

# Working Memory Impairment on Underage Students: A Critical Discussion of How It Interferes with Their Learning Procedure and Ways It Can Be Addressed

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## ABSTRACT

This critical discussion examines the impact of working memory (WM) deficits on underage students' learning process. WM, a key executive function, plays a vital role in information storage and processing, stimulus filtering, and cognitive tasks facilitation. Approximately 10% of the general population and a significant portion of students with learning disabilities exhibit poor WM performance. This paper explores the effects of WM impairment on students and suggests strategies to address these challenges. Poor WM performance hinders students' focus, learning, and engagement in complex tasks. Stigma from peers and teachers exacerbates these difficulties. The essay proposes practical interventions such as screening tools for identifying WM impairments, task modification to reduce cognitive load, visual cues and graphic organizers, cognitive training programs, self-advocacy development, and the "Memory Mates" intervention utilizing visual prompts. These strategies aim to support students with WM deficits and enable them to overcome learning difficulties. However, further research is necessary to validate the efficacy and implementation of these interventions. By employing these strategies, educators can effectively assist underage students with WM deficits and help them achieve their full potential in the classroom

**Keywords:** working memory, WM, learning difficulties, cognitive load, visual cues, interventions, underage students

## HOW WORKING MEMORY DEFICITS AFFECT UNDERAGE STUDENTS

Working memory (WM) is one of the main executive functions of the brain. Among its functionality, WM is a system of limited capacity, responsible for storing and processing information, filtering stimuli based on their importance and for many other cognitive tasks which occur on a daily basis, like learning, problem-solving and decision-making [1]. The core structure of WM, as proposed and revised by Baddeley in 2000 [2], consists of four main components: The phonological loop, a sub-system that handles any information regarding written and spoken language, like mathematical problems, vocabulary learning and written addresses. It is sub-divided into two further categories which work independently but cooperate with each other, the phonological store, which holds for few seconds all audio stimuli that the individual receives, and the articulatory control process, where the audio stimuli from the first category is interpreted and stored as verbal information [3]. The visuo-

spatial sketchbook is another sub-system that is responsible for storing any visual and spatial information, as per its name suggests, assisting in recalling shapes and navigation [3]. The episodic buffer is a latter addition to the model, working as the main communication link between short-term and long-term memory, the transitioning and interaction between these two [2]. Finally, the central executive system is responsible for allocating data to the corresponding sub-systems, coordinating those sub-systems, while also dealing with cognitive tasks, such as problem-solving [3].

There is no fixed WM performance for all people. The functioning and the capacity of WM differentiates on each individual, with approximately 10% of the general population and a range of 20%-50% of students with certain learning disabilities to show poor performance on these aspects, according to the International Dyslexia Association [4]. It is uncertain how pervasive a WM deficit can be, nor if it can even align with a diagnostic category, but it is usually about a smaller than the average capacity with difficulties in accessing information from a certain sub-system [5,6,7]. Many learning difficulties, like dyslexia, autistic spectrum disorders, ADHD, are also frequently co-existent and highly correlated with low WM performance [8,9,10,11,12]. Therefore, WM deficits are some of the core reasons for children to experience learning difficulties.

Whether it extends to specific learning difficulties, a poor WM performance on its own is enough to cause symptoms which will make it hard for the average underage student to focus or learn from the typical educational environment. While the theory by Craik & Lockhart in 1972 [13], which claims that the more elaborate the process of learning is, the higher the probability gets that it will be transferred to the long-term memory, is heavily supported by studies [14,15,16], students with poor WM performance are unable to benefit from this, since the more complex the task they are given is, the more strain they put in their

WM, causing them to overload and ultimately forget what they were doing, get easily distracted, fail to recall the steps of their task while also thinking how to process them [17,18,19]. Qualitative studies constantly show that, not only the mainstream educative environments for underage students are disadvantageous for children with almost any learning difficulty [20,21,22,23,24], but also that teachers globally are not satisfyingly aware of those issues [25,26,27,28,29,24]. The main difficulties that a child with WM impairment will probably experience in the classroom consist of below average performance in most modules, especially in reading and math, as well as problems with multi-step tasks, concentration and remembering the correct line-up of a task's steps [30,31,32,33,34]. Hence, these children will differentiate from the others due to their inability to keep up with the rest of the classroom.

The differences between underage students against the rest of their classmates creates the social psychology's concept of stigma. Stigma, as described by Goffman [35], is a disgrace labeling those whose attributes are considered to be unnatural, out of the ordinary, which can make the stigmatized receiver to perceive these negative labels as reality [36]. Nevertheless, the stigmatizing occurs, not only from the classmates, but from the teachers as well. Many teachers, up to this date, are still not completely aware or properly trained to identify many learning difficulties, especially general WM deficits, which can become hard to notice or distinguish from the rest [37, 38, 28, 39]. Students stigmatized and labeled as 'bad, 'stupid' or 'irresponsible', regardless the reason, are susceptible to the effects of labeling theory, which claims that people who are attributed a label by society will tend to embrace it and behave the same way with what is expected of such labeled people to do, whether they fit these labels or not [40]. While the applications of this theory were initially inside the spectrum of the forensic sciences, it has been associated

with social psychology and all its' fields, including the educational system [41]. While a WM deficit on its own is enough to make underage students have a hard time learning and participating in classroom activities, all of the above exacerbate their performances, while also causing them to feel anxious [42]. Anxiety is subsequently magnifying those problems and it leads to a vicious cycle, where, without any interference, it is highly unlikely that any change will be made [43].

### **HOW WORKING MEMORY DEFICITS ON UNDERAGE STUDENTS CAN BE ADDRESSED**

Research has led to practical methods which can help underage students with WM deficits inside the classrooms. Gathercole & Alloway [44] suggest that teachers should take a four-step approach to support these students, which consistently fits with up to date's research on the subject and will be thoroughly examined below.

In order for something to be dealt with, it must first be diagnosed and understood. As it was noted before, WM deficits are hardly recognized by teachers in comparison to other learning difficulties, which often leads to false speculations and stigmatizing. In order to address this issue, for the first step of their approach, Alloway and her colleagues [45] devised the Working Memory Rating Scale (WMRS), a type of measurement focusing solely on WM related problems inside the classroom, with high internal reliability and no required experience in psychometric assessment from the teachers, helping them identify potential WM impairments among their students [45]. The WMRS has been furtherly tested continuously on multiple cultures and languages, which further strengthen its validity, while also being adopted, up to this date, as the best way to predict WM deficits in the classroom [46, 47, 48, 49, 50, 51, 52, 53]. As Alloway and most of the above studies note however, this is but a screening tool to help teachers identify potential cases of students with WM deficits, and should

not be used as a way to give a diagnosis, but prompt them to suggest to their parents a further examination from a psychologist.

By being aware of the presence of a WM deficit in classroom, teachers are able to proceed with interventions. The best possible way to deal with a WM deficit, not only inside a classroom but also in every environment, is by reducing the WM load. While, as it was already mentioned, it is generally supported that a more elaborate process of thought leads to better memorization and learning [13], the suggested approach when dealing with a WM impairment is quite the opposite [44]. On that account, as also the second part of the approach suggests, teachers should review the tasks that they give to their students in regard to the cognitive load that they accompany, meaning the number of steps for their tasks, the amount of information that each step holds, and try to reduce them [44]. A recent study by Mitre-Hernandez et al. [54] also proposes a way to measure the volume of the difficulty of a WM task by using eye-tracking data which, while not having received satisfying evaluation, can possibly provide a fundamental way for teachers to have a deeper understanding of how their methods actually incommode their students. This leads to the third part of the approach, which is about methods of dealing with a WM deficit.

The way that information is processed by students plays a significant role in WM capacity. Typically, in a classroom the teacher is usually speaking and explaining the lecture, with common situations where the students are required to read something from a book. During such situations, the highest strain can be observed in the phonological loop. Inefficient access to the phonological loop compared to the other sub-systems is also reported as the most frequently observed symptom of a WM deficit regarding learning difficulties [55]. For that reason, many studies consistently support that, when visual cues are used to replace many of the verbal or written

stimuli, the WM load becomes significantly more bearable for the student [42, 56, 57, 58]. The findings of Wang et al. [59] also suggest that the alteration of written and auditory stimuli into a visual form is highly correlated with increased development of word recognition on underage students. Those visual cues are ways of assisting in reducing the memory load, while also being processed from the visuo-spatial sketchbook, relieving even more cognitive load from the phonological loop.

Visual cues are often utilized in multiple ways in order to tackle the effects of WM deficits. Computerized cognitive interactions are rising, promising methods to train students into increasing their WM capacity. Studies consistently support that training can help underage students increase their capacity on its own or through video games, programs and virtual classrooms [56, 57, 60, 34, 61, 62], although their effect sizes are mediocre and there is no significant difference in comparison to their previous state. Graphic organizers also provide excellent assistance to children with WM deficits since, not only are they inside the spectrum of visual stimulation, they also help to keep the student on track with the steps of a task, which would normally be very challenging for them [63, 64, 65]. Another interesting approach to address the issues with memorizing is drawing. While the current bibliography is very poor regarding this matter, scarce evidence can be found indicating that drawing as a practice boosts memory performance and recall rates in children or adults with memory difficulties like dementia [66, 67, 68, 69, 70]. Due to the simplicity of this action and the population that it has been practiced so far, Fernandes and her colleagues [67] suggest that drawing could work to enhance memory on people with cognitive impairments as well [67], while also being an action that is appealing to children and therefore can attract their attention.

The final step of Gathercole & Alloway's approach [44] states the importance of

students to become self-advocate. Children with WM deficits should be aware of their own capabilities and adapt on strategies to cope with their learning difficulties while also feeling free to ask for help when they need to [44]. The Self-Regulated Strategy Development (SRSD) is a method that perfectly supports the needs of that part. SRSD is a six-step process of an individualized strategic approach against learning difficulties that aims for the teachers to teach their students self-monitoring and goal setting, up to the point that the students are able to apply that strategy independently and without guidance [71]. SRSD has been heavily supported by studies to cause significant improvements on the school performance of children with any learning difficulty, especially WM deficits [72, 73, 74, 75, 76]. Attentiveness and investment are crucial to improving a student's performance inside the classroom. Studies show that students who are more interested and engaged in their classroom activities demonstrate significantly higher academic participation and achievement [77, 78, 79]. Taking that into account, Davis et al. on 2014 [80] devised a method that would draw the attention of underage students, while also dealing with the difficulties that WM deficits can cause, named 'Memory Mates'. Memory Mates are a set of visual prompt cards which provide short explanations on simple strategies that will help the students to keep on track with the lecture, engage with it and learn [80]. More specifically, this intervention has two goals: First, it attempts to raise the teacher's awareness regarding WM deficit cases inside the classroom and second, to provide the students affected by these with methods to overcome them mostly individually [80]. At the beginning, teachers are given instructions on the intervention including what a WM impairment is, and then they are given the WMRS to identify any possible cases inside the classroom [80]. The prompt cards have graphical illustrations that represent the strategy they are inscribed, and

are placed in common view for everyone to have visual access to them [80]. The strategies include actions like ‘listen to the teacher’s instructions’, ‘create a picture of the activity in my mind’ and there is usually a memory coach for each student that is there to help them whenever they need [80]. The teacher and the memory coach were constantly reminding the students to look at the prompt cards and follow their instructions [80]. The results showed significantly higher attentiveness and learning rates, while also the students reported in the first and other studies that tested this method that they find the Memory Mates intervention really helpful [80, 81, 82]. The same researchers however found no significant difference using this intervention in 2016, although they hypothesize that it is due to the short period of time that the experiment took [83].

### **Recommendations**

As it can be seen from the above interventions, bibliography provides many clustering interventions that studies continuously find ways to utilize and support, providing specific approaches to address WM deficits on underage students. The first thing to be taken account of is the identification from the teachers, since all of the interventions are taking place inside the classroom. The WMRS is proven to be probably the best method to indicate possible cases among the students, given the strong validity it receives from the numerous times it has been tested.

With substandard planning and decision-making being one of the main challenges that underage students with WM deficits have to face, the reduction of WM load is another cluster intervention of great importance, which leads to another cluster intervention, the visual stimulation. Many of the interventions discussed are using visual cues to reduce the load of the phonological loop and increase their learning performance. Training WM to increase its capacity seems to be an effective approach, but does not provide satisfying results on its

own. Helping the students become self-advocate on the other hand provides satisfying improvements on their school performance, while also the SRSD can be utilized to assist students with any learning difficulty.

With these methods taken into consideration, one intervention manages to capture all of them and apply them during its process. Memory Mates make a great use of all these methods strategically, while also boosting the engagement of the students during classroom activities. The information and awareness of the teacher are the first steps to take place, while the students receive the visual stimulation from the prompt cards which act as guidelines to keep on track with the lesson, and the information that gets transferred to the phonological loop is shared and linked with the visuo-spatial sketchpad sub-system. The process remains simple and trains the children to increase their WM capacity, while at the same time it makes them become more self-advocate, taking advantage of every aspect that current bibliography suggests on how to restrict any learning difficulties caused by WM deficits. While a new and promising intervention, Memory Mates still need more support to increase their validity and further confirm these results. Further research should be taken into consideration, using this intervention in more cultures as well to test whether it can be considered globally acceptable. While insufficient access to the WM is a major difficulty for a learning environment with no treatment options, many creative ways can be used by the teachers to provide ways for the children to cope with it, even movies and video games. For a child with a WM deficit, as the famous colloquialism says, “a picture is worth a thousand words”.

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