a web-based collaborative inquiry learning environment. From a systemic perspective, the learners together with the external collaboration script form a person(s)-plus-system. As both learners repeatedly follow the rules of the external collaboration script, they might develop a more sophisticated internal script on how to perform this task. The executive function may shift gradually from the external collaboration script to the learners' personal cognitive systems, resulting in the artifact (the external collaboration script) becoming less and less important and learners being enabled to engage in fruitful discussions without being guided by an external collaboration script. Another perspective on the changing relationship of internal and external scripts and task support, is to acknowledge the changing environment and affordances that are available in pursuing the goal. As

Suchman (1987) pointed out, the scripts required to attain the desired goal must change as the abilities and the environment change, and thus the external scripts must adapt to differing situations.

In the cognitive disabilities scenario, individuals lack the ability to detect similarities between a situation, in which an external script once helped and a similar new situation. Then, there is no opportunity to internalize contents from the external script, and no gradual shift of script information from the surround to the person-solo can occur. As a consequence, the external script has to remain active (e.g., can not be faded out) and accessible over time to support individuals in accomplishing the task again and again.

3. ANALYZING SCRIPTS FROM A DISTRIBUTED COGNITION PERSPECTIVE

We saw that different script types contribute to an individual accomplishing a specific task. However, a more systematic analysis of internal and external scripts and their interplay is needed. This analysis should focus on the different conceptual components scripts are made up of and try to delineate the interrelations between these components within and between internal and external scripts. Therefore, in this section we aim to extract the components of both internal and external scripts that are relevant to the models of distributed cognition and thereby draw on a model that was proposed by Kollar et al. (in press). A distributed cognition perspective is valuable, since it points to the importance of a person's internal script with respect to a particular task. We assume that accomplishing a task requires three factors: (a) the *activity* leading to task accomplishment, (b) *knowledge* underlying this activity, and (c) the *executive function*, i.e., the instance that chooses and controls how to conduct the activity and what knowledge to use in order to accomplish the task. Each of these three components can be broken down into several subcategories (see Table 17-1).

Table 17-1. Overview over the different script dimensions and sub-dimensions from a distributed cognition perspective.

Main dimension	Sub-dimensions
Activity	Goal
	Subactivities
	Sequencing
	Roles
Knowledge	Type of representation
	Locus of representation
	Accessibility characteristics
Executive function	Goal setting control
	Performance setting control

On behalf of the *activity*, we distinguish between four defining features. First, the activity can be described in terms of the *goal* it pursues. For example, a major goal might be "learning to drive". Second, these activities can include *subactivities* like "fastening seatbelts", "switching gears", etc. Third, these subactivities can be *sequenced* in a specific order. For the present example of "learning to drive", one sequence would be "getting into the car", "fastening seatbelts", "turning the ignition key", etc. Finally, a script can cluster activities to *roles*, for example a "driver" role or a "customer" role. These aspects can be evoked by the contents of both an internal, or an external script. Although we assume a certain equivalence with respect to functionality in a distributed cognition system (e.g., internal and external structures might both evoke specific cognitive processes), we do not assume a structural equivalence between internal and external scripts (cf. Cox, 1999).

With respect to *knowledge* that is underlying the performance of specific tasks, there can first be different *types of representation*. For example, (1) knowledge residing in an external script might be represented textually, like in a user's manual, or graphically like in a scaffold for assembling furniture, or (2) mentally in the cognitive system of a person. Second and in relation to this, there can be different *loci of representation* as well. In the case of internal scripts, knowledge is residing in the person-solo, whereas in the case of external scripts, knowledge is represented in the persons' surround. Often, the knowledge residing in an external script is supposed to become internalized by the individual interacting with it, so that the locus of representation thereby is gradually switching from external to internal (or from the surround to the person-solo). Knowledge necessary to perform a task can third be described in terms of its *accessibility characteristics*, hence different kinds and pieces of knowledge can be more or less easily accessible, which can have physical as well as cognitive reasons. For example, the information that 32*32 equals 1024 is highly accessible when an individual has a handheld calculator at his or her disposal, whereas it is less accessible when she has to compute without this support.

With respect to the *executive function*, we differentiate two subcategories. First, scripts can be characterized with respect to who is setting and controlling the accomplishment of the intended goals (*goal setting control*). There might be instances in which an external person sets goals for an individual; in other situations, the individual is developing a script for herself, and in yet other situations an external tool sets the goals for the individual. Second, it is important to ask how it is assured that the specific individual in fact performs the activities and accomplishes the task she is supposed to perform (*performance control*). For example, technological tools can be designed in a way that they always give immediate feedback when the individual took the right steps and/or if performance was accurate. In other cases, it might be left to the individual to evaluate if she performed the activities correctly or not.

In the next section we use these categories to describe and analyze two scenarios in which we have explored external scripts that are suitable for specific types of individuals and specific tasks: (1) *The Memory Aiding Prompting System (MAPS;* Carmien, 2006a) is being developed in the context of the Cognitive Levers (CLever) project (Carmien, 2005; CLever, 2005) at the University of Colorado to provide external scripts for persons with cognitive disabilities, thereby representing a prototype of a tool for living; (2) *The collaborative argumentation script* for 8th to 10th graders, which was developed at the Knowledge Media Research Center in Tübingen (Kollar, et al., 2005), which can be viewed as a tool for learning.

4. EXAMPLES FOR AN INTERPLAY OF INTERNAL AND EXTERNAL SCRIPTS

4.1 Memory Aiding Prompting System (MAPS): A tool for living

Cognitively impaired individuals are often unable to live on their own because of deficiencies in memory, attention, and executive functions. These deficits can create an inability to consistently perform normal domestic tasks like cooking, taking medications, performing personal hygiene, and using public transportation. A common way of transitioning from assisted living to independent or semi-independent living is through the use of prompting systems. A prompting system decomposes a task into constituent parts, the parts comprising a script, and evoking each part with a prompt consisting of a pair of an image and a verbal instruction. MAPS (Carmien, 2002) consists of a mobile PDA based cellular phone (Figure 17-2) to be used by the person with the cognitive disability and a PC-based script editor tool (Figure 17-1)

to be used by the caregiver to create scripts. At script design time the caregiver chooses appropriate images and verbal prompts and assembles them, using the MAPS script editor, into scripts, that can then be loaded into the hand held MAPS prompter. At use time the person with cognitive disabilities uses the multimedia prompts displayed on the hand held computer to cue internal scripts (Carmien, DePaula, Gorman, & Kintsch, 2003; Carmien, DePaula, Gorman, & Kintsch, 2005b).

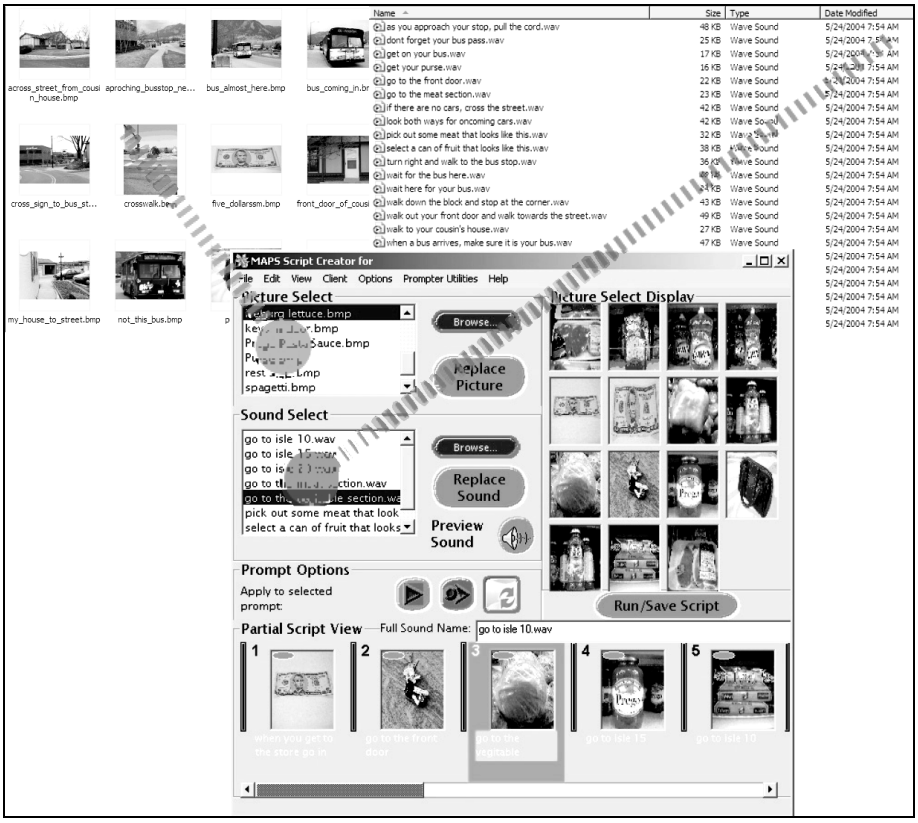

Figure 17-1. The MAPS Script Editor the upper left are the images in directories that may be inserted into the developing script, similarly the upper right shows a directory holding sound files to match with the images and make a prompt, a series of which for the script.

The MAPS script editor allows caregivers to easily create, store, and share scripts or prompts. MAPS implements multimedia prompting on its PDA platform by playing the sequence of pairs of images and vocal cues that step a user through a script to affect a task. Each prompt is an external script that triggers the stored/learned behavior of the users, their internal script. Additionally, the MAPS prompting system is designed to provide a learning

tool to acquire skills and scaffolding for daily life. When used as a learning tool the repetition of the external scripts may cause the script itself to become an internal script; but for most, the MAPS prompter will be used as a tool for living. The target population for MAPS, is cognitively disabled individuals; using standard notation (The American Association on Mental Retardation, 1992) "trainable Mentally Handicapped' IQ 55-72 and the upper range of 'Severely Mentally Handicapped" IQ < 55. However diagnostic language does not describe the desired population as well as a list of needs and abilities: they cannot read and have significant memory and executive function deficiencies; they must be able to work well with prompting techniques; have social skills sufficient to use commercial establishments without problems; have fine enough motor coordination to use a PDA, and be sufficiently capable to not lose or damage a PDA.

The design of the caregivers' script editor reflecting a *meta-design perspective* (G. Fischer, 2004, 2006a) on design time and use time requirements provides a tool to non-programmers to create scripts, in effect creating small programs to be run on the MAPS handheld prompter (Figure 17-2: MAPS handheld prompter in use). Grounded in our distributed cognition framework, the computational environment allows users to operate within the band of optimal flow (Csikszentmihalyi, 1990). This is achieved by fitting the granularity of executive function cues, the elements of external scripts, to the existing internal scripts of the user with cognitive disabilities. By doing so we obtain the precise fit that does not "over-control" the user (many more cues than is necessary) nor "under-cue" the user (asking for tasks to be accomplished that the user can not achieve). In effect, MAPS mediates the collaboration between caregivers and persons with cognitive disabilities aimed towards more independence for the persons with cognitive disabilities, which benefits both stakeholders. Over time the MAPS logs (which reflect script usage and effectiveness) aid in refining this asynchronous process. MAPS additionally provides simple ways to backtrack or to start over, to allow for mistakes during task completion, and a *'panic button'*.

The MAPS user interface is twofold; the Graphical User Interface (GUI) for the user with cognitive disabilities and the GUI for the caregiver. Because the target population has a limited number of possible internal scripts, the set of available prompting scripts will not change dramatically, the same prompting scripts being used over and over. Thus, many prompting scripts can be constructed by reusing sub-scripts (i.e., the steps to "get from getting ready to go out to the closest bus stop"). What will change is the timing and, to a small degree, the content of the scripts. MAPS is equipped with GPS and wireless networking so that, for example, when users get to their bus stop, a specific bus coming in will trigger the prompt to get on the bus (Sullivan & G. Fischer, 2003).

Figure 17-2. MAPS prompter guiding a user in boarding the correct bus. The middle image shows a user holding a MAPS prompter and being aided in selecting the correct bus. The lower image shows the correct bus on the MAPS prompter.

4.2 Collaborative argumentation script: A tool for learning

Kollar et al. (2005) developed a script aiming at improving high-school students' collaborative argumentation in a web-based collaborative inquiry learning environment. Background of this work was that students' collaborative argumentation often appears to be deficient, i.e., they have low-level internal scripts: they often have difficulties in generating well-grounded arguments (Toulmin, 1958), and they rarely generate longer argumentation sequences, which may contribute significantly to collaborative knowledge construction ("argument – counterargument – integrative argument"; Leitão, 2000). In order to address these problems, the authors developed an external script that was supposed to alleviate the construction of complete arguments and longer argumentation sequences and implemented it into a curriculum project of a web-based collaborative inquiry learning environment, namely the Web-based Inquiry Science Environment "WISE" (Slotta, 2004). In the

WISE curriculum project ("The Deformed Frogs Mystery"), dyads of learners learned that many frogs with physical deformities were found during the late 90's, and that biologists are discussing two hypotheses that might account for the problem. One hypothesis states that a parasite causes the deformities, whereas the other hypothesis states that there is an environmental-chemical substance in the water, which causes legs to develop strangely. The learners' task was to discuss and evaluate the two hypotheses against the background of various information they could explore in the learning environment (e.g., maps to see how the deformities are distributed, photographs of deformed frogs, journal articles about the phenomenon, etc.). The curriculum project included five content-specific parts (e.g., "The Problem", "Where are the frog deformities?", "What's in the water"), at the end of which the external script was implemented. Screenshots of a translated version of the script can be seen in Figure 17-3 and Figure 17-4.

When learners first clicked on the button with the inscription "Discuss the parasite hypothesis" (left hand side of the screen in Figure 17-3), they received general instruction concerning the way they were supposed to structure their argumentation, specifying that at first there should be an argument, then a counterargument, and then an integrative argument. Moreover, it was prescribed that each of these arguments was supposed to include data, a claim and a reason (see Figure 17-3). When learners then scrolled further down, several empty textboxes appeared, for each of which it was specified, who should fill them in and what argument component should be generated (see Figure 17-4). For example, for the first three textboxes, it was specified that learner A had to formulate her argument (in favor of the parasite hypothesis), typing the data she was referring to in the first textbox, the claim she wanted to make in the second one, and the reason specifying the relation between data and claim in the third box. During this time, learning partner B had to monitor whether the argument A was producing was complete or not. The next three textboxes were prestructured analogically, this time demanding B to develop a counterargument, and A monitoring the completeness of the counterargument. In the end, both partners had to generate an integrative argument and both had to monitor whether their argument was complete. In order to assure the correct application of the script instructions, for the first time learners were completing the task to generate an argumentation sequence, the textboxes always were headlined with sentence starters (e.g., "It has been found that…").

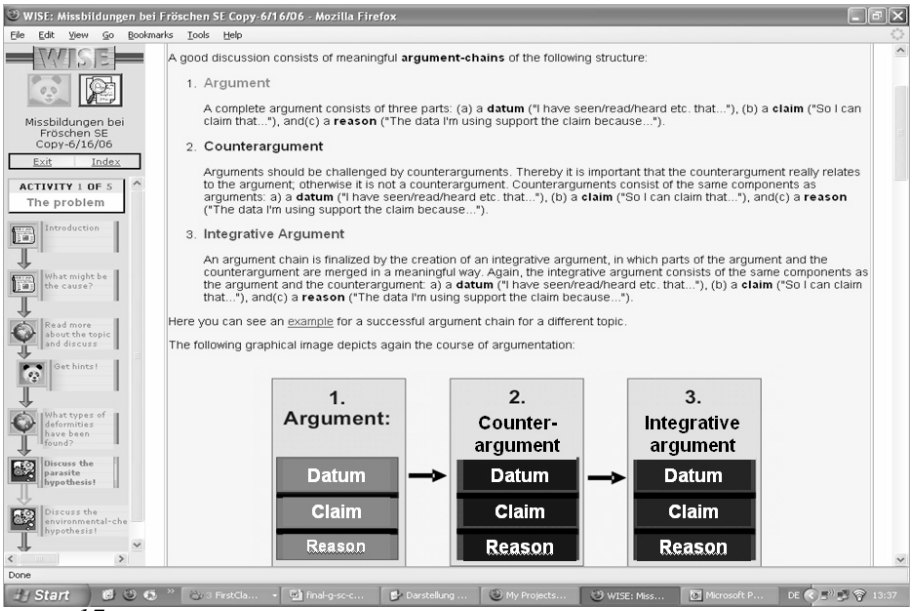

Figure 17-3. External collaboration script. Left hand frame: WISE navigation buttons. Right hand frame: Instructional text and graphical image depicting guidelines for collaborative argumentation (translated into English).

As learners proceeded more and more through the learning environment, the instructional support provided by the external script continuously faded out, expecting a gradual internalization of the strategic knowledge provided in the external script. For example, in the end of the second part of the curriculum project, learners received only three textboxes (one per argument) without the sentence starters just described, in the end of the third part only one text box for creating a whole argumentation sequence, and finally only one text box for discussing both hypotheses. In order to avoid biased information processing for one or the other of the two hypotheses, roles concerning who had to advocate which hypothesis were switched several times during the learning process.

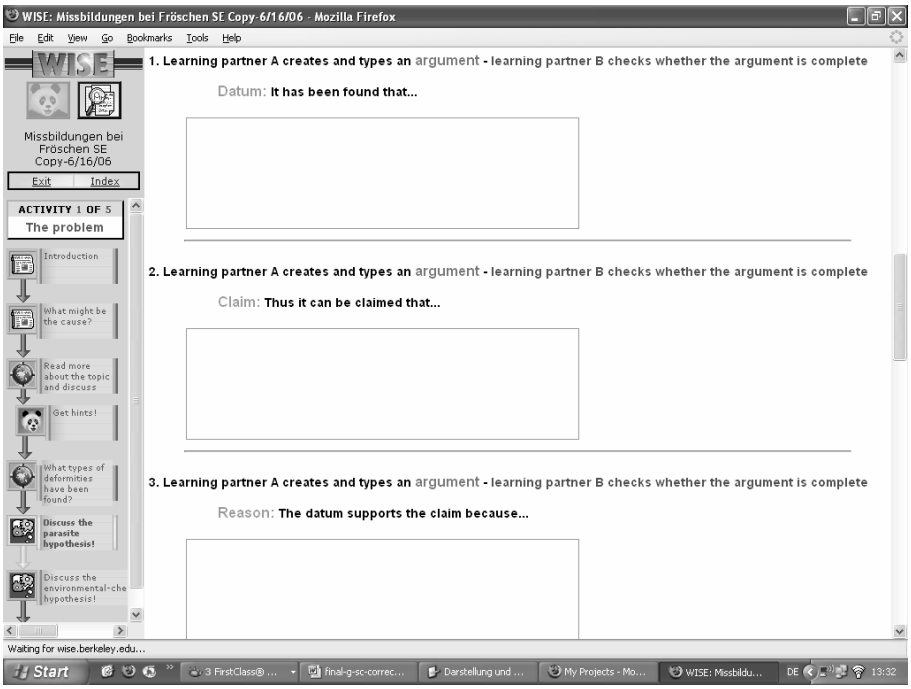

Figure 17-4. Collaborative argumentation script: blank text boxes with script prompts and role assignments (translated into English).

5. INTERNAL AND EXTERNAL SCRIPTS IN A TOOL FOR LIVING AND A TOOL FOR LEARNING SCENARIO

The contribution of this chapter is to describe and analyze situations, in which a person X is asked to perform a task Y from a distributed cognition perspective. We argued that during the process of task accomplishment, both internal and external scripts are important. In the following, we are using the categories described in section 3 to analyze and compare MAPS as an example for a tool for living and the collaborative argumentation script as an example for a tool for learning.

Activity Dimension. Concerning the *activity* level, there are both similarities and differences between the approaches. Although MAPS is a *device* to augment intelligence (Engelbart, 1995) and to change tasks (Norman, 1993), and the collaborative argumentation script is a *tool* to augment intelligence, the major goals of the two activities are rather distinct: In MAPS, the aim of the activity is the accomplishment of an everyday task like “using public

transportation", whereas in the collaborative argumentation script, the goal is to engage dyads in learning about biology and argumentation. In both approaches, the goal of the activity is accomplished by conducting a variety of sub-activities that are externally induced in the target individual(s) ("walk to bus stop" or "leave bus here" in MAPS; "give data for your argument" or "formulate a claim for your counterargument" in the collaborative argumentation script) and that are bundled to specific types of roles ("customer" in MAPS; "advocate for parasite hypothesis" and "advocate for environmental-chemical hypothesis" in the collaborative argumentation script). At the start of a scripted session the external scripts of both systems provide a rather clear sequence concerning when to engage in which sub-activity as well as a clear description of what role the target individual is supposed to take on. As task accomplishment progresses, sequencing as well as the strictness of role assignment in the two approaches develop differently. While in MAPS, strict sequencing of activities is realized throughout the whole task performance, in the collaborative argumentation script sequencing features are faded out over time, meaning that individuals in the end can define their own sequence according to which they want to build arguments and argumentation sequences. Further, in MAPS, the target individual stays in his or her customer-role until the end of task accomplishment, while the collaborative argumentation script provides learners with growing degrees of freedom to choose which role (if any) they want to take on (e.g., monitorer or arguer-role).

Knowledge Dimension. With respect to the knowledge dimension, in the MAPS approach the knowledge necessary to accomplish the target task of "take bus to recreation center" is represented in graphical images on the screen of the PDA the target individual is carrying. To properly trigger the appropriate internal script, the target individual must build up an internal representation of the object that is presented on the PDA at a particular point in time. This internal representation may be likely to vanish in a short period of time, so the main *type of representation* remains graphical until the task has been accomplished, thus being prescriptive in a sense that the user is constantly reminded not to deviate from the activity portrayed by the external representation on the screen. In case of the collaborative argumentation script, however, at the beginning of the learning situation the knowledge necessary to engage in argumentation is represented in multiple forms, namely textually and graphically. As learners interact more and more on the basis of the external script, an internalization process is intended to occur, which results in the development of a gradually more stable mental representation (however, learners may already possess internal scripts that comply with the external script instructions prior to the collaborative learning situation). With the fading of the external script instructions, textual and graphi-

cal representations become less visible. Further, an individual can also access the learning partner's representations, i.e., she can ask the partner about how to proceed to accomplish the task, thereby receiving auditively coded sequential representations of the information. While in MAPS, the *locus of representation* is, from the beginning of the episode, strongly external, in the collaborative argumentation script it shifts more and more from *strongly external* to *strongly internal*. These differences in the two approaches can be attributed to the different notion of what kind of internal scripts the target individuals are holding. In MAPS, due to the end user's cognitive disabilities, the internal scripts are more static and less developable than is the case for the target individuals of the collaborative argumentation script. Through constant interaction with the collaborative argumentation script, learners get to internalize relevant portions, having the effect that the induced processes are being controlled by their internal scripts that are gradually improving and enabling them to lead better discussions in the future. The underlying assumption is that an optimal fit between internal and external scripts might be reached by internal scripts becoming more and external scripts becoming less sophisticated over time, i.e., the more the learners internalize through following the script instructions, the less specific the script instruction have to become. That way, the external script becomes more and more a prompting system for the activation of internal scripts. For Pea (2004), such fading is essential for a scaffold like an external collaboration script to be called a scaffold and thereby what can be called a tool for learning. If not faded, the external script would rather be an example for distributed intelligence, meaning that users would not necessarily have to learn what the script induces but rather use it as a tool for living that is constantly accessible. The *accessibility characteristics* of knowledge residing in the two script approaches are assumed to remain stable. In fact, one main aim of every scripting approach must be to hold accessibility of task-relevant knowledge high. In the MAPS approach, accessibility can only be guaranteed by locating knowledge in the external surround, due to target individuals not being able to build up an internal representation of relevant knowledge. In contrast, in the collaborative argumentation script approach, at the beginning of a learning episode relevant knowledge is made accessible in learners' external surround in a graphical and textual manner, but by constantly and intentionally using the external scripts, knowledge is becoming easily accessible in the person-solo, which is accounted for by making the external script continuously less accessible (via fading). However, it is likely that some learners might require having the external script longer externally accessible than it is the case here, because learners will differ in the amount of time they need to internalize the contents of the external script.

Executive Function Dimension. With respect to the executive function, MAPS and the collaborative argumentation script exhibit differences: Concerning *goal setting control*, in the MAPS approach there are at least two kinds of persons involved: the designer of the MAPS environment and the caregiver who designs the script for the particular needs of the target individual, making as efficiently as possible use of the design constraints set by the environment designer. Such a collaborative effort between several persons is not present in the collaborative argumentation script approach – there, it is solely the designer(s) of the external script who set(s) the goals for the target individuals. However, in both cases, the target individuals themselves have personal goals, which sometimes comply with the goals that are set externally. *Performance control*, in the collaborative argumentation script, is transferred in part to the learning partner, who is not supposed to generate an argument but to monitor whether the argument his or her partner is developing is complete in the sense of Toulmin's (1958) argument scheme. The interface design includes some low-level performance control that can sense whether one or more textboxes remained blank and then asks learners whether they want to go on anyway. In both script scenarios, the target individuals themselves could engage in performance control to a certain extent. A basic assumption of the MAPS approach is that the target person's cognitive disabilities are not so severe that they would not allow her to realize that something has gone wrong, so she can press the "panic button" informing the caregiver that help is needed. In a similar vein, learners in the collaborative argumentation script approach are expected to be able to monitor whether the external script is being followed by them or not.

6. CONCLUSIONS

In this chapter, we explored the value of a distributed cognition perspective on scripts for different situations. We illustrated this by using two examples:

- MAPS, a socio-technical environment creating external scripts representing *tools for living* by supporting people with cognitive disabilities in accomplishing everyday tasks like "using public transportation", and
- the collaborative argumentation script representing a *tool for learning* for supporting high school students in acquiring argumentation skills.

A distributed cognition perspective can be used to describe and analyze both – situations, in which scripts help in genuine living tasks as well as situations, in which external scripts are explicitly designed to facilitate learning. The provided conceptual framework is simultaneously broad

enough to describe scripts from different backgrounds and to capture conceptual differences between scripts as tools for living and scripts as tools for learning.

Adopting a distributed cognition perspective can give new insights into how external scripts should be designed for better task accomplishment and thereby better learning. As we noted at the beginning of this article, the development of scaffolding tools is often focused on their design processes or their usage and simultaneously puts less attention on internal consequences of this usage. It has largely been ignored that different individuals hold different internal scripts (a fundamental challenge addressed by the CLever project; Carmien, 2005) that might require differently structured external scripts and that this interplay between internal and external scripts can change over time when an individual gradually represents contents internally that were originally represented in the external script. Different target persons and different prerequisites of an individual interacting with an external script might require this external script to be sometimes prescriptive and sometimes permissive. In MAPS, the external script needs to be prescriptive because of (a) the low reliability of individuals' internal scripts and (b) their restricted ability to internalize relevant information that is located in the external script. In the collaborative argumentation script, the external script becomes more permissive the longer dyads are interacting with it, i.e., by giving learners increasingly more degrees of freedom (after a while), they are provided with the opportunity to let their improved internal scripts guide their argumentation in a less restricted surround.

We presented two prototypical examples for a tool for living (MAPS) and a tool for learning (collaborative argumentation script). The main difference between the two is that tools for living are designed to augment intelligence and change tasks (G. Fischer, 2006b) by being continuously accessible in the surround of a person-solo and tools for learning representing a way of supporting learners to acquire new skills and knowledge (Pea, 2004). As a consequence, one main component of tools for learning is that they include fading mechanisms so that learners have the opportunity to practice the learned skills without external support being available. In the case of tools for living, such fading is not necessary, since there is no internalization intended. Defining (and designing) an external script as a tool for living or a tool for learning depends on user characteristics. If users do not have the capability to internalize external script contents, the script represents a tool for living – accordingly, it should remain stable in the external surround of the users. In contrast, if users do have the chance (and maybe even the task) to internalize the strategies that are imposed by the external script, it is a tool for learning.

One further potential of adopting a distributed cognition perspective on scripts is that it points to the relevance of the *accessibility characteristics* of scripts and script portions. It is clear that accessibility of script information should be high throughout an individual accomplishing the target task. But how does accessibility change through internalization and fading? How long and in what ways do users have to interact so that the script portions are as accessible in the person-solo as they were before when the script was represented externally? These are questions that are up to future research.

Earlier, we said that three domains are particularly concerned with scripts, as it is also represented in the structure of this book: computer science, cognitive psychology, and education. For each of these disciplines, specific challenges can be derived from our analysis.

In *computer science*, an important challenge for designers of software to be used by specific types of users is to create a design that accounts for the customers' needs in the best possible way, including *user-centered* (Norman, 1986) and *participatory design* approaches (Schuler, 1993). Most of the times, user groups are very heterogeneous with respect to important aspects like their prior knowledge about how to interact with a specific class of computer programs, thereby making it difficult to realize a high fit between software design and user needs. Very often, this problem is accounted for by providing specific help systems a user can access when experiencing a problem as well as including diverse opportunities for preference settings a user can individually design. This is what is called *meta-design* (G. Fischer, 2004, 2006a): a conceptual framework for socio-technical systems in which end-users (not only professional software developers) can create external scripts. MAPS is an environment supporting meta-design in which caregivers (knowing the internal scripts of the person with cognitive disabilities) can create external scripts fitting an individual. Meta-design is an important challenge computer science is facing to develop highly usable external scripts.

For *cognitive psychology*, an important challenge is to get a clearer picture of how different external scripts affect acting and thinking in particular situations and if and how they can change individuals' internal scripts with respect to these situations. Thereby, external scripts with respect to one person can have their origin in another person, and it might be interesting to see how the internal scripts of two persons are influencing each other. For example, Rummel and Spada (this volume) investigate how two individuals with different background knowledge (a psychologist and a medical doctor) collaborate in solving a psychological-medical case that requires a coordination of both individuals' internal scripts. Likewise, Runde, Bromme, and Jucks (this volume) analyze collaboration processes between experts and laypersons, in which the internal scripts of the interaction partners have to be

coordinated to come to a satisfying problem solution. It is an interesting question whether and how components of the two internal scripts are transferred and what determines this transfer process.

For *education*, one main challenge is to investigate how the different script types that are distributed over a classroom can be used and instructionally designed in a way that learners are engaged in meaningful learning processes yielding significant learning outcomes. First, individuals can be conceptualized as holding internal scripts that guide them concerning how to engage in particular classroom activities. Second, a computer program can provide an external script guiding learners to process the specific classroom activities in a specific way. Third, the teacher can be conceived as holding a teaching script that is external to the learners and that influences the way learners are accomplishing the classroom activity. It is the question how these different script types can be orchestrated on a classroom level in order to realize productive learning. A distributed cognition model including different levels of regulation (e.g., Cole & Engeström, 1993; Dillenbourg & Jermann, this volume) seems highly valuable here to guide research and to help accumulate scientific knowledge appropriately in this respect.

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