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Development of a Theoretical Framework and Practical Application of Games in Fostering Cognitive and Metacognitive Skills

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In this article, traditional games are proposed as complementary tools for metacognitive intervention. Games allow addressing various cognitive and metacognitive processes and strategies involved in learning and thinking. They are easily available, stimulating for students who usually exhibit resistance to learning, and represent valuable learning devices for students for whom few cognitive education programs are available (young children and students with intellectual disability). A framework for analyzing games with regard to the (meta)cognitive processes involved is presented and criteria for mediation are formulated. Two adolescents with intellectual disability participated in an intervention based on this model. The students progressed on a procedural level as well as on different untrained tasks. Results were maintained after 8 weeks. This study, although not generalizable, illustrates the relevance of using games in a metacognitive perspective.

Keywords: games; metacognition; intervention; learning difficulties; intellectual disability

Metacognition plays an important role in learning and thinking (Blair & Razza, 2007; Pintrich & De Groot, 1990; Veenman, Van Hout-Wolters, & Afflerbach, 2006; Zimmerman & Schunck, 2001). Students with learning difficulties (e.g., Montague & Bos, 1990; Short et al., 1991; Swanson, 1990) as well as people with intellectual disability (Bebko & Luhaorg, 1998; Brown, 1978; Brown & Campione, 1981; Cornoldi & Campari, 1998; Short et al., 1991) prove to have underdeveloped metacognitive skills. In the scientific literature, specific cognitive education programs can be found that are aimed at developing cognitive and metacognitive skills in different age groups and populations. These programs are used to train different processes and strategies either with non-school-related tasks (e.g., Büchel & Büchel, 1997; Feuerstein, Rand, Hoffman, & Miller, 1980; Haywood, Brooks, & Burns, 1992; Klauer, 1989) or within specific curriculum domains, such as reading (e.g., Brown & Palinscar, 1987; Paris, Cross, & Lipson, 1984),

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writing (e.g., Harris & Graham, 1996; Re, Cazzaniga, Pedron, & Cornoldi, 2009), and mathematics (e.g., Mevarech & Kramarski, 1997; Montague, 2003; Van Luit & Kroesbergen, 2006). Non-school-related tasks have been preferred by some authors for two major reasons. Firstly, as those tasks require little specific knowledge, the child can entirely focus its attention on processes and not on content (Feuerstein et al., 1980). Secondly, beliefs of low self-efficacy (Bandura, 1997) or negative emotions are avoided as the child has no experience of repeated failure with those kinds of tasks. School-related tasks, on the contrary, may provoke negative feelings and emotions and can lead to a mental block or resistance from the child in engaging in the task and accepting the mediation process.

The aim of this article is to show that games[1] can be considered as highly valuable tools for metacognitive interventions. Games can be applied exclusively, but they can also be used as complements to cognitive education programs. They can further be used by teachers or special educators who do not have cognitive education programs available to them, who cannot implement an entire program in their curriculum, or who lack the specific training associated with certain programs. They also are useful for young children or persons with intellectual disability, for whom few programs that are adapted to their cognitive level are available (sometimes a program may be suitable, but only available in another language). Games present the same advantages as the non-school-related exercises in cognitive education programs. They allow addressing various cognitive and metacognitive processes as well as motivational aspects. Since they are non-school-related, they circumvent possible negative emotions. In our own clinical practice we observe that games represent excellent means to get students exhibiting strong resistance to learning involved in the learning process. Games are intrinsically motivating by definition, and, generally, students spontaneously allocate attentional resources and engage in cognitive effort when playing a game (see, e.g., Malone & Lepper, 1987; Tusch, Hussy, & Fritz, 2002). According to Wong (1993), and experienced in our own clinical practice, especially adolescents often do not see the utility of working on non-school-related cognitive education tasks. The perceived utility (Eccles & Wigfield, 2002) of what has been learned with regard to strategic behavior while playing a game may be more substantial, as students can immediately experience the benefits of a strategic task approach. Likewise, students are more disposed to seek reasons for success or failure in their own way to deal with the task than attributing the outcome to factors that they cannot control. Thus, an adequate attributional style, which favorably influences learning and transfer (e.g., Borkowski & Thorpe, 1994), can be fostered. Also, the same processes and strategies can be applied in a large variety of games, thus giving the child the opportunity to practice the taught strategies with diverse material, which is a condition for transfer (Borkowski & Muthukrishna, 1992; Brown & Campione, 1981; Fuchs et al., 2003).

It will be clear to the reader that games in this context are not merely played for fun. They are tools to have students engage in strategic learning and develop metacognitive skills in a nonthreatening situation. One must, of course, make the students aware that they can apply the discovered strategies and trained processes in their academic learning and that strategic behavior in school tasks can be equally rewarding.

Several authors (Borkowski & Muthukrishna, 1992; Dignath & Büttner, 2008; Dignath, Büttner, & Langfeldt, 2008; Ellis, 1993; Haywood, 1997; Perkins & Salomon, 1989) have criticized the fact that the general cognitive education programs are not enough linked to the classroom context and the curriculum. Conway and Hopton (2000, p. 140) refer to this as "academic and locational isolation." Games can easily be integrated in the regular classroom lessons. The teacher can then directly link the trained processes and strategies to current school tasks. In order to promote transfer (we will come back to this later on), the games should immediately be followed by tasks in which we want the students to apply the taught strategies.

It is important to stress that an effective application of games aiming at the improvement of children's cognitive and metacognitive processes requires being knowledgeable about metacognitive theories and principles of cognitive education, as is the case for the application of any cognitive education program, but the teacher does not need to undergo specific program training.

No systematic evaluations of using traditional games as metacognitive training tools are known to us. Existing studies mostly address computer games, either in the prospect of knowledge acquisition or reasoning skills development (see, e.g., Rebetez & Betrancourt, 2008), or in a neuropsychological perspective. In the latter, computer games are typically proposed to assess, train, or rehabilitate specific executive functions, such as attention or working memory. In the scope of metacognitive intervention, the work of Fritz and Hussy (1996, 2001) can be mentioned. These authors have developed a training program (two hours per week during two years) for special education classes or classes in disadvantaged neighborhoods. Their program consists of three kinds of playful activities: role-play, pretend play, and construction games. According to the authors, these activities require metacognitive processes, such as defining the goal and the steps needed to achieve that goal, and controlling one's own actions and results. However, these processes are trained only during the last six months of the program; the eighteen months before, the children mainly learn to self-regulate their behavior. The training effects after two years have been evaluated in a study involving 4 special education classes with 65 children who received the program (experimental group), and 3 other special education classes with 47 children without training (control group). A task, in which the children had to transport six wooden animals from their enclosures to a specified location in a zoo, according to a set of rules, was used for pre- and posttest evaluation (for a description, see Fritz & Hussy, 2000). The task allowed estimating four metacognitive processes: planning, control of one's own actions (number of moves), respecting the rules, and evaluation (correcting the plan when needed). The experimental group showed significant gains on the four variables contrary to the nontrained children who did not improve their scores. In this intervention, only one kind of traditional games was used (construction game) and it represented only a very small part of the program. Moreover, the training effects due to the construction game cannot be differentiated from those due to the role-play and pretend play, two activities that do not correspond to the parlor games I refer to in this contribution.

Games also have been used for observation or assessment of cognitive and metacognitive processes. Saldaña (2004) used Master Mind for the dynamic assessment of metacognitive processes with participants presenting moderate to severe intellectual disabilities; Allal, Baeriswyl, Bach Mai, and Wegmüller (1987) used a number game to assess self-evaluation skills in young children at primary school; and Dermitzaki, Leondari, and Goudas (2009) examined the relationship between cognitive, metacognitive, and motivational strategies in young children while playing a construction game.

A TASK ANALYSIS FRAMEWORK FOR GAMES

Using games as tools for metacognitive intervention requires a precise task analysis. This allows identifying which (meta)cognitive processes may be inefficient and explain the student's difficulty, choosing a game that addresses the specific processes one wants to develop in the student, designing tailored mediational strategies, and modifying or simplifying the game in accordance to the student's needs. An important argument for task analysis also resides in the fact that this will enable the teacher to identify transfer tasks for the trained processes and strategies. Transfer requires a deliberate abstraction of principles that are applicable to different tasks or contexts (Perkins & Salomon, 1989). It must be remembered that not only students with learning difficulties or intellectual disabilities encounter difficulties when they have to transfer what they have learned to new situations (see, for instance, the 1980 study by Gick & Holyoak with university students). It is often difficult for teachers to identify concrete, curriculum-related exercises for which the same strategies can be applied. They tend to seek tasks that share surface similarities instead of tasks with similar underlying structures or processes. Leat and Lin (2003) reported that the teachers participating in their study and who were trained in teaching thinking skills found it most difficult to show to their students in which other situation the trained skills could be applied. Generally, cognitive education programs neither comprise a systematic identification of school-related exercises, nor provide a direct application in school tasks. This may partly explain the often observed lack of transfer of what has been learned in

TABLE 1. Components of the Framework for Task Analysis

Processing components (object of intervention)

1. Basic cognitive processes
   - Exploration
   - Encoding
   - Mental representation
   - Attention: sustained, selective, inhibition, cognitive flexibility
   - Visual organization
   - Working memory (structural aspect)
2. Complex cognitive processes
   - Comparison
   - Induction
   - Deduction
3. Metacognitive processes
   - Planning
   - Monitoring
   - Evaluation
4. Cognitive strategies

Task components

5. Task features
   - Presentation format: verbal, paper-and-pencil, material that can be manipulated
   - Content: concrete, abstract
   - Declarative knowledge

these programs to school contents (see, e.g., Arbitman-Smith, Haywood, & Bransford, 1984; Loaer, Chartier, Huteau, & Lautrey, 1995; Tomic, 1995). In a recent intervention study in a special education class (Hessels, Hessels-Schlatter, Bosson, & Balli, 2009), tasks from cognitive education programs were regularly alternated with school exercises. Moreover, the teacher who directed the intervention analyzed all tasks with regard to the underlying processes, which allowed him to guide his students in discovering how a same strategy could be applied in very different contexts (including mathematics, text comprehension, and their cooking lessons), and how to operationalize a strategy and adapt it to the specificities of the different activities.

I propose hereafter a framework for task analysis for traditional parlor games (see Table 1). The framework is based on recent theories of information processing and metacognition (Baddeley, 1999; Bjorklund, 2005; Brown, 1987; Davidson & Sternberg, 1998; Pintrich, Wolters, & Baxter, 2000; Schraw, 1998; Sergeant, 1996; Veenman, Wilhelm, & Beishuizen, 2004). The first level of the framework concerns the cognitive processes, metacognitive processes, and cognitive strategies that are required for a given task and which may be tackled in the intervention (processing components). The second level includes specific task features, such as the way the game is presented, as well as the declarative knowledge that is needed to fulfill the task (task components).

Processing Components

Basic Cognitive Processes. Basic cognitive processes are mental activities that enable the individual to process information coming from the outer world or retrieved from long-term memory. These are: 1) exploration: systematic scanning of available information; 2) encoding: identifying the relevant characteristics of the task and encoding them in working memory; 3) mental representation (in the sense of having a sketch of the problem in mind); 4) attention, which includes four components: sustained attention (sustaining one's attention over time), selective attention (focusing attention on a given object), inhibition (suppressing a dominant or automatic answer, resisting to interferences or irrelevant information), and cognitive flexibility (shifting one's attention from one aspect to another); 5) visual organization: visual information processing such as visual discrimination, figure-background discrimination, spatial relations, part-whole relations; and 6) working memory, usually considered as part of the structural aspect of cognition; as the working memory load of a certain task is of particular interest in understanding the students' difficulties and for remediational purposes, it is integrated in this framework.

Complex Cognitive Processes. Complex cognitive processes are manipulations of information or representations that include the application of logical relations. The complex cognitive processes included are: 1) comparison; 2) induction; 3) deduction.

Metacognitive Processes. Although differences exist among researchers in the way metacognition is conceptualized, Hacker (1998) sees an emerging consensus in the sense that a definition of metacognition should include at least two components. The first component is the knowledge one has about one's own knowledge and cognitive functioning, which is called metaknowledge or metacognitive knowledge. The second component refers to the control and regulation of one's own cognitive activities, which are called metacognitive processes, metacognitive strategies, or metacognitive skills. Metaknowledge typically refers to three kinds of knowledge (Flavell, 1987; Pintrich et al., 2000): knowledge about one's own strengths and weaknesses, knowledge about the task characteristics and difficulty, and knowledge about strategies (knowing strategies, knowing about their utility and the conditions under which these can be applied). With regard to metacognitive processes, three main activities are to be found in most theories (e.g., Borkowski, Chan, & Muthukrishna, 2000; Brown, 1987; Paris et al., 1984; Schraw, 1998; Zimmerman & Schunck, 2001): planning, monitoring, and evaluation. 1) Planning includes activities such as defining the task, evoking prior knowledge, anticipating potential difficulties, defining the steps to be implemented and their order, choosing strategies and procedures, estimating the time and cognitive effort required to perform the task; 2) monitoring consists of controlling and regulating one's ongoing activities, such as being aware of a problem, going back to the instructions when needed, adjusting the plan and strategies, predicting consequences of actions, estimating results, verification and justification of obtained results; 3) evaluation processes take place at the end of an activity and are devoted to a final control, global judgments about the problem-solving process and results, and connecting the implemented strategies and procedures with their effectiveness.

Cognitive Strategies. Cognitive strategies are activities that enable the individual to more effectively and efficiently learn and solve problems. Examples are summarizing, highlighting information, verbalizing, predicting, and organizing information.

Cognitive processes and strategies are at the same time the vehicle for metacognitive processes and are determined by them. For instance, the cognitive process of comparison can be applied for monitoring; the strategy of numbering can be applied for planning. Conversely, anticipating difficulties (planning) will lead the individual to use strategies to overcome them. This reciprocal relationship between cognitive processes and strategies and metacognitive processes is also expressed by Veenman et al. (2006, p. 6), when they declare: "If metacognition is conceived as (knowledge of) a set of self-instructions for regulating task performance, then cognition is the vehicle of those self-instructions. These cognitive activities in turn are subject to metacognition, for instance to ongoing monitoring and evaluation processes."

Task Components

Task Features. Task features are the components that are inherent to the task. A game may be presented verbally, in a paper-and-pencil format, or can consist of material that can be manipulated. The game can contain concrete and/or abstract information, and require specific declarative knowledge, for example, about numbers or geometrical shapes. The analysis of these components may help choosing a game according to the child's level, identifying factors that render the task difficult for a particular child, or simplifying and/or modifying the game. For instance, the child may lack prerequisite declarative knowledge or have trouble understanding the meaning of signs or symbols (abstract information) included in the game. It can also help to decide to present a paper-and-pencil game after a game with material that can be manipulated in order to lead the child to a more abstract level of reasoning.

All cognitive and metacognitive processes are involved in playing games, but at varying levels according to the kind of game. For instance, exploration, selective attention, comparison, and monitoring are strongly implied in observation and visual comparison games (see example below). Mental representation, cognitive flexibility, deduction, working memory, and planning are highly required in strategy games such as chess.

APPLICATION OF THE FRAMEWORK ON TWO DIFFERENT GAMES AND TRANSFER TO SCHOOL SUBJECTS

To illustrate how the framework for task analysis can be applied and how to promote transfer to school-related tasks, I present two examples of widely found games: Differix and Cluedo.

Differix

Differix is an observation and visual comparison game (see Figure 1). The game consists of a series of boards, each containing 9 variations of the same image. The images differ in very small details (in this example, e.g., the position of the tail or of the whiskers). All nine images are also represented on separate cards and the child has to put the identical card on each of the nine images on the board. The main basic cognitive processes involved in this game are exploration (inspection of the entire board and the nine alternatives), selective attention (focusing on one single aspect at a time, e.g., the eyes), inhibition (ignoring other possible differences), and visual organization (discrimination, spatial, and part-whole relations). With regard to the complex cognitive processes, Differix essentially requires comparison

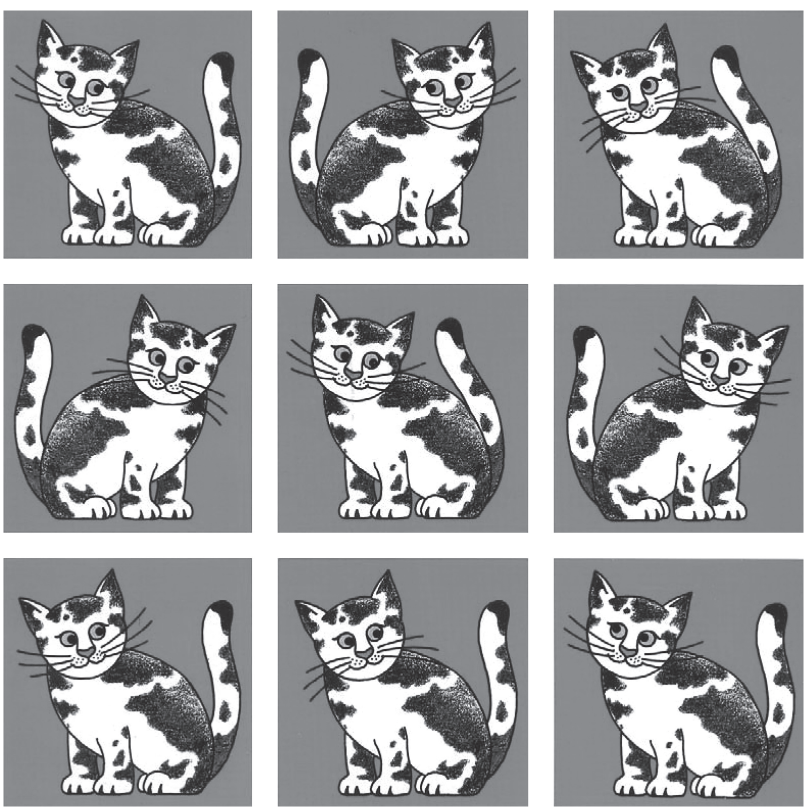

FIGURE 1. Example of Differix.
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(determining relevant and discriminative criteria for comparison and maintaining these constant during the comparison process). In the metacognitive processes that are activated, monitoring is the most essential. The child must refrain from impulsivity (giving a response before proper evaluation), has to control small details, and should be systematic in its exploration, comparison, and control when evaluating the alternatives.

In order to develop the different cognitive and metacognitive processes, the teacher's role will be to lead the children to an awareness of the game's characteristics and difficulties (in particular that all images are very much alike) by asking them to explore, describe, and compare the images. The teacher should prompt the children to focus their attention on specific and relevant details and encourage them to systematically control, from left to right and from top to bottom. Being systematic supports both selective attention (focusing on one element at a time) and working memory (reduction of the number of elements to be processed). The teacher should further facilitate the children becoming aware that an unplanned and uncontrolled approach leads to errors that have repercussions on the whole task. Different strategies that support perception (e.g., taking reference marks, counting, verbalizing) can be introduced by the teacher.

A school-related task (Figure 2), in which the same processes and strategies must be activated, can then be presented, giving the children the opportunity to transfer the trained strategies. In this example, the transfer task is very different from the game, both in surface and structure. The aim is that the children suitably apply previously learned strategies in tasks or situations that differ from those in which the strategy was originally learned.

It can be ascertained that an efficient execution of this reading task requires all the underlying processes and strategies of the above mentioned game. For example, the children need to explore the model and the various words, have to focus their attention on one letter at a time (selective attention), must inhibit other words or already checked letters, detect parts in wholes (letters in words), discriminate the letters and consider their order and spatial

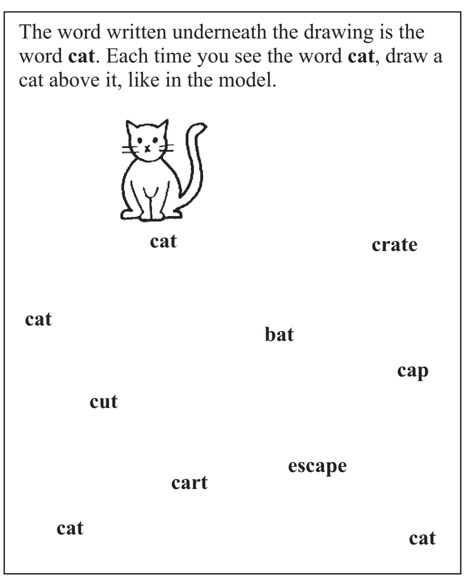

FIGURE 2. Transfer task in reading.

position (visual organization), and compare the different letters of each word with the word cat. Also, monitoring plays a role in task resolution, as well as strategies such as taking reference marks (e.g., using the letter c for the beginning of the words), counting the number of letters, and verbalizing (reading out loud the words actually written). With an adequate mediation (see next section), the teacher will help the children apply the acquired processes and strategies to this new task.

Cluedo

The second game described in this article is Cluedo, which is a game of deduction. The players are detectives who must find out who the criminal is, where the crime has been committed, and what kind of weapon has been used. To do so, the players move on a board representing different rooms of a house in search of clues. The players use the collected clues to make hypotheses and, by deduction, to solve the enigma. The main cognitive and metacognitive processes involved in this kind of game are mental representation (of the situation and the suspect), cognitive flexibility (changing one's hypotheses, adapting one's mental representation), working memory, deduction, planning (in which order to proceed), and monitoring (e.g., systematic control of one's hypotheses). An important difficulty in this kind of game is remembering the gathered clues and intermediate conclusions (working memory). In order to keep track of all the information, each player is provided a notebook (which represents an external memory strategy).

An example of a mathematic problem for which the application of the trained processes and strategies will be beneficial, goes as follows:

> Normally, a chicken lays one egg a day. Mary owns 48 chickens. This Monday she found 40 eggs, Tuesday and Wednesday as many eggs as there are chickens, Thursday 45 eggs, and Friday 44. Mary has 15 egg boxes and each can contain 6 eggs. Does she have to buy more boxes? If yes, how many more boxes does she need? If not, how many eggs can she still put in the remaining boxes?

In this task, the children need to create a mental representation of the situation, must be able to shift attention from one bit of information to another and change their representation when needed, deduce different information ("as many eggs as," the operations that must be executed), plan the steps and their order, and monitor problem-solving activity. To better deal with the task, they can underline the relevant data in the instructions, draw a schema, write down the calculations and intermediate results, give titles to the calculations, or in other words, use an external memory strategy (leaving traces).

An example of a transfer task in reading would be text comprehension, for which the children must create a mental representation, seek for clues (textual, contextual, knowledge base), make inferences, and monitor their own comprehension. Underlining, taking notes, or making a schema would also be useful in this kind of task. An example is given in Figure 3.

When reading the first line, the children can already make a mental image of the situation of two boys who play together every day. The children then have to show cognitive flexibility and change their initial mental representation, because the next sentence indicates that they do not play together on Wednesday. The children have to take into account various

The boy who loved broccoli

John and Peter are best friends. Everyday they play together, except on Wednesday when John goes swimming and Peter plays soccer after school. John often comes to eat at Peter's house, but he does not like vegetables at all. Peter always takes a long time to finish his meal: "The longer it takes, the longer I enjoy it", he always says with a big smile.

1) Who takes a long time to finish his meals?
2) Do the boys play together on Monday and Thursday?
3) Which of the two boys likes broccoli?

FIGURE 3. Transfer exercise in text comprehension.

information, which means that working memory plays an active role. To unload working memory, they can use strategies like underlining or encircling. The children have to deduce that it is Peter who likes broccoli as John does not like vegetables. To plan the exercise, the children can first read the questions, which will direct their attention toward essential information. Finally, the process of monitoring is important: did I understand well or do I have to re-read, is my representation of the story coherent?

MEDIATION

In order to develop the student's cognitive and metacognitive skills, the teachers should provide a well-prepared mediation during the game. They must stimulate metacognitive reflection in the students so that they become aware of their own cognitive functioning, guide them in the discovery of strategies, and induce active problem-solving behavior. Such mediation is carried by metacognitive questioning. The teachers invite the student to think about the game characteristics and its potential difficulties. They prompt them to plan ahead, guide their attention toward relevant task characteristics, and encourage them to generate and test hypotheses. They question them about the way they proceeded, the efficacy of the applied strategies and the conditions under which they can be applied, and lead them to apply logical reasoning for controlling. Finally, the teachers foster an active and self-regulated behavior by returning the students' questions.

Verbalization has mainly two functions in cognitive education. First, it represents a powerful tool for awareness (Piaget, 1971; Prawat, 1989). Procedures and strategies are often applied automatically, which renders them inaccessible to consciousness, and thus not modifiable (Ericsson & Simon, 1993). Second, verbalization favors reflective and strategic behavior (Brown & Palinscar, 1987), as the students are brought to seek for clarifications, plan their activities, make predictions, and control and justify their actions. Research into the effects of on-line verbalization on learning and transfer has demonstrated that asking the participants to explain how they proceeded during the task and to justify their actions and answers leads to significant improvements in performances (Bannert & Mengelkamp, 2008; Carlson & Wiedl, 2000; Dominowski, 1998; Rojas-Drummond, Pérez, Vélez, Gómez, & Mendoza, 2003; Short et al., 1991). Indeed, verbalization does not only operate on metacognitive processes but also on cognitive processes (Carlson & Wiedl, 2000; Hessels & Hessels-Schlatter, 2008). In particular, verbalization allows a double encoding of information, as visual information is also encoded in a verbal modality. This verbal encoding requires abstraction (concept induction), which activates the knowledge base in long-term memory. Mental representations must be organized and structured so that the child can communicate its thoughts. Verbalization also directs attention toward relevant information in the problem. Finally, justifications and arguments necessitate the child to follow a deductive reasoning. Metacognitive questioning thus plays a central role in mediation. As Paour and Cèbe (1999, p. 127; translation by the author) have formulated it, "Cognitive education devotes much more time to the anticipation of the action and the analysis of its consequences, rather than the action itself, the action being only the necessary starting point for a critical metacognitive reflexion."

A crucial aspect of mediation is fostering transfer. Indeed, transfer of knowledge and skills to new contexts or tasks is not a natural and automatic consequence of learning: it must be explicitly prepared (Brown, 1978; Fuchs et al., 2003). The research literature shows five teaching principles that are effective in promoting transfer:

1. Developing metacognitive awareness (metaknowledge). In order to select a relevant strategy for a given problem, students must not only know strategies, but they must know when and how they can be best applied (e.g., Borkowski & Muthukrishna, 1992; Borkowski & Thorpe, 1994; Brown & Campione, 1981; Paris & Jacobs, 1984; Wong, 1994). In other words, students should get the opportunity to reflect upon the taught strategies as well as on the relationship between strategy use and performance. The meta-analyses conducted by Dignath and Büttner (2008; Dignath et al., 2008) show that interventions that include teaching of metaknowledge yield more important training effects than interventions that do not include metaknowledge. Students must also have knowledge about the tasks' characteristics and about the similarities between a given problem and other known problems (Fuchs et al., 2003). Brown and Campione (1984) showed that students who displayed high transfer capacity spent more time in analyzing and classifying the solutions they considered to a given problem.
2. Reformulation. The teacher has to bring the students to reformulate the strategies on a general and abstract level so that they do not remain embedded in a particular task or situation. This means that strategies need to be decontextualized (Perkins & Salomon, 1989) and deconcretized in order that they can be generalized to new situations for which their application may need to be adapted. For example, one might cross out something in order to remember that it has been done. Crossing out is a concrete and context-bound strategy. Its formulation on a more abstract and general level would be "leaving traces."
3. Comparing tasks. The teacher must incite the students to regularly compare current activities with previous ones or new activities in order to lead them to detect similarities or common principles within the tasks. This process allows developing more rich and flexible representations. Comparison must be directed on the structure of the task and not on its surface characteristics or the contextual specificities that do not apply to other situations. The students must learn to broaden the categories they are using in order to be able to group problems requiring the same underlying principles or strategies (Barnett & Ceci, 2002; Fuchs et al., 2003). Differences between tasks must also be discussed so that the students become aware that a strategy can rarely be applied in exactly the same way across tasks, but that it must be adapted to the characteristics of the new problem (Prawat, 1989).

4. Alternating between games and school-related tasks. The students must be given the opportunity to directly apply in a school-related task what they have just learned in a non-school-related task. This is another way of bypassing the context-bound issue. Researchers (Bosson et al., 2010; The Cognition and Technology Group at Vanderbilt, 1993; Conway & Hopton, 2000; Davidson & Sternberg, 1998; Dignath & Büttner, 2008; Hessels et al., 2009; Perkins & Salomon, 1989) are more and more convinced that interventions that are conducted without any direct link to academic content do not lead to transfer. Another noteworthy argument for alternating between different types of tasks is perceived utility. It is often difficult for the students to acknowledge how principles and strategies trained on non-school-related tasks can be useful for their school learning (Kuhn & Pearsall, 1998; Wong, 1993). It is also difficult for them to recognize in which situations these strategies could be beneficial, simply by discussing other (virtual) situations. Students need hands-on experiences (see also Wong, 1994). In this view, the analysis of the games in terms of cognitive and metacognitive processes is mostly helpful as it assists the teacher in the choice of relevant school tasks requiring the same processes to be applied.
5. Developing self-efficacy and adequate attributional style. The application of cognitive and metacognitive strategies is subjected to motivational conditions (Pintrich, 1999). A deliberate strategic behavior requires more effort than routine procedures. Students must have the motivation to carry out this effort, must feel capable of doing the task at hand, and must be convinced that they have some control over the learning situation (Bereby-Meyer & Kaplan, 2004; Borkowski & Thorpe, 1994; Pintrich, 1999). Metacognitive interventions that tackle self-efficacy and attributional style have been shown to be more successful than interventions that do not consider those variables in their training (Borkowski, Weyhing, & Carr, 1988; Dignath & Büttner, 2008; Dignath et al., 2008).

Practice also is of great importance. Strategies and processes that are not applied automatically require cognitive resources next to those needed for the task at hand, which can lead to working memory overload (Fitzsimons & Bargh, 2004; Perkins, Simmons, & Tishman, 1990). This explains the often observed inefficiency of newly acquired strategies (utilization deficiency; Miller, 1990; see also Bjorklund, 2005; Bjorklund, Schneider, Cassel, & Ashley, 1994). Consequently, teachers should give enough opportunities for practice so that strategies become automatic and integrated in the students' repertoire (Borkowski & Muthukrishna, 1992; Dignath & Büttner, 2008; Feuerstein et al., 1980; Veenman et al., 2006).

ILLUSTRATION OF A METACOGNITIVE INTERVENTION USING GAMES

The model presented in this article has not yet been submitted to extensive experimental studies. Two pilot studies have been undertaken in order to estimate the potential value of a metacognitive intervention based on games. These case studies cannot offer a validation of the model, but give insight in intra-individual change following a game-based training. Such qualitative data are of interest for the development of effective interventions, as Borkowski, Reid, and Kurtz (1984) already underlined. As opposed to strongly controlled and group designs, case studies are more sensitive to individual characteristics and their interrelations, and present more ecological validity as they embed all contextual and individual related natural variations (Baumeister, 1984).

A first exploratory case study (Grossniklaus, 2008) was conducted to see which games would be adequate for use with people presenting moderate to severe intellectual disabilities. A girl aged 15 years and 8 months with moderate intellectual disability (IQ < 55) participated in a short metacognitive intervention (8 sessions). Pre- and posttests consisted of two analogical reasoning tasks, a geometry task, and exercises taken from the Analytical Perception instrument from Feuerstein et al.'s (1980) Instrumental Enrichment. The games used in this study proved to be useful and adequate tools for training of the various processes. Improvements in cognitive and metacognitive processes could be observed by both the teacher and researcher. However, no performance gains were found on the different (untrained) tasks. This was attributed to the before mentioned utilization deficiency (Miller, 1990) and to the fact that the training was extremely short, considering the population.

A second study (Grossniklaus, 2009) involving two 17-year-old adolescents with moderate to severe intellectual disability was undertaken. The metacognitive intervention consisted of 19 sessions of 45 minutes during which the same games and similar others were used. These were observation and visual comparison games, induction games, and construction games. The targeted cognitive and metacognitive processes during training were: exploration, selective attention, inhibition, cognitive flexibility, comparison, planning, impulse control, monitoring, and evaluation. The aim was also to develop various strategies (being systematic, verbalization/description, counting, using external memories, and making reference marks), as well as metaknowledge. The games were chosen according to their underlying processes and thus their relevance for the goals of the intervention. At the beginning of each training session, the teacher recalled the strategies that were learned in the previous session. Each session ended with a short application of the learned strategies in a transfer task that could be either school-related (reading, arithmetic), or non-school-related (i.e., other games or tasks taken from cognitive education programs).

The fifth and sixth training sessions will be described here as example. The game Differix that was presented earlier was used during these sessions. The specific goals for

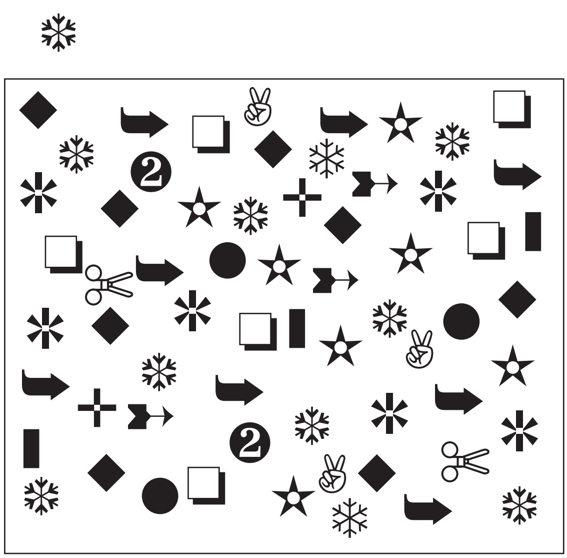

FIGURE 4. The Signs task (adapted from the DELV program).

canapé lit divan chaise

buffet armoire commode

c	o	m	m	o	d	e	b
a	r	m	o	i	r	e	u
n	m	e	l	i	t	b	f
a	d	i	v	a	n	l	f
p	c	h	a	i	s	e	e
é	u	e	e	l	b	a	t

FIGURE 5. Hidden words.

these sessions were to train exploration, selective attention, comparison, being systematic, and use of external memory strategies (e.g., turning around a card that was already checked). Before beginning the game, the participants were asked to precisely describe some of the cards, and then to compare some pairs of cards. After this preliminary phase, they could place each of the cards on the corresponding image on the board. With the next board, difficulty was augmented by adding irrelevant cards. Finally, a variation of the game was presented: the participants had to describe a card of their choice to the teacher who had to find the corresponding one on the board. The participants then had the opportunity to apply the trained processes and strategies on two transfer tasks: a simplified version of a task from a cognitive education program (DELV; Büchel & Büchel, 1997; Figure 4) and a school-related task (Figure 5). The participants were shown how the application of the different processes helps them in solving these new tasks.

In the Signs task (Büchel & Büchel, 1997), the participants have to cross out all the signs in the figure that are identical to the model. In the Hidden words task, the participants have to search for the given words in the grid. These can be presented horizontally or vertically.

The research questions were: 1) does the intervention improve cognitive and metacognitive processes and strategy use (procedural level)? 2) does this improvement lead to enhanced performance in different untrained tasks in which these processes play a role at varying levels (performance level)? The intra-individual training and maintenance effects were estimated with a pretest – intervention – posttest 1 – posttest 2 – design. The instruments used at pretest and posttests are presented in Table 2.

The instruments used to measure performance included inductive reasoning, selective visual attention, visual organization, geometry, mathematic problem-solving, and short-term memory. The learning capacity of the participants was assessed with the Analogical Reasoning Learning Test (ARLT; Hessels-Schlatter, 2002; Schlatter, 1999; Schlatter & Büchel, 2000). The test phase of the ARLT was presented again at posttest 1 in order to estimate the effects of the intervention on analogical reasoning. An observational checklist was used to evaluate the participant's problem-solving behaviors (procedural level) and included the targeted processes and strategies as well as additional aspects, such as sustained attention, rigidity/perseveration, and perseverance (motivation). Moreover, during the three test sessions, the participants' regular teachers filled in a questionnaire that assessed the students' manner to approach different kinds of tasks (strategic behavior) in their classroom

TABLE 2. Tasks and Instruments Used for Pretest, Posttest 1, and Posttest 2

Inductive reasoning
Analogical Reasoning Learning Test (ARLT; Hessels-Schlatter, 2002)
K-ABC: Picture arrangement subtest (Kaufman & Kaufman, 1993)
Selective visual attention
NEPSY: Visual attention subtest (Korkman, Kirk, & Kemps, 2003)
Visual organization (parallel tasks at posttest)
Instrumental Enrichment, Analytical perception: Drawings to complete (Feuerstein, Rand, Hoffman, & Miller, 1980)
Instrumental Enrichment, Part–Whole
School-related tasks (parallel tasks at posttest)
Geometry: Figures to copy on a grid
Mathematic: Mathematics problems
Short-term memory (only at pretest)
K-ABC: Digit span
K-ABC: Spatial memory
Observational checklist and questionnaire
Questionnaire filled in by the teachers
Observational checklist of cognitive/metacognitive processes and strategies

setting (which can be considered as far transfer). For example: "Does the student take time to explore the whole task before beginning to solve it?"; "Is the student able to focus his/her attention on one bit of information at a time?"; "Is the student out of task?" Each item was scored using a Likert scale with 4 = regularly, 3 = often, 2 = sometimes, and 1 = seldom/never. The questionnaires were completed with interviews with the teachers to have a more complete view of the classroom performance of the two adolescents, as well as examples from the teachers' experiences. A delayed posttest (posttest 2) was administered 8 weeks after posttest 1 in order to evaluate maintenance effects.

Synthesis of Nina and Leo's Results

Leo's scores on the short-term memory tasks were higher than those of Nina.[2] In the digit span task, Nina obtained a developmental age (DA) of 4.0, and Leo of 6.3. Spatial memory elicited a floor effect for Nina (DA < 4.0) and corresponded to a DA of 5.9 for Leo.

Both participants significantly improved their scores on the Picture arrangement subtest of the K-ABC (Nina: DA < 5.0 at pretest, and 5.6 at posttest 1; Leo: DA = 6.0, and 7.9, respectively). Leo's score on the analogies of the ARLT (max. 20) improved from 11 to 15. Nina showed no gain on the ARLT, but she already showed a relatively high score at pretest, which was an indication of high learning capacity (her pre- and posttest scores were 17 and 16, respectively). Leo's performance on both inductive reasoning tasks is a good illustration of the intelligence-educability issue. The application of cognitive and metacognitive processes and performance largely concurred. At posttest and compared to the pretest, Leo applied or was much more efficient in applying the following cognitive and metacognitive processes: exploration, selective attention, cognitive flexibility, impulsivity control, monitoring, systematic, and using a reference mark strategy. This shows the potentiality of improving general reasoning ability through training of the underlying cognitive processes (see also Haywood & Switzky, 1992).

We simplified the visual selective attention task (NEPSY) for this study, but eventually it proved to be too easy, as both participants obtained the maximum score at pre- and posttest. However, Nina improved on execution speed, taking half the time to perform the task at posttest. Leo, on the contrary, took more time at posttest. However, this change can also be interpreted as a positive sign, in this case of enhanced monitoring during the task. Indeed, Leo never controlled anything he did during pretest, but he did do so at posttest.

With regard to visual organization, two tasks were presented, each with a parallel form at posttest. Both participants showed large performance gains for the "Drawings to complete" task, and also the cognitive and metacognitive processes and strategies they applied improved. For the "Part–Whole" task, Nina showed some improvement, but Leo did not.

With respect to the geometry task, Nina's progress was impressive, both at the performance and procedural level. At posttest, she had learned to consequently apply several planning and monitoring strategies, as well as cognitive strategies that allowed her to perform the task correctly and also much more precisely. The posttest results were only slightly better for Leo.

Concerning the mathematic problem, no gains were expected with respect to the performance per se, as mathematic reasoning and arithmetic skills were not at all trained. We did expect to find some change on the procedural level. However, the task appeared much too difficult and beyond their competence, which certainly also affected their way to deal with the task. Nina improved only on two aspects (planning and using one cognitive strategy), and Leo demonstrated some more verbalization and perseverance at posttest.

The questionnaires filled in by the teachers indicated to which extent the participant transferred what they had learned to the classroom context, which is considered as far transfer. Nina's teacher pointed out that she showed large improvements on 7 out of 12 items: more reflective behavior (less trial-and-error), more systematic behavior, improved selective attention, less outerdirectedness and attention more focused on task, increased comparing, using new strategies (e.g., counting), and increased monitoring. Leo, on the other hand, did not show progress in his way to tackle the tasks in the classroom context.

Eight weeks after training, the two participants not only maintained what they had learned, but even progressed. Especially Nina showed drastic improvements at posttest 2. Nina maintained the same performance on 2 tasks (geometry and selective visual attention task; the latter already showed a ceiling effect at pretest), but improved her performances on the 4 other tasks (Picture arrangement, Drawings to complete, Part–Whole, mathematic problem) compared to posttest 1. The progress she made in the classroom was also maintained after eight weeks. Leo's performance in the Part–Whole task was equal to pretest performance. The gains he showed on four other tasks were maintained at posttest 2, and the performance for mathematic problem improved from posttest 1 to posttest 2. His scores on the teacher questionnaire and interview were still the same as at pretest. An unexpected result was found in the performance of both adolescents on the mathematical problem. At posttest 2, they correctly solved the problem, meaning they were able to infer the required operations, to select the relevant figures for the calculations, and to compute correctly the calculations. Although we cannot control for external factors, drastic progress was observed on the procedural level that might explain the improved performances. Both participants exhibited valuable application of almost all cognitive and metacognitive processes and strategies during task completion, such as selective attention, cognitive flexibility, comparison, planning, and monitoring.

Comparatively, Nina showed more improvement after training than Leo, and she was also more able to transfer what she had learned to the classroom context. A first explanation can be found in their respective learning capacity as was assessed with the ARLT. Nina's learning capacity was estimated as high, whereas Leo's learning capacity was estimated as moderate. A second explanation can be found in motivational factors. Leo never saw much utility in learning all those strategies (which also is a question of metaknowledge), did not show any need for mastery, and often exhibited avoidance behaviors when confronted with difficulty or cognitive effort. He would say that he did not like it when he was supposed to "think a lot," and that "thinking is tiring."

Summarizing, it can be concluded that the results of this study are encouraging. Participants' performances on 3, respectively 5 out of 7 tasks (including the ARLT) improved after a short intervention. These tasks were not directly trained and thus required near to very far transfer. The training effects were substantially (Nina) or partly (Leo) maintained after eight weeks, and performance on some tasks even improved.

CONCLUSION

Metacognition plays an important role in learning and thinking, and it has been shown that students with learning difficulties, as well as people with intellectual disabilities have underdeveloped metacognitive skills. The aim of the present article was to demonstrate the relevance of using games as tools for metacognitive intervention. Games allow addressing the cognitive and metacognitive processes involved in thinking, problem-solving, and learning. They are stimulating and non-threatening for the students and help them engage in active, effortful, and strategic behavior. They can be used as complements to cognitive education programs, or applied exclusively in a design as was illustrated in this article. They can also easily be integrated within the teaching curriculum. Research has shown the benefits of implementing metacognitive interventions directly in the classroom settings as part of the regular class instruction (Dignath & Büttner, 2008), the effects being larger than when the interventions take place out of school. This is due to the fact that the students can more easily transpose the acquired skills to their school activities. When the training is applied by the teacher, he/she can link the trained strategies to the actual school tasks, as was done in the Hessels et al. (2009) intervention study. However, Dignath and Büttner's (2008) meta-analysis showed that interventions were more successful when they were directed by the researcher rather than by the teachers. Teachers often lack knowledge about strategic learning and how to promote it in their students (Borkowski & Muthukrishna, 1992; Dignath & Büttner, 2008; Veenman et al., 2006). Teachers' training in promoting metacognitive skills in their students remains an important issue.

This article clearly illustrates the usefulness of games as tools for cognitive education when they are securely analyzed following the proposed framework and used accordingly. In addition, appropriate mediation (incorporating the five mediational aspects) is required. After a relatively short intervention of 19 sessions, the two participants in this study improved (either moderately or substantially) their strategic behavior and performance on several cognitive and school-related tasks. More importantly, they were also able to transfer the acquired strategies to untrained tasks and (for one participant) to the school context. The gains proved to be substantial and generally were maintained after eight weeks. These results are even more promising when we consider the participants' low level of cognitive functioning before the intervention. For people with moderate to severe intellectual disabilities, interventions should, of course, be run over a long-term period in order to secure their acquisitions. Although these case studies do not offer a strong validation of the intervention, the provided procedural data and how they varied with participants' performance can bring insight in our understanding of "whether an intervention works and why" (Pressley, Graham, & Harris, 2006, p. 5).

To conclude, games can represent a convenient, flexible, and manifold vehicle to promote a strategic attitude in students and enhance their cognitive and metacognitive skills. However, as Fritz and Hussy (1996) have shown, children, especially those with learning difficulties or intellectual disabilities, do not develop such skills simply by playing. Only deliberately training metacognitive skills leads to significant improvements. Especially, to promote transfer to school contents, the game playing must be based on clearly defined objectives, accompanied by rigorous mediation that explicitly focuses on the development of cognitive and metacognitive processes, metacognitive awareness, as well as motivational variables. By providing the students with regular opportunities that stimulate them to think about their own cognitive functioning and learning processes, one can contribute to the development of adequate metacognitive skills.

NOTES

1. With games I refer to all kinds of parlor games such as board games, card games, construction games, puzzle games, and educational games that anyone can buy in a toy shop. Computer games or other types of play activities are not considered in the context of this article.

2. Fictitious names.

REFERENCES

Allal, L., Baeriswyl, E., Bach Mai, T., & Wegmüller, E. (1987). Le jeu comme situation d'auto-évaluation [Game as setting for self-evaluation]. *Mesure et évaluation en éducation, 10,* 47–63.

Arbitman-Smith, R., Haywood, H. C., & Bransford, J. D. (1984). Assessing cognitive change. In P. H. Brooks, R. Sperber, & C. McCauley (Eds.), *Learning and cognition in the mentally retarded* (pp. 433–471). Hillsdale, NJ: Erlbaum.

Baddeley, A. D. (1999). *Working memory.* Oxford, UK: Clarendon Press.

Bandura, A. (1997). *Self-efficacy: The exercise of control.* New York: Freeman.

Bannert, M., & Mengelkamp, C. (2008). Assessment of metacognitive skills by means of instruction to think aloud and reflect when prompted. Does the verbalisation method affect learning? *Metacognition and Learning, 3,* 39–58.

Barnett, S. M., & Ceci, S. J. (2002). When and where do we apply what we learn? A taxonomy for far transfer. *Psychological Bulletin, 128,* 612–637.

Baumeister, A. A. (1984). Some methodological and conceptual issues in the study of cognitive processes with retarded people. In P. H. Brooks, R. Sperber, & C. McCauley (Eds.), *Learning and cognition in the mentally retarded* (pp. 1–38). Hillsdale, NJ: Erlbaum.

Bebko, J. M., & Luhaorg, H. (1998). The development of strategy use and metacognitive processing in mental retardation: Some sources of difficulty. In J. A. Burack, R. M. Hodapp, & E. Zigler (Eds.), *Handbook of mental retardation and development* (pp. 382–407). Cambridge, UK: Cambridge University Press.

Bereby-Meyer, Y., & Kaplan, A. (2004). Motivational influences on transfer of problem-solving strategies. *Contemporary Educational Psychology, 30,* 1–22.

Bjorklund, D. F. (2005). *Children's thinking: Cognitive development and individual differences* (4th ed.). Belmont, CA: Wadsworth/Thomson Learning.

Bjorklund, D. F., Schneider, W., Cassel, W. S., & Ashley, E. (1994). Training and extension of a memory strategy: Evidence for utilization deficiencies in the acquisition of an organizational strategy in high- and low-IQ children. *Child Development, 65*, 951–965.

Blair, C., & Razza, R. P. (2007). Relating effortful control, executive function, and false belief understanding to emerging math and literacy abilities in kindergarten. *Child Development, 78*, 647–663.

Borkowski, J. G., Chan, L. K. S., & Muthukrishna, N. (2000). A process-oriented model of metacognition: Links between motivation and executive functioning. In G. Schraw & J. C. Impara (Eds.), *Issues in the measurement of metacognition* (pp. 1–42). Lincoln, NE: Buros Institute.

Borkowski, J. G., & Muthukrishna, N. (1992). Moving metacognition into the classroom: "Working models" and effective strategy teaching. In M. Pressley & K. R. Harris (Eds.), *Promoting academic competence and literacy in school* (pp. 477–501). San Diego, CA: Academic Press.

Borkowski, J. G., Reid, M. K., & Kurtz, B. E. (1984). Metacognition and retardation: Paradigmatic, theoretical, and applied perspectives. In P. H. Brooks, R. Sperber, & C. McCauley (Eds.), *Learning and cognition in the mentally retarded* (pp. 55–75). Hillsdale, NJ: Erlbaum.

Borkowski, J. G., & Thorpe, P. (1994). Self-regulation and motivation: A life-span perspective of underachievement. In D. Schunck & B. Zimmerman (Eds.), *Self-regulation of learning and performance* (pp. 45–73). Hillsdale, NJ: Erlbaum.

Borkowski, J. G., Weyhing, R. S., & Carr, M. (1988). Effects of attributional retraining on strategy-based reading comprehension in learning-disabled students. *Journal of Educational Psychology, 80*, 46–53.

Bosson, M. S., Hessels, M. G. P., Hessels-Schlatter, C., Berger, J.-L., Kipfer, N. M., & Büchel, F. P. (2010). Strategy acquisition by children with learning difficulties in a metacognitive training. *Australian Journal of Learning Difficulties, 15*(1), 1–22.

Brown, A. L. (1978). Knowing when, where, and how to remember: An approach in metacognition. In R. Glaser (Ed.), *Advances in instructional psychology* (Vol. 1, pp. 77–175). Hillsdale, NJ: Erlbaum.

Brown, A. L. (1987). Metacognition, executive control, self-regulation and other more mysterious mechanisms. In F. E. Weinert & R. H. Kluwe (Eds.), *Metacognition, motivation and understanding* (pp. 65–116). Hillsdale, NJ: Erlbaum.

Brown, A. L., & Campione, J. C. (1981). Inducing flexible thinking: The problem of access. In M. P. Friedman, J. P. Das, & N. O'Connor (Eds.), *Intelligence and learning* (pp. 515–529). New York: Plenum Press.

Brown, A. L., & Campione, J. C. (1984). Three faces of transfer: Implications for early competence, individual differences, and instruction. In M. Lamb, A. Brown, & B. Rogoff (Eds.), *Advances in developmental psychology* (Vol. 3, pp. 143–192). Hillsdale, NJ: Erlbaum.

Brown, A. L., & Palinscar, A. S. (1987). Reciprocal teaching of comprehension strategies: A natural history of one program for enhancing learning. In J. D. Day & J. Borkowski (Eds.), *Intelligence and exceptionality: New directions for theory, assessment and instructional practice* (pp. 81–132). Norwood, NJ: Ablex.

Büchel, F. P., & Büchel, P. (1997). DELV: A metacognitive programme for adolescents and adults. In J. H. M. Hamers & T. Overtoom (Eds.), *Teaching thinking in Europe* (pp. 45–49). Utrecht, Netherlands: Sardes.

Carlson, J., & Wiedl, K. H. (2000). The validity of dynamic assessment. In C. S. Lidz & J. G. Elliott (Eds.), *Dynamic assessment: Prevailing models and applications* (pp. 681–712). New York: Elsevier.

The Cognition and Technology Group at Vanderbilt. (1993). Toward integrated curricula: Possibilities from anchored instruction. In M. Rabinowitz (Ed.), *Cognitive science foundations of instruction* (pp. 33–55). Hillsdale, NJ: Erlbaum.

Conway, R. N. F., & Hopton, L. J. (2000). Application of a school-wide metacognitive training model: Effects on academic and planning performance. *Journal of Cognitive Education and Psychology* [Online], *1*, 140–153.

Cornoldi, C., & Campari, S. (1998). Connaissance métacognitive et contrôle métacognitif dans le retard mental [Metacognitive knowledge and metacognitive control in mental retardation]. In F. P. Büchel, J. L. Paour, Y. Courbois, & U. Scharnhorst (Eds.), *Attention, mémoire, apprentissage: Etudes sur le retard mental* (pp. 119–128). Lucerne, Switzerland: Editions SZH/SPC.

Davidson, J. E., & Sternberg, R. J. (1998). Smart problem-solving: How metacognition helps. In D. Hacker, J. Dunlosky, & A. Graesser (Eds.), *Metacognition in educational theory and practice* (pp. 47–68). Mahwah, NJ: Erlbaum.

Dermitzaki, I., Leondari, A., & Goudas, M. (2009). Relations between young students' strategic behaviours, domain-specific self-concept, and performance in a problem-solving situation. *Learning and Instruction, 19*, 144–157.

Dignath, C., & Büttner, G. (2008). Components of fostering self-regulated learning among students. A meta-analysis on intervention studies at primary and secondary school level. *Metacognition and Learning, 3*, 231–264.

Dignath, C., Büttner, G., & Langfeldt, H.-P. (2008). How can primary school students learn self-regulated learning strategies most effectively? A meta-analysis of self-regulation training programmes. *Educational Research Review, 3*, 101–129.

Dominowski, R. L. (1998). Verbalization and problem-solving. In D. J. Hacker, J. Dunlosky, & A. C. Graesser (Eds.), *Metacognition in educational theory and practice* (pp. 25–45). Mahwah, NJ: Erlbaum.

Eccles, J. S., & Wigfield, A. (2002). Motivational beliefs, values, and goals. *Annual Review of Psychology, 53*, 109–132.

Ellis, E. S. (1993). Integrative strategy instruction: A potential model for teaching content area subjects to adolescents with learning disabilities. *Journal of Learning Disabilities, 26*, 358–383.

Ericsson, K. A., & Simon, H. A. (1993). *Protocol analysis: Verbal reports as data* (Rev. ed.). Cambridge, MA: MIT Press.

Feuerstein, R., Rand, Y., Hoffman, M. B., & Miller, R. (1980). *Instrumental enrichment: An intervention program for cognitive modifiability*. Baltimore: University Park Press.

Fitzsimons, G. M., & Bargh, J. A. (2004). Automatic self-regulation. In R. F. Baumeister & K. D. Vohs (Eds.), *Handbook of self-regulation: Research, theory, and applications* (pp. 151–170). New York: Guilford Press.

Flavell, J. H. (1987). Speculations about the nature and development of metacognition. In F. E. Weinert & R. H. Kluwe (Eds.), *Metacognition, motivation, and understanding* (pp. 21–29). Hillsdale, NJ: Erlbaum.

Fritz, A., & Hussy, W. (1996). Evaluation eines Unterrichtskonzepts zur Förderung der Planungsfähigkeit in der Grundschule [Evaluation of an intervention concept for the development of planning ability in elementary school]. *Heilpädagogische Forschung, 22*, 1–9.

Fritz, A., & Hussy, W. (2000). Das Zoo-Spiel: Bericht über einen Test zur Planungsfähigkeit von Kindern im Grundschulalter [The Zoo-game: Report of a planning ability test for elementary school children]. *Heilpädagogische Forschung, 26*, 105–109.

Fritz, A., & Hussy, W. (2001). Training der Planungsfähigkeit bei Grundschulkindern: Eine Evaluationsstudie [Training planning ability in elementary school children: An evaluation study]. In K. J. Klauer (Hrsg.), *Handbuch kognitiver Trainingsverfahren* (2nd ed., pp. 97–127). Stuttgart, Germany: Hogrefe.

Fuchs, L. S., Fuchs, D., Prentice, K., Burch, M., Hamlett, C. L., Owen, R., et al. (2003). Explicitly teaching for transfer: Effects on third-grade students' mathematical problem-solving. *Journal of Educational Psychology, 95*, 293–305.

Gick, M. L., & Holyoak, K. J. (1980). Analogical problem-solving. *Cognitive Psychology, 12*, 306–355.

Grossniklaus, S. (2008). *Rapport de stage de formation en éducation spéciale* [Internship in special education report]. Unpublished document, University of Geneva, Switzerland.

Grossniklaus, S. (2009). *Le jeu comme outil d'intervention cognitive et métacognitive: une étude de cas avec deux adolescents présentant une déficience intellectuelle modérée à sévère* [Games as tool for cognitive and metacognitive intervention: A case study with two adolescents presenting moderate to severe intellectual deficiency]. Unpublished master's thesis, University of Geneva, Switzerland.

Hacker, D. J. (1998). Definitions and empirical foundations. In D. J. Hacker, J. Dunlosky, & A. C. Graesser (Eds.), *Metacognition in educational theory and practice* (pp. 1–23). Mahwah, NJ: Erlbaum.

Harris, K. R., & Graham, S. (1996). *Making the writing process work: Strategies for composition and self-regulation*. Cambridge, MA: Brookline Books.

Haywood, H. C. (1997). Cognitive education: The once and future king. *Cognitive Education, 7*(2), 4–7.

Haywood, H. C., Brooks, P. H., & Burns, S. (1992). *Bright start: Cognitive curriculum for young children*. Watertown, MA: Charles Bridge.

Haywood, H. C., & Switzky, H. N. (1992). Ability and modifiability? What, how, and how much? In J. Carlson (Ed.), *Theoretical issues: Intelligence, cognition, and assessment* (pp. 24–85). Greenwich, CT: JAI Press.

Hessels, M. G. P., & Hessels-Schlatter, C. (2008). Pedagogical principles favouring the development of reasoning in people with severe learning difficulties. *Educational and Child Psychology, 25*, 66–73.

Hessels, M. G. P., Hessels-Schlatter, C., Bosson, M. S., & Balli, Y. (2009). Metacognitive teaching in a special education class. *Journal of Cognitive Education and Psychology, 8*, 182–201.

Hessels-Schlatter, C. (2002). A dynamic test to assess learning capacity in people with severe impairments. *American Journal on Mental Retardation, 107*, 340–351.

Kaufman, A. S., & Kaufman, N. L. (1993). *K-ABC. Batterie pour l'examen psychologique de l'enfant* [Kaufman Assessment Battery for Children]. Paris: Editions du Centre de Psychologie Appliquée.

Klauer, K. J. (1989). *Denktraining für Kinder I: Ein Programm zur Förderung des induktiven Denkens* [Teaching thinking for children I: A program for the development of inductive reasoning]. Göttingen, Germany: Hogrefe.

Korkman, M., Kirk, U., & Kemps, S. (2003). *NEPSY: Bilan neuropsychologique de l'enfant* [NEPSY: A Developmental Neuropsychological Assessment]. Paris: ECPA.

Kuhn, D., & Pearsall, S. (1998). Relation between metastrategic knowledge and strategic performance. *Cognitive Development, 13*, 227–247.

Leat, D., & Lin, M. (2003). Developing a pedagogy of metacognition and transfer: Some signposts for the generation and use of knowledge and the creation of research partnerships. *British Educational Research Journal, 29*, 383–415.

Loaer, E., Chartier, D., Huteau, M., & Lautrey, D. (1995). *Peut-on éduquer l'intelligence? L'évaluation d'une méthode d'éducation cognitive* [Can we educate intelligence? An evaluation of a cognitive education method]. Berne, Switzerland: Peter Lang.

Malone, T. W., & Lepper, M. R. (1987). Making learning fun: A taxonomy of intrinsic motivations for learning. In R. E. Snow & M. J. Farr (Eds.), *Aptitude, learning and instruction, III: Cognitive and affective process analyses* (pp. 222–253). Hillsdale, NJ: Erlbaum.

Mevarech, Z. R., & Kramarski, B. (1997). IMPROVE: A multidimentional method for teaching mathematics in heterogeneous classrooms. *American Educational Research Journal, 34*, 365–394.

Miller, P. H. (1990). The development of strategies of selective attention. In D. F. Bjorklund (Ed.), *Children's strategies: Contemporary views of cognitive development* (pp. 157–184). Hillsdale, NJ: Erlbaum.

Montague, M. (2003). *Solve it! A mathematical problem-solving instructional program*. Reston, VA: Exceptional Innovations.

Montague, M., & Bos, C. S. (1990). Cognitive and metacognitive characteristics of eight grade student's mathematical problem-solving. *Learning and Individual Differences, 2*, 371–388.

Paour, J.-L., & Cèbe, S. (1999). Le mouvement de l'éducation cognitive [The cognitive education movement]. In P. A. Doudin, D. Martin, & O. Albanese (Eds.), *Métacognition et éducation* (pp. 107–139). Berne, Swtizerland: Peter Lang.

Paris, S. G., Cross, D. R., & Lipson, M. Y. (1984). Informed strategies for learning: A program to improve children's reading awareness and comprehension. *Journal of Educational Psychology, 76*, 1239–1252.

Paris, S. G., & Jacobs, J. E. (1984). The benefits of informed instruction for children's reading awareness and comprehension skills. *Child Development, 55*, 2083–2093.

Perkins, D. N., & Salomon, G. (1989). Are cognitive skills context-bound? *Educational Researcher, 18*, 16–25.

Perkins, D. N., Simmons, R., & Tishman, S. (1990). Teaching cognitive and metacognitive strategies. *Journal of Structural Learning, 10*, 285–303.

Piaget, J. (1971). *The language and thought of the child* (3rd ed.). London: Rougledge & Kegan Paul.

Pintrich, P. R. (1999). The role of motivation in promoting and sustaining self-regulated learning. *International Journal of Educational Research, 31*, 459–470.

Pintrich, P. R., & De Groot E. V. (1990). Motivational and self-regulated learning components of classroom academic performance. *Journal of Educational Psychology, 82*, 33–41.

Pintrich, P. R., Wolters, C. A., & Baxter, G. P. (2000). Assessing metacognition and self-regulated learning. In G. Schraw & J. C. Impara (Eds.), *Issues in the measurement of metacognition* (pp. 43–97). Lincoln, NE: Buros Institute.

Prawat, R. S. (1989). Promoting access to knowledge, strategy, and disposition in students: A research synthesis. *Review of Educational Research, 59*, 1–41.

Pressley, M., Graham, S., & Harris, K. (2006). The state of educational intervention research as viewed through the lens of literacy intervention. *British Journal of Educational Psychology, 76*, 1–19.

Re, A. M., Cazzaniga, S., Pedron, M., & Cornoldi, C. (2009). *Io Scrivo: Valutazione e potenziamento delle abilità di espressione scritta* [I write: Evaluation and development of writing ability]. Florence, Italy: Giunti Scuola.

Rebetez, C., & Betrancourt, M. (2008). Video game research in cognitive and educational sciences. *Cognition, Brain, Behavior, 11*, 131–142.

Rojas-Drummond, S., Pérez, V., Vélez, M., Gómez, L., & Mendoza, A. (2003). Talking for reasoning among Mexican primary school children. *Learning and Instruction, 13*, 653–670.

Saldaña, D. (2004). Dynamic master mind: Interactive use of a game for testing metacognition. *School Psychology International, 25*, 422–438.

Schlatter, C. (1999). *Le Test d'Apprentissage de la Pensée Analogique: Fondation théorique et empirique d'un outil d'évaluation pour personnes présentant un retard mental modéré* [The Analogical Reasoning Learning Test: Theoretical and empirical fundation of a diagnostic tool for individuals with moderate mental retardation]. Unpublished doctoral dissertation, University of Geneva, Switzerland.

Schlatter, C., & Büchel, F. P. (2000). Detecting reasoning abilities in persons with moderate mental retardation: The Analogical Reasoning Learning Test (ARLT). In C. S. Lidz & J Elliott (Eds.), *Dynamic assessment: Prevailing models and applications* (pp. 155–186). New York: Elsevier Sciences.

Schraw, G. (1998). Promoting general metacognitive awareness. *Instructional Science, 26*, 113–125.

Sergeant, J. (1996). A theory of attention: An information processing perspective. In G. R. Lyon & N. A. Krasnegor (Eds.), *Attention, memory, and executive function* (pp. 57–69). London: P. Brookes.

Short, E. J., Schatschneider, C., Cuddy, C. L., Evans, S. W., Dellick, D. M., & Basili, L. A. (1991). The effect of thinking aloud on the problem-solving performance of bright, average, learning disabled, and developmentally handicapped students. *Contemporary Educational Psychology, 16*, 139–153.

Swanson, H. L. (1990). Influence of metacognitive knowledge and aptitude on problem-solving. *Journal of Educational Psychology, 82*, 306–314.

Tomic, W. (1995). Training in inductive reasoning and problem-solving. *Contemporary Educational Psychology, 20*, 483–490.

Tusch, M., Hussy, W., & Fritz, A. (2002). Ausmass und Förderbarkeit der Planungsfähigkeit Lernbehinderter: Ein prozessorientierter Ansatz im Sinne des Metacognitionskonzeptes [Measurement and modifiability of planning ability in students with learning difficulties: A process oriented approach based on the concept of metacognition]. *Heilpädagogische Forschung, 28*, 176–188.

Van Luit, J. E. H., & Kroesbergen, E. H. (2006). Teaching metacognitive skills to students with mathematical disabilities. In A. Desoete & M. V. J. Veenman (Eds.), *Metacognition in Mathematics Education* (pp. 177–190). New York: Nova Science.

Veenman, M. V. J., Van Hout-Wolters, B. H. A. M., & Afflerbach, P. (2006). Metacognition and learning: Conceptual and methodological considerations. *Metacognition and Learning, 1*, 3–14.

Veenman, M. V. J., Wilhelm, P., & Beishuizen, J. J. (2004). The relation between intellectual and metacognitive skills from a developmental perspective. *Learning and Instruction, 14*, 89–109.

Wong, B. Y. L. (1993). Pursuing an elusive goal: Molding strategic teachers and learners. *Journal of Learning Disabilities, 26*, 354–357.

Wong, B. Y. L. (1994). Instructional parameters promoting transfer of learned strategies in students with learning disabilities. *Learning Disabilities Quarterly, 17*, 110–120.

Zimmerman, B. J., & Schunck, D. H. (2001). *Self regulated learning and academic achievement: Theoretical perspectives* (2nd ed.). Mahwah, NJ: Erlbaum.

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