2016

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Original Publication Citation

Watson, S. M. R., Gable, R. A., & Morin, L. L. (2016). The role of executive functions in classroom instruction of students with learning disabilities. *International Journal of School and Cognitive Psychology, 3*(167), 1-5. doi:10.4172/2469-9837.1000167

International Journal of School and Cognitive Psychology

Watson, et al., Int J Sch Cog Psychol 2016, 3:1
http://dx.doi.org/10.4172/2469-9837.1000167

Opinion Open Access

The Role of Executive Functions in Classroom Instruction of Students with Learning Disabilities

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Rec date: Jan 28, 2016; **Acc date:** Mar 10, 2016; **Pub date:** Mar 14, 2016

Abstract

In this article, we describe executive functions and their role in determining student academic success. We focus on the executive function difficulties of students with learning disabilities and explain how executive dysfunctions can negatively affect different academic areas (e.g., reading comprehension, mathematics). Finally, we offer ways teachers can modify their instruction to better address the diverse needs of students with learning disabilities who are struggling to perform various academic tasks.

Introduction

The fields of learning disabilities and neuropsychology have always been interwoven, but only recently have special educators begun to look at cognitive psychology and neuroscience to better understand possible causal factors underlying learning disabilities (LD). Several researchers have examined different cognitive processes and their association with learning difficulties [1-3]. Recent research has drawn attention to the cognitive construct of executive functions, a neuropsychological concept that includes several cognitive processes (e.g., attention, working memory) required for learning and problem solving. The term "executive" was first used by Pribram in 1973 to describe functions of the pre-frontal cortex. Since then, the same concept has been termed differently by various authors. For example, Meltzer uses the term "executive function," while Dawson and Guare [4] refer to "executive skills," Wiebe et al. name those cognitive processes "executive control," and McCloskey [5] uses "executive functions" to discuss them. In the following discussion, we will use the term executive functions (EFs).

Many scholars have defined EFs using different theoretical models and different cognitive processes. Some researchers [6,7] have used unitary or process-oriented models that focus on how several skills or components work together to complete complex problem solving tasks. Other researchers have looked at EFs using multiple-component models that focus on the core skills involved in EFs and emphasize dissociable processes. There is accumulating evidence to support both models. The literature indicates that research on young children supports a unitary construct of EFs, while studies on older students tend to show differentiation in multiple factors such as working memory and processing speed. Although there is evidence to support both the unitary and multiple-component models of EFs, an integrative model has become the preferred view advocated by some researchers [8,9]. From this perspective, EFs are viewed as a unitary construct with dissociable components.

As a result of having different theories to explain EFs, there are 30 or more EF definitions. The following examples are a small sample of some of the definitions.

Barkley [10-12]: "EF is thus a self-directed set of actions intended to alter a delayed (future) outcome (attain a goal for instance)" (p. 11).

Dawson and Guare [4]: "Executive skills allow us to organize our behavior over time and override immediate demands in favor of long-term goals" (p. 1).

Sesma, Slomine, Ding, and McCarthy: "Executive functioning refers to an individual's ability to carry out goal-directed behavior and includes skills such as planning and sequencing multistep actions, inhibiting inappropriate behavior, and sustaining effort for extended periods of time" (p. 1687).

It seems safe to conclude that EFs is an umbrella term that comprises cognitive processes directly related to the successful negotiation of both educational and life-related tasks. EFs encompass the ability to be mentally and behaviourally flexible, as well as make use of problem-solving skills that assist in goal attainment [13]. Because EFs are considered to be largely under the control of the frontal lobe of the brain, they involve metacognitive knowledge (i.e., knowledge about one's own thinking) regarding strategies and task, attention, and memory systems that support these processes (e.g., working memory- the ability to temporarily hold and manipulate information for cognitive tasks). Self-regulatory processes such as planning and self-monitoring are associated with frontal lobe processing, which suggests a potential relationship between these skills and EFs [14,15]. Furthermore, the multidimensional nature of EF processes also includes attention control, working memory, cognitive flexibility, planning, initiation of activity, impulse control, and inhibition. Hofmann, et al. [16] synthesized the aforementioned skills into three basic EFs: working memory operations (updating), inhibitions of impulses (inhibiting), and mental set or task shifting (shifting). Together, these basic EF skills comprise "the cognitive system that controls and manage other cognitive processes" [17]. Thus, EFs play an important role in determining successful cognitive, academic, and social functioning of students with and without disabilities.

Executive Functions and Learning Disabilities

The focus of our discussion is on EFs and students diagnosed with learning disabilities (LD). We highlight how EFs contribute to the academic and social difficulties of students with this disability. That is, students with LD often evidence significant problems in EFs which includes working memory operations (updating), inhibitions of impulses (inhibiting), and mental set or task shifting (shifting). They often have difficulty accessing, organizing, prioritizing, and coordinating information in simultaneous mental activities (e.g., writing). They struggle with self-regulatory behavior, are unaware of effective strategies to solve problems and have little flexibility in their thinking [15,18]. Students with LD have particular difficulty with metacognitive skills (i.e., knowledge about cognition and its regulation, and strategies that affect performance), problems which are usually manifested by ineffective ways to plan, monitor their own learning, and detect and correct their errors [19].

For students with LD, EF measures have been associated with academic achievement, socialization, as well as the inhibition of maladaptive and/or aggressive behaviors. Jacobson et al. [20] investigated the relationship between EFs assessed in elementary school and students' academic and social behavior achievements in sixth grade. They found that those students with poorer EFs were less successful and had more difficulties adjusting to middle school where there are fewer external supports than in elementary school. Mattison and Mayes [21] compared 437 students with LD with 158 children without LD, ages 6 to 16, and found that those students with LD performed significantly worse in EF measures than those without LD. Those students with comorbid LD and ADHD had more executive dysfunction. The researchers also found a significant correlation among IQ, EF, and achievement. Furthermore, students with impaired EFs are at risk for engaging in impulsive or hostile responses to stressful situations [22,23] and, repeated academic failure can trigger either student withdrawal or acting-out behavior. In sum, poor EF skills place students on a slippery slope that all too often leads to significant social and/or academic problems.

Executive Functions Issues for Students with LD

It is well documented that students with LD have a wide range of EF difficulties. These students are often viewed as inefficient learners because they are disorganized, do not have effective learning strategies, or are unaware of their usefulness for problem solving. Furthermore, they have difficulties with self-regulation [18] and accessing and manipulating mental activities simultaneously [16]. Students with LD also have problems prioritizing, organizing, and sorting information relevant to classroom instruction [15,19]. Singly or collectively, EF problems adversely affect academic outcomes of students with LD.

As students with LD grow older, the curriculum reflects more complex tasks demands that require students to possess more EF skills. Academic tasks that involve reading comprehension, written expression, and note taking are particularly challenging because these tasks require the use of EF skills, such as self-regulation, planning, organizing, shifting strategies, and metacognition [24-26]. For these reasons, students' content knowledge is not always reflected in their academic performance [15,27].

The Effects of EFs on the Academic Performance of Students with LD

Academic success has been linked to various aspects of classroom performance. One area that EFs significantly influence is written language. Different EF skills contribute uniquely to the writing process [28,29]. For example, planning and organization are associated with prioritizing of ideas, self-monitoring required for revising/editing, while inhibition seems to contribute to note taking [18,23]. Written language often is an area of weakness for many students with LD because it involves the coordination of many EFs [28].

Another academic area affected by EFs is reading comprehension. Reading comprehension depends on cognitive processes that go beyond basic decoding and fluency skills. Reading comprehension requires the coordinated multitasking of EFs for the integration of all the components of the reading process [27]. Working memory, planning, and self-monitoring have been found to be related to reading comprehension. Knowledge of how these EFs affect reading comprehension can contribute to planning for instruction.

To be successful academically, students must be able to complete assignments independently. Many students with LD struggle with homework, independent study, and long-term projects because these tasks require self-regulated learning [26]. To start, they need working memory to remember the assignment and they often forget to bring the necessary materials/books home for homework completion [29]. Secondly, to complete these types of independent assignments requires task initiation which is another EF skill. Planning how the task will be accomplished (e.g., choice of topic, materials needed) and developing a timeline to complete the assignment by the due date are very important skills. While many students with EF deficits have a tendency to procrastinate, self-regulation and self-monitoring are essential EF skills for performing independent activities. Many students with LD are deficient in these important skill areas and in independent work habits [4,28].

In addition to written language and reading comprehension, EFs negatively impact student mathematical skills as well. Compelling evidence exists demonstrating that many students with LD have difficulty acquiring mathematics conceptual understanding (e.g., number sense) and skills (e.g., computation facts) and have multiple cognitive deficits that include EFs [30-33]. Thus, researchers have found that students with mathematics learning disabilities (MLD) have different cognitive processes (e.g., working memory, inhibition) associated with various mathematics knowledge and skills [34-36].

As we have suggested, students with LD who have EF problems are likely to struggle with mathematical-related tasks. Both research and experience indicate they may have difficulty controlling distracting thoughts and focusing attention on math operational signs; they may have difficulty determining the most important information in word problems. Furthermore, students with LD may have impaired knowledge of algorithms; struggle to perform mental math; do not know what they need to do first to initiate the task, and they may make careless mistakes because they do not check their answers and/or otherwise evaluate their performance. Even so, because mathematics includes multiple skills (e.g., calculation, geometry), students with LD have different types of mathematics problems, which makes it difficult to identify the specific cognitive process that contributes to mathematics learning disability. Nevertheless, it is important to consider the role of varying cognitive processes play in which EFs are involved when delivering instruction to students with MLD [2,37].

Addressing Executive Functions Deficits in Students with LD

Because EF deficits are present in many students with LD, strategies to improve EFs are an essential component of classroom instruction. Some interventions may be designed to ameliorate the underlying cognitive process while other interventions may focus on teaching students compensatory strategies to overcome executive dysfunctions. Still others may combine both types of interventions. Regardless of the intervention, emphasis should be on increasing the student's awareness of the executive functions needed to achieve the target goal [27]. According to Hawley and Newman [38], teaching EF skills should follow certain stages, both sequential and repeatedly as the student develops the skills. They suggest five stages for teaching EF skills: 1) engagement (i.e., attention and motivation), 2) awareness of strengths and needs, 3) goal setting (i.e., identifying realistic and measurable goals), 4) skill mastery, and 5) generalization. Because EFs include cognitive processes that coordinate, integrate, and control processes, strategies to promote EFs generally address three main areas, self-regulation (i.e., ability to monitor one's own performance and reflect on it), working memory, and metacognition, all of which allow students to engage in problem solving and goal-directed behavior. Finally, when learning EF skills, students with LD will need external supports to achieve their goal.

Implications for the Classroom

Studies suggest that students with LD experience EFs deficits, especially in inhibition and updating, in several critical academic areas [39,40]. Because of the strong association between EFs and the academic performance of students with LD, it is important for educators to consider the role of EFs when designing classroom instruction and ways to improve EFs. Interventions may be designed to ameliorate the underlying cognitive process or to focus on teaching students' compensatory strategies to overcome executive dysfunctions. Still others may combine both types of interventions. Regardless of the focus of the intervention, the focus should be on increasing the student's awareness of the executive functions needed to achieve the target goal [27].

In our discussion of EF skills related to academic success, self-regulation was an EF skill associated with written expression, reading comprehension, mathematics, and homework completion. Teaching students self-regulatory strategies that specifically relate to the academic and independent skills they need to succeed in school is critical. For that reason, students must be taught self-regulation within the academic areas [41]. Thus, academic strategies [42] should support self-regulation skills by having a built-in self-regulation component. Throndsen suggests that for low performing students, instruction should address the cognitive, metacognitive, and motivational aspects of self-regulation.

Students with executive dysfunctions need a highly structured and well-organized classroom environment to circumvent the difficulties related to poor inhibition. Any potential distractions should be carefully controlled to restrict the amount of irrelevant stimuli students must deal with [4]. Orderliness and predictability can help the student to create a sense of self and an increased understanding of environmental events. Environmentally-based interventions (e.g., cueing, providing concrete information) may evade inhibition and facilitate student behavior self-regulation. The use of compensatory strategies and externally generated structures (e.g., checklists, computerized reminder systems, limit number of tasks that require updating) at both encoding and retrieval stages can facilitate student self-regulation during complex task performance [43].

One EF skill that often is a problem for many students with LD is working memory (updating). Limited working memory capacity can have a wide variety of negative effects on student academic performance. To offset the problem, teachers can support a student's working memory by presenting concepts and ideas that are limited in number. Miller's (1956) notion of the "magic number seven" (minus or plus two) can be helpful when planning how much information to convey at one time. For example, it is easier to remember a five-to seven-word sentence than a longer one; by the same token, it is much easier to remember five new concepts than nine.

Grouping information into chunks is another way to reduce overload of a student's working memory. Organizing visual or verbal information according to specific categories is one way of grouping or chunking information [3]. Chunks are clusters of items that can be stored as a single unit. For example, it is easier to remember these numbers presented in chunks, 758-598-3895, than remembering the same ten numbers without being grouped, 7585983895. It is easier to remember spelling words chunked by word families than a list of random words. Chunking or grouping increases the number of items a student can recall which is important for those students who have limited working memory capacity and updating difficulties.

The mnemonic keyword method is another research-based strategy that has been shown to improve paired-associated learning such as learning vocabulary words. Atkinson and Raugh [44] conducted one of the early studies using the keyword method. They showed its effectiveness in the acquisition of Russian vocabulary. A keyword is a concrete, associated word that is acoustically similar to the information to be learned (e.g., vocabulary words, places) that can be associated with the information to be remembered. An interactive visual image or a drawing of the associated word is then created and /or a sentence that shows the definition doing something with the keyword can be added. For example, Scruggs and Mastropieri [45] used the keyword method to teach students with mild disabilities the concept of "radial symmetry" (i.e., structurally similar body parts that extend out from the center of some organisms like a starfish), chose the acoustically similar keywords "radio" and "cemetery." They created an interactive picture of skeletons dancing to music from radios in a cemetery shaped as a star with each arm similar in appearance to strength the concept of similarity. The keyword method combines verbal information and visual imagery. A number of researchers [45,46] have documented the effectiveness of the keyword strategy. In all, a variety of research-based strategies are available that address the diverse needs of students who evidence executive dysfunctions.

Conclusion

There is compelling evidence that EFs play a critical role in student academic performance. Indeed, academic success is largely dependent on a student's ability to plan, organize, and prioritize information, regulate his/her attention, manipulate information in working memory, monitor his/her progress, and reflect on his/her work. For that reason, students who have EF dysfunctions, including students with LD, will likely struggle in the classroom. Accumulated research indicates that EF interventions success depends, in large part, on the support provided by those adults who are directly involved with the student (e.g., teacher and family). The EF environment must be structured, consistent, organized, and caring. Teachers must model good use of executive functions and ways to handle the lapses in executive function that are part of normal life [27]. A better understanding of students' deficits and ways to address their needs can help to close the achievement gap between students with LD and their peers without disabilities.

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