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# From Declarative and Procedural Knowledge to the Management of Declarative and Procedural Knowledge

Michel Fayol
*University of Bourgogne, Dijon, France*

*Research on domain-specific knowledge and general knowledge such as strategies has shown that information can indeed be available to a subject and still not be used. Several hypothesis have been set forth to explain this phenomenon; they as briefly exposed. An alternative, complementary hypothesis is then presented. It is assumed that most activities have several components organized in the form of a complex hierarchy. These interdependent components require monitoring because, at certain times, they are competing with one another for resources. Competition for resources and problems in component coordination may lead to a drop in performance. Several studies dealing with diverse knowledge domains are reviewed, which provide evidence for such resource problems. The same theoretical framework is then applied to explain several facts concerning teaching and learning: the impact of advance organizers; the instability of performance across repeated executions; some effects of social variables; the efficiency of tutoring and of taking into account the 'proximal zone of development'.*

*The limited cognitive capacity construct proves extremely useful in interpreting a large number of phenomena in a wide variety of domains.*

During the past ten years, the cognitive sciences have uncovered two fundamental aspects of learning. Firstly, a subject's ability to learn is highly dependent upon his or her previously acquired knowledge. Secondly, high-level skills (such as strategies) are essential elements of a subject's ability to construct a knowledge base.

I would like to begin by reviewing our current understanding of these two aspects of learning. I would then like to show that there is a problem which arises in both cases. This

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problem is the subject's failure to make use of declarative or procedural knowledge in certain circumstances, even though it is indeed available and is effectively used in other situations.

## Effect of previously acquired knowledge

A subject's previously acquired declarative or procedural knowledge has been clearly shown to affect learning in numerous areas, including reading comprehension, text writing, problem solving, data retention, and cognitive arithmetic.

Several researchers have found evidence of the fact that previously acquired knowledge has an impact on sentence and text comprehension (Fayol, 1992). Experts in a particular field seem to be very good at quickly deciding what information is important in a text (Afflerbach, 1990; Cirilo & Foss, 1980). This skill allows them to adjust their reading speed to the importance of the information being·read (Birkmire, 1985). Experts also readily make inferences, and can therefore construct an integrated representation of the situation described in a text with much greater ease than novices (Pearson, Hansen, & Gordon, 1979). Two consequences of this are that (a) experts can easily summarize texts which deal with their field of expertise, whereas nonexperts have difficulty doing so, and (b) experts are much less proficient at summarizing texts about other subject matters.Previously acquired knowledge has also been shown to have an impact on writing skills (Fayol, 1991). Compositions written about topics which are familiar to the author are of a higher standard (as assessed by judges) (see Caccamise, 1987; McCutchen, 1986). Furthermore, as well as affecting the text actually produced, a subject's knowledge influences the way the writing task is carried out. When a topic is familiar, writers take less time to plan, pause less frequently and for shorter periods, etc. (see Chanquoy, Foulin, & Fayol, 1990; Matsuhashi, 1981).

The study of the influence of acquired knowledge on problem solving has overshadowed the 'mental skills' approach, although perhaps only on a short-term basis. In the 'mental skills' approach, subjects solve problems and learn to solve problems via general processes (for example, the 'means-end strategy', which consists of a trial-and-error search for ways to achieve a goal. Processes of this type are context- and content-independent (Frederiksen, 1984).

However, the data collected over the past ten years has clearly shown that the very existence of these general skills causes problems. Indeed, research on the behavior of experts in fields such as mathematics, physics, and medical diagnosis has shown that the more expertise individuals have, the less they use general skills to solve problems (Sweller, 1988, 1993). Be they chess players (de Groot, 1965), physicists (Chi & Greeno, 1987), or radiologists (Myles-Worsley, Johnston, & Simons, 1988), experts make extensive use of their large knowledge bases. These knowledge bases are believed to 'contain' patterns which are recognized as such and serve to quickly and almost automatically categorize the problem at hand and associate a solving procedure to it.

Finally, the effect of acquired knowledge on memory has been demonstrated. Some studies have found evidence of phenomena which could be interpreted as a reflection of exceptional abilities in certain individuals. For example, Morris, Gruneberg, Sykes, & Merrick (1981) and Morris, Tweedy, & Gruneberg (1985) reported that soccer fans are capable of memorizing most of the scores of the various teams participating in a play-off by simply looking once at the list of scores. The performance of non experts is mediocre. But in the end, when the soccer fans are not dealing with information from their field of expertise, they do not exhibit better memory than others.

The impact of previously acquired knowledge has generally been interpreted in the schema theory framework. According to this theory, in the long-term memory of experts, there are networks of organized and interconnected concepts. Activation 'spreads' through these networks (Collins & Loftus, 1975; Anderson, 1983), such that the activation of a data item in memory is dependent upon three factors: its perceptual encoding, its activation threshold, and its links with other items (an item in a given knowledge base can be central or peripheral, and to varying degrees, depending on how many other items in the same network are connected to it). This idea of activation spreading through a network can be employed to explain all of the positive effects of previously acquired knowledge in complex activities discussed above, in addition to some other phenomena such as priming effects, false recognition, etc. (see Yekovich & Walker, 1986).

The organization of information in network form does not only apply to knowledge of oral and written language. It also appears to be applicable to other kinds of knowledge such as cognitive arithmetic. In a recent study in our laboratory (Lemaire, Barrett, Fayol, & Abdi, 1994), we found that the simple presentation of a pair of unsigned digits (2 3) is enough to activate the sum (5). If subjects are then shown the number 5, they take more time to answer the question '*Did you see that number*' than if they are shown the number 4 or 7. And even more important, the automatic activation of the sum only occurs for small numbers (both below 5) in second graders, extends on to intermediate numbers (one below 5 and one above 5) for third graders, and then on to larger numbers (both above 5) for fifth graders.

These studies suggest that it is indeed possible to follow the stages in the gradual construction of knowledge bases, whether it be in the field of biology, physics, cognitive arithmetic, or language production (Dell, 1988).

However, simply having acquired declarative or procedural knowledge is not enough to guarantee that a subject will in fact employ it in tasks where it is applicable. This non-activated/inactive knowledge is what Whitehead (1929) termed 'inert ideas'. Bereiter and Scardamalia (1985) uncovered a particularly good example of the problem of 'inert ideas' in expository text writing. The children in their experiment had trouble retrieving declarative knowledge about a given topic. They produced texts which were much shorter and much more poorly organized than they could have been. It seems as though children are incapable of carrying out the kind of metamemorial search needed to access the knowledge available to them.

Again in the area of written production, we showed that, by the age of 7 or 8 (second grade), children are able to copy over a written text that has no punctuation, and add the correct punctuation marks in the same places as adults (Fayol & Lété, 1987). Thus, children have knowledge of punctuation marks and know how to apply it, but may 'forget' how to use the marks when they are writing an essay expressing their own ideas. Here again, it looks as though children may be unable to activate knowledge they are known to possess.

However, the influence of domain-specific knowledge cannot alone explain learning, comprehension, or problem solving. Researchers and teachers alike have been led to postulate the existence of general procedural knowledge, i.e. strategies.

## Strategies and their role

The notion of strategy was first studied in research on memory and its development (Bjorklund, 1990; Kail, 1979). It was later examined in other fields, including reading (Deschênes, 1991; Paris, Wasik, & Turner, 1990), writing (Hayes, 1986; Scardamalia & Bereiter, 1986), and mathematics (Goldman, 1989).

A strategy is a variable-length, integrated sequence of procedures selected with a particular goal in mind and designed to optimize performance (Fayol, 1992). For a strategy to be used, a subject must:

- Have acquired a certain number of procedures, among which the appropriate one will be chosen.
- Select a procedure according to the goal currently being pursued, the task constraints, and knowledge of his or her own capabilities. This selection process resembles a problem solving task;
- Control and evaluate the execution of the procedure. Since procedures are not in algorithmic form, their execution must be continuously checked and monitored.

These three aspects make strategies into flexible, high-level skills (Resnick, 1987) which can be modified and adapted to the current situation. They are very valuable tools for all persons attempting to aid pupils, students, or trainees in acquiring general abilities which permit self-teaching throughout life. In this light, many studies have been conducted in an attempt to determine whether and under what conditions procedures can in fact be taught and learned.

Research has shown that it is often quite easy to teach strategies which are specifically suited to solving a given problem. For example, children have been taught without major difficulty to use various mnemonic strategies, including rehearsal, categorization, elaboration (for a review, see Schneider & Pressley, 1989). Another illustration of this is the ease with which the pupils in Day's (1986) study learned a series of summary writing rules. Thus, many of the procedural components of strategies can be effectively applied and used by children, even young ones. However, it is often the case that the positive results obtained from training are not maintained or transferred beyond the training session (in some cases, as many as 60% of the subjects do not apply the procedure they have just learned).

The authors of these studies have tried to find out why procedures which have been learned are not used spontaneously. Various reasons have been put forward and tested experimentally. Accordingly, it was shown that failure to implement known procedures often results from the subject's ignorance of the positive effect that such procedures have on performance. Substantial increases in the frequency of use of procedures have been obtained when subjects are (a) given feedback on procedure effectiveness, and (b) explicitly informed of the situations in which such and such a procedure should be used (see for example Day, 1986; Kennedy & Miller, 1976; Rindel & Springer, 1980).

Other studies have demonstrated that pupils and students do not use a given procedure to perform a certain task unless they realize that their success or failure is dependent upon their own efforts. Accordingly, '*good readers*' and '*poor readers*' can be distinguished by the fact that the former believe they have control over their own performance and regard the procedures they are taught to be instrumental in permitting them to reach their goal. They establish a causal relation between their own actions and the result they obtain. Subjects who fail, on the other hand, feel that their efforts are futile and that they have no control over the level they attain (Butkowsky & Willows, 1980; Paris, Wasik, & Turner, 1990). These findings indicate that metacognitive guidance is only feasible with individuals who believe in the potential ability of their own efforts to affect performance.

However, even if subjects feel they have the power to improve their performance, and even if they know how to use the appropriate procedure to solve the problem at hand, and what is more, even if they know that using that procedure improves performance, they frequently do not implement it or transfer it to the current situation.

## The problem of the on-line management of knowledge

Research on domain-specific knowledge and general knowledge such as strategies has shown that information can indeed be available to a subject and still not be used. Various hypotheses have been set forth to explain this discrepancy in knowledge activation. As suggested above, some regard the non-activation of knowledge to be a consequence (at least in certain cases) of the subjects' belief that what they do (i.e. the strategy they use) does not change their performance. Other authors contend that subjects may not 'transfer' the procedures learned in one context to other contexts, either because they do not 'recognize' the conditions in the new context which cause the activation of the relevant procedures, or because the procedures were learned in contexts where cues were too sparse to provide the necessary elements for subsequent identification of the real-world conditions for procedure activation. This conception argues in favor of 'situated learning', precisely because situated learning avoids the problem of the non-transferal of procedures, so common in school-learning situations.

Yet other authors contend that the non-activation of knowledge stems from the fact that subjects lack metacognitive skills and processes. They are incapable of taking task-linked constraints into account, and do not know how to analyze the prerequisites of goal achievement or organize their actions in accordance with their awareness of their own capabilities. Based on this metacognitive interpretation, efforts have been made to teach both the strategies and their corresponding conditions of applicability (see Dole, Duffy, Roehler, & Pearson, 1991; Paris, Wasik, & Turner, 1990).

I would like to defend an alternative, complementary hypothesis, and then give a few empirical arguments to support it. I assume that most of the activities studied so far have several components, and that these components are organized in the form of a complex hierarchy. Reading, for example, requires at least three operations: word identification, access to word meaning, and syntactic segmentation (see Perfetti, 1985). For writing, we have retrieval and organization of ideas, construction of frames, lexical selection, and transcription (Hayes & Flower, 1980, 1986; Scardamalia & Bereiter, 1986). These components are interdependent and interrelated in ways which are sometimes poorly understood, and therefore require monitoring to varying extents and frequencies. The amount of monitoring needed is dependent upon the nature of the operations at play. On the one side, we have highly automatized processes which run with very little control: only the final result demands attention (e.g. lexical access). On the other side, we have processes whose execution necessitates nearly continuous surveillance (e.g. elaboration and organization of ideas in written production, construction of a situational model in comprehension, and inferential reasoning in problem solving). These components differ in the attentional load they incur and in the cognitive resources they demand. Yet when an individual is faced with a particular task, the cognitive resources available at a given moment are limited in quantity (see Baddeley, 1986; Bjorklund & Harnishfeger, 1990; Case, 1985). It follows that at certain times, various subgoals, processes, or components of a given activity are competing with one another for resources. In addition, the very coordination of these diverse components uses attentional resources, at least until the corresponding procedures have been 'compiled' (Anderson, 1983).

Competition for resources and problems in component coordination may lead to a considerable drop in performance 'in real situations' in comparison with what could be expected of subjects who have the necessary declarative and procedural knowledge for carrying out the task. There are many illustrations of coordination and competition problems and their effects. Gelman and Meck (1983) showed that children at the age of 4 know the basic principles of counting (one-to-one correspondence, stable order, cardinality principle). They are able to detect whether the experimenter (or a 'counting doll') is in fact abiding by these principles. Yet the success rate of these same children is very low when it is their turn to apply and coordinate the principles to count the items in a collection. Their performance declines as the size of the collection increases, that is, as the cognitive load of managing and coordinating the various components becomes heavier.

The above example concerns young children, so one might object by saying that the difficulties encountered are due to the highly limited functional cognitive capacity of children at that age (Case, Kurland, & Goldberg, 1982). While it is true that the usable functional capacity increases with age, it is also true (a) that the difficulty level of tasks increases as well, and (b) that the learning of new tasks and/or a modification in the way a familiar task is executed creates a cognitive load of its own, often even a substantial one.

Accordingly, it was shown that some of the reasoning difficulties experienced by children aged 4 to 6 solving series problems are due to limitations in cognitive capacity. In adults, Kyllonen and Christal (1990) obtained a very strong correlation between working memory capacity (assessed on the basis of the Baddeley theory, 1986) and the ability to solve classical psychometrics problems. These results suggest that limitations in cognitive capacity and/or resources affect both adults and children. This effect has been observed both for reasoning as well as reading tasks (see Daneman & Carpenter, 1980, 1983; Engle, Cantar, & Carullo, 1992; Raney, 1993; Walczyk, 1993). For example, reading difficulty increases when a greater number of inferences must be made and a larger number of anaphoric references must be resolved (determining the antecedent of a pronoun). Most authors have deduced that inference making and anaphoric reference resolving use up cognitive resources (Britton, Glynn & Smith, 1985).

Determining the cognitive load of a given component of a task or of the task as a whole is not always a straightforward endeavor. Subjects are often 'strategic': they may anticipate, defer, or even eliminate some of the processing. Thus, it is often impossible to discern whether a given instance of poor performance is the direct result of inaccurate declarative or procedural knowledge, or whether it stems from problems connected with the management of that knowledge. In order to properly assess the problem and later take appropriate action, the reasons for the poor performance must be understood.

The problem of determining the source of the errors and the origins of inadequate performance has been addressed in several domains. The issue was first attacked in the study of memory strategies. As I stated previously, even when subjects know of a procedure, know how and when to use it, and are motivated to do so, it is often the case that they do not in fact implement it. In attempting to explain this paradox, several researchers have used the secondary task paradigm (or added task paradigm) to show that the mere implementation of certain procedures is cognitively costly in its own right (Bjorklund & Harnishfeger, 1987; Guttentag, 1984; Kee & Davis, 1988). In some cases, this cost is so high that the use of the procedure deteriorates performance instead of improving it.

In another domain, that of problem solving, Sweller (1988, 1993; Sweller & Chandler, 1991; Paas, 1992) and his colleagues recently showed that the use of the conventional 'means-end' strategy creates a heavy cognitive load for novices. This load is thought to perturb the construction and storage in memory of a solving schema like the ones used by experts in the field (e.g. mathematics, physics, etc.). For geometry or algebra problems, for example, the implementation of a strategy like means-end analysis amounts to creating a secondary task, which leads to poorer performance. Consequently, lightening the cognitive load enhances performance considerably. Sweller and his colleagues.obtained substantial improvements in performance by having pupils work on sample problems which were already totally or partially solved. The children's progress was reflected in their higher performance on immediate and delayed transfer tests (see Paas, 1992). Sweller reasoned that learning was hampered when activities which increase the cognitive load were added to a primary task, thereby acting as a secondary task. Backed by this assumption, he extended his research to other domains, where he showed, for instance, that the way in which a diagram or graph is presented influences how well it is learned. With an 'integrated' presentation, where both the graph or diagram and the labels of the items drawn or plotted on it are presented together, learning and memorization were better than in the control condition where the two sources of information (the diagram and the legend) were presented separately. According to Sweller and Chandler (1991), diagrams presented in the conventional manner force subjects to divide their attention and do the integrating themselves. This creates an additional cognitive load which hinders learning.

These two examples pertain to reasoning and problem solving. They mainly show that an activity which introduces a cognitive load surpassing the subjects' capacity either infringes upon the reasoning and/or problem solving process or thwarts learning. My final illustration is aimed at showing that the addition of a secondary task can cause a decline in performance, even in adults who are considered to be experts.

In French, the verb and the subject must agree in number. However, in most cases, there is a written mark of agreement but no oral trace. Subject-verb agreement therefore cannot be detected in the spoken language (we hear '*il chante*' for he sings as well as for they sing). In general, all university students know the verb agreement rule and have no difficulty applying it . The verb forms used by students are usually correct, even in difficult cases like '*Le chien des voisins arrive*' (literally, the dog of the neighbors is arriving). From time to time, however, errors such as '*Le chien des voisins arrivent*' (the dog of the neighbors are arriving) are made by students who otherwise know and apply the rule. We hypothesized that errors of this type, which are rare but made by all subjects, are enhanced by a temporary cognitive overload. The temporary nature of this overload is what makes the occurrence of these errors difficult to predict. To test this hypothesis, we asked students to recall a series of very simple sentences in which the noun phrase contained two nouns which were either the same in number (both singular or both plural) or different in number (singular/plural or plural/singular), as in the above example. The students recalled these sentences either alone or while executing a secondary task (recall the five words given after the sentence, or count the clicks heard while recalling the words). The students (experts) did indeed make agreement errors based on adjacency, i.e. they had a tendency to make the verb agree with the immediately preceding noun (especially if it was plural). However, most of the mistakes were made in the secondary task condition. Thus, the secondary task tended to make apparent (but not trigger) errors which would not be detected in normal circumstances (Fayol & Got, 1991; Fayol & Largy, 1992; Fayol, Largy, & Lemaire, 1994). It is legitimate to conclude that the secondary task altered the message checking process and brought out errors which were caused by the (automatic) activation of the number morpheme of the verb, but which would normally be edited by the writer before the sentence is written down (see Levelt, 1983; 1989). The series of examples I have just given shows very clearly that even the performance of experts declines, and often considerably, when a secondary task is added to the main task. In activities as complex as reading, writing, or arithmetic problem solving, any one of the component processes of the task may be difficult to carry out. Difficult components such as the coordination process generate an additional cognitive load similar to that of a secondary task. If the corresponding cognitive resources are drawn from a common pool, then the other components utilizing that resource pool may no longer have enough resources to accomplish their task. A degradation in the performance of one or more of the components ensues (the components of one and the same activity acting as opposing activities).

A study using a simple writing task (Bourdin & Fayol, in press) provides a good illustration of a decline in how well one component of a task is carried out when another component becomes more difficult to manage. Eight-year-old children and adults were given lists of words to be recalled orally or in writing. As predicted, an interaction between age and recall mode was observed, i.e. children recalled more words in the oral mode than in writing, while adults were more effective at written than oral recall. We hypothesized that the poorer performance of the children in the written mode was partially due to difficulty planning and managing the graphic transcription. Indeed, 8-year-olds most likely have not yet automatized the writing system. This means that they must devote more cognitive resources than adults to the management of the writing process. To validate this hypothesis, we (a) made the children's task simpler by asking them to dictate the words to an adult and (b) further burdened the adults by making them write the recalled words in longhand with capital letters only (a system they know but seldom use, especially not with capital letters in succession). The results went along with our predictions: the children's performance improved and the adults' performance deteriorated. In short, simply altering the handling ease of the graphic component is enough to induce a change in short-term memory performance.

## On some of the implications of the cognitive resource management approach

The theoretical framework I have just outlined not only accounts for and serves as a common ground for explaining numerous, well-known facts, it also forms a basis for designing teaching methods that might promote an improvement in the use of declarative or procedural knowledge in complex situations.

One series of findings which can easily be interpreted in terms of cognitive resource allocation concerns the impact of so-called advance organizers (text titles and questions asked before a text is read or heard). In all of the very numerous cases where advance organizers are used, performance is better than in the control condition (no titles, questions asked after text reading or listening). This improvement can be explained by the lighter processing load or by the encoding strategy changes brought about by the advance organizers. Indeed, readers or listeners who are given titles and questions in advance can select important information as it is needed. Without these cues, they do not know what task will be requested and therefore must try to remember as much of the information as possible. The influence of the task instructions can be interpreted in much the same manner.

A second series of findings which can also be partially explained in terms of cognitive resource management deals with the instability of performance across repeated executions of the same task. For example, Siegler (1991), Siegler & Jenkins (1989) found that 4- and 5-year-olds who were solving a large number of addition problems did not discover the 'min(m, n)' strategy for several weeks. All of the children used a variety of strategies (at least five), and in a highly variable fashion. Moreover, the min(m, n) strategy was not discovered on the problems the experimenters deemed the most conducive (e.g. 1 + 24). In the majority of the cases, the strategy was only used on problems the children apparently had no trouble solving. It appears as though the discovery was in fact made because the easier solving process released some of the subject's cognitive resources (Case, 1985). In addition, the discovery of the strategy did not systematically or immediately lead to a generalization. In other words, the discovery of a strategy is only a preliminary step towards its mastery. Siegler's results are consistent with the correlations observed elsewhere between previously acquired knowledge and strategy use. These correlations can also be interpreted in terms of cognitive resources. When declarative knowledge is well acquired and complete, its activation is less costly, and the newly available resources facilitate the implementation and management of strategies.

There is a third series of findings obtained in an area which is not traditionally studied in the joint research terrain of cognitive and educational psychology. These findings pertain to the effects of social variables. Within the past decade, a great deal of research has shown that human cognitive activity is not only influenced by the intrinsic properties of objects, but is also determined by the social conditions underlying the subject-object relationship (Doise, 1982; Doise & Mugny, 1981; Gilly, 1989). The subject-task relationship is socially mediated in all cases. A subject's performance is dependent upon the degree of compatibility between the social situation in which it is inserted and the past personal experiences associated with the accomplishment of 'similar' tasks. Performance is better when the learning situation is consistent with past school-learning experiences. Monteil (1992, 1993) also interprets these findings (and many others) in a theoretical framework based on the notion of cognitive resources. According to Monteil, the more consistent the current learning or problem solving situation is with the subject's past, the lower the demand for resources to process the current context, and thus, the higher the performance. In contrast, performance deteriorates when the degree of congruency declines, since the resources allocated to the processing of the context are no longer available for task execution.

The same perspective can be used to account for another series of findings related to tutoring and the *'proximal zone of development'* (Bronckart, 1985). We know that when a child is tutored by another child or an adult, there is often a long-lasting improvement in performance. It can be assumed that this progress is to some extent the result of (a) the decreased processing load during the interaction itself (Gelman & Meck, 1983), and (b) the subsequent improvement in the child's understanding of the concepts, and above all, in his or her ability to coordinate them. However, the gain is only possible if each of the individual components is not too difficult to acquire, and if their coordination is not too complex. The number of cognitive resources allocated to the management of each component and/or to their coordination may be a determining factor in whether the tutoring will be effective immediately or subsequently, and may limit the potential extent of the improvement.

A final series of studies in the field of pathology should also be integrated into the cognitive resource perspective. In a recent study, Nicolson and Fawcett (1990) showed that dyslexic adolescents did just as well as normal ones in a simple motor balance task. However, as soon as a secondary task was added (counting backwards auditory choice task) the performance of the dyslexics was significantly inferior to that of the normals. The authors interpreted these results by presuming that dyslexics need to allocate more cognitive resources to the control of balance, in such a way that any secondary task leaves fewer resources for maintaining balance and thereby causes a decline in performance.

To summarize, then, the notion of cognitive resources appears to be extremely useful in interpreting a large number of phenomena in a wide variety of domains. Its scope is so broad that it can be used to establish some conceptual links between perspectives often considered to be unrelated. These include developmental psychology, social psychology, research on instruction methods, types of learning aids, etc. Although this notion only deals with one aspect of the problem, it can serve as a common ground and facilitate exchange and joint action.

In the perspective of direct instruction and as a complement to general psychology research, the notion of limited cognitive resources can contribute to the furthering of our understanding of why the availability of declarative and procedural knowledge is a necessary but insufficient condition for success. This holds true for activities ranging from automobile driving (Duncan, Williams, & Brown, 1991) to verb-subject agreement (Fayol, Largy, & Lemaire, 1994). An effective approach might be to design activities where procedures are selected and carried out in parallel (see Spelke, Hirst, & Neisser, 1976). In other words, subjects could be taught to implement a given procedure even when it is only one part of a more complex activity, and even if the other components interfere with it to varying degrees.

It goes without saying that the notion of cognitive resources is but one aspect of learning and of the implementation of declarative and procedural knowledge. It should not be considered as the most important concept in learning, nor should it be neglected simply because it is different in nature from the knowledge itself.

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**Michel Fayol.** LEAD/CNRS, URA 1838, Faculté des Sciences, 6 Bd Gabriel, 21000 DIJON.

*Current theme of research:*

Production of writen language, with special attention to spelling, Numerical abilities.

*Most relevant publications in the field of Educational Psychology:*

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