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Working memory in children: How does it affect learning? Different methods and techniques that can be used to train and enhance the working memory of children

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Introduction:

This paper tackles the issue of working memory and how it affects learning of different children. As a kindergarten teacher, I have come across many children who showed signs of poor working memory. Those children shared common behavioral profile when they were supposed to get engaged in an activity that included different steps. They often never see the completion of the learning activities that they start. The reason behind this incompletion of tasks and activities is the inability to store the information or the different steps that they should go through to get the task done. Another common attitude that is usually encountered in those children is inattentiveness. When they lose the information, they simply cannot focus on the task anymore and so become unfocused. As a result, they show signs of disinterest and disengagement when they were asked to follow multi-step directions. On a one-on-one basis, it is very obvious to notice that they always lack the necessary information that can keep them engaged. It is not that they do not have the information or that the information cannot be comprehended, but it is usually lost. They forget it. They were always unable to recall given instructions that can keep them interested in completing any given task and hence will always fail to reach successful and concrete conclusions. They do not have the ability to keep the information stored for a sufficient amount of time. They do receive the information and comprehend it, but it is usually lost after a very short time span. This inability to keep the necessary information consistently leads them to either guess what should be done next (and guessing, definitely, ends up by faulty procedures and choices) or totally lose interest in learning.

Working memory is the mental workbench in the brain where given information is stored in order to be used and manipulated. It is a very important determinant of the academic achievement and interest of all learners. Children with weak working memory often struggle to

learn. Throughout the learning process, one needs to keep and hold information in mind while being engaged in different activities. The child for example should be able to keep the sentence that s/he wants to write in mind while spelling individual words. Also the child needs to keep numbers in mind while using these numbers in lengthy mathematical problems. Children in upper grade levels need to keep laws, equivalents and equations in mind in order to be able to use them while solving problems. If the child does not have this working memory capacity that would enable him/her to store and keep the information intact, the child would definitely face huge problems while learning.

Knowing about the behavioral profile of children with weak working memory can help parents and educators understand why some children exhibit such patterns of carelessness and indifferent attitude towards learning. It is illogical to assume that a child is not smart enough or to directly jump to the conclusion that a child has a behavioral problem once the behavioral profile of children with weak working memory is encountered. Hence, it is of crucial importance to know the real reasons for such behaviors, which can either be nature dependent or nurture dependent. Facing this fact makes it possible to know that the working memory can be trained and enhanced through many methods, the choice at which depends on the initial cause.

Throughout this paper, many interventions are highlighted as enhancers of poor working memories. Medications can be used as well as intrinsic and extrinsic training to enhance weak working memory. Experiments have shown that the training of working memory has resulted in better results than the medication alone, so this finding gives great hopes for teachers, educators and parents who are keen to help those children with poor working memory. It is of great help to know that training the working memory can be partially achieved, simply, by intrinsic methods that depend mainly on the repetition of certain working memory tasks for a prolonged period of

time and the continuous feedback and support given to the child. Besides the intrinsic training, there is also the extrinsic one which depends on learning different meta-cognitive strategies and techniques.

Knowing about different and varied topics that are all related to the working memory helps form a holistic understanding of the topic and helps the reader to know more about children suffering from weak working memory and different ways to help them.

My Research Study:

In my study, I evaluated the effectiveness of a classroom intervention framework that was implemented on selected kindergarten children, aged between 4 and 6 years old, who showed signs of weak working memory. It is a single subject experiment. This design allowed me to evaluate the engagement of students, who showed signs of weak working memory in different activities and tasks that took place in their classrooms. This design was also chosen because it did not have the drawback of treatment withdrawal. To withdraw a certain treatment after proven to be effective with children with poor working memory is considered very unethical. Although it is not a must to establish a baseline measure in this kind of design, I decided to establish this pre-treatment measure to have a means of comparison and to evaluate the performance of the selected children before and after the implementation of both treatments. Different methods and practices were included during the study to ensure the internal validity and the reliability of the experiment.

Literature Review:

In the first part of this paper, working memory is defined, and some examples of certain situations when we use our working memory are mentioned as well. The different functions of the working memory are explicitly mentioned. I have found out some answers to my questions about the children whom I have encountered in my teaching career who showed these signs of disinterest in the learning process. The working memory is exactly as its name entails. It is not just memory that is stored in our minds, but it is also a "working" and active memory which helps us to use the pieces of information that are temporarily stored and manipulate them to reach new and different conclusions. In this paper, the different components of working memory are discussed as well as their different functions. Baddeley's multicomponent model of working memory is presented.

The *Capacity Theory of Language Comprehension* is also presented in the paper and it allows the understanding of how pieces of information are stored and manipulated. This theory explains why the capacity of the working memory differs from one person to another and hence its performance is not the same among all individuals.

Also this paper has a description of the Cogmed working memory training which is widely used in working memory training and assessment studies.

What is working memory?

The working memory is the term used to refer to the ability we have to hold onto certain information in our minds for a short period of time and to be able to use and manipulate this information as well (Gathercole & Alloway, 2007). It is described as a mental workbench where we can jot down certain pieces of information for a short while until we manipulate and use them

(Ibid.). It is used when no other external resources are available in which to record information, such as notes or a calculator (Ibid.).

Examples when we do use our working memory:

When we ask for oral directions to go to a certain place, we definitely need to listen to the directions, keep them in mind and follow them (Ibid.). When mentioning a number that consists of five or six digits, we use our working memory to keep the number in mind until a paper and a pen are found to write it down (Ibid.). We use our working memory usually when we mentally calculate a certain mathematical problem. In this case, we use our working memory to add, subtract, multiply or divide certain numbers and we have to keep them in mind to go on with the calculations that we need to finish (Ibid.).

It is stated that the working memory consists of multiple components and they all operate by neural circuits. It consists of a *central executive* which acts as a control of attention center (Holmes, Gathercole, Place, Dunning, & Elliott, 2009). The working memory contains *two storage buffers* which are responsible for the storage and processing of the verbal and visuo-spatial information (Holmes et al., 2010). The working memory also consists of an *episodic buffer* which integrates different and multiple representations and pieces of information (Ibid.). So it is clear from the components that constitute the working memory that the working memory is not only concerned with the storage of the information but also with the manipulation and processing of this information (Ibid.). In other words, the working memory is concerned with the usage of the information that was just received.

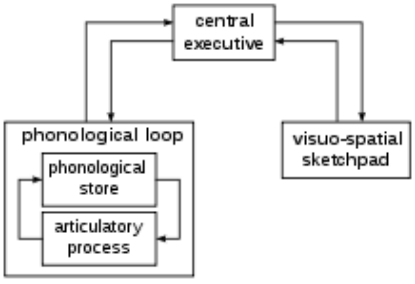

Figure 1: Baddeley's Model - Components of the Working Memory – Retrieved from http://upload.wikimedia.org/wikipedia/commons/thumb/e/ed/Working_memory_model.svg/269px-Working_memory_model.svg.png

Talking about working memory can never be complete without the introduction of *Baddeley's Model of the Working Memory (2003),* which is almost the same as the model mentioned above. Figure 1 shows the multiple components of Baddeley's model which still consists of the central executive, a phonological loop and a visuo-spatial sketchpad (Baddeley, 2003). The central executive is responsible for the attention of the individual during the performance of a certain task (Baddeley, 2012). The phonological loop is considered to be a phonological/verbal store and an articulatory system (Baddeley, 2003). The phonological store stores traces of sounds for a few seconds (Ibid.). The articulatory system is used in the rehearsal process, when the memory traces are being manipulated and certain productions are produced (Ibid.). Together with the phonological loop, there is the visuo-spatial sketchpad, which is considered to be the visual or the non-verbal aspect (Baddeley, 2012). It stores visual information, and at the same time can manipulate this nonverbal information and result in different productions (Baddeley, 2003). Figure 2 shows the different areas in the brain which are responsible for different working memory tasks.

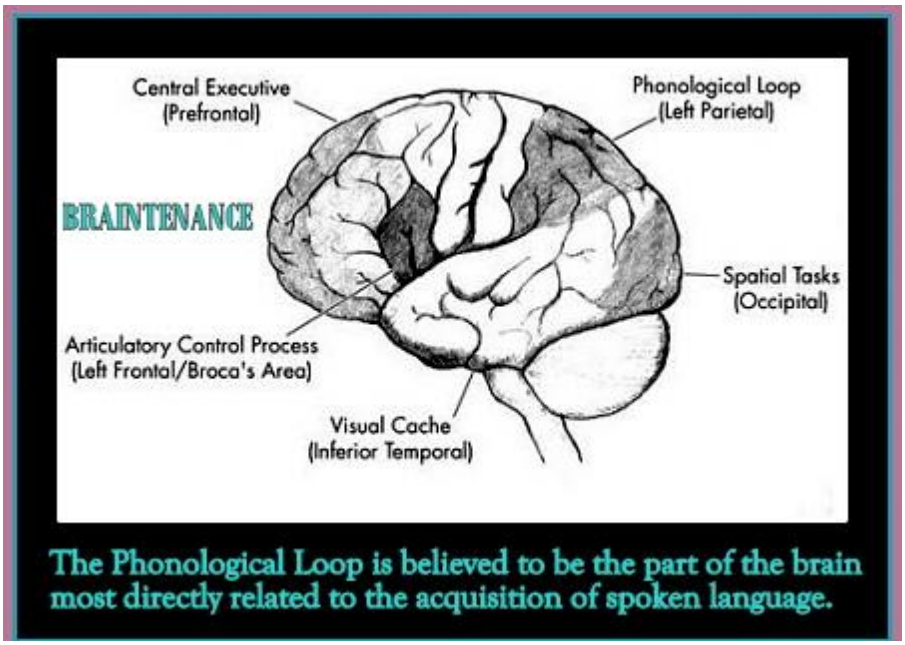

Figure 2: Baddeley's Model – Brain areas resposible for different functions of the Working Memory - Retrieved from: http://3.bp.blogspot.com/-ti-sO5qb2DE/UeCzLxoCaPI/AAAAAAAAK08/mrGGPr42cyc/s1600/Phonological+Loop+-+Braintenance+-+Learning+Language+-+Douglas+E.+Castle.jpg

To understand how the working memory works, specifically in language comprehension – as an example, the *Capacity Theory of Language Comprehension* (Just & Carpenter, 1992) will be introduced. It is stated that for the working memory to perform its functions, a certain level of activation should be reached (Ibid.) which differs from one person to another. This specific level of activation is reached when any piece of information is presented to the individual. In other words, any piece of information is believed to have a certain activation level. Information in any spoken or written text becomes activated by either being encoded, generated and manipulated or by being retrieved from the long term memory (Ibid.). Thus, the level of activation is determined according to the activity that would be generated after the presentation of the piece of information. It is very important to note that the generated activity varies from one person to another. One person might perceive the piece of information as a totally new one, while another may use the information presented and manipulate it to form new productions or conclusions and

a third person could already have this piece of information and would try to retrieve it from the long term memory. Any of the previous processes will result in a specific activation level (Ibid.) that is different from the others. When this activation level reaches a certain minimum threshold, the piece of information which resulted in the activation will be considered part of the working memory (Ibid.). If the activation level that is reached, is less than the amount required to perform a certain comprehension task, then the activation that is used to maintain old elements will be deallocated resulting in displacement of these elements and hence forgetting (Ibid.).

On the other hand, it is assured that the processes that underlie activation occur simultaneously and many productions are formed in parallel (Ibid.). If the number of processes (productions) is large and in turn the amount of activation which they propagate exceeds the capacity of a person's working memory, then processing will slow down and partial processes might be forgotten (Ibid.). In other words when the demands of a certain task exceed the available resources (capacity), both the storage and the computational functions of the working memory are graded. This theory is called *Capacity Constrained Comprehension* (Ibid.). This theory is similar to the *Cognitive Load Theory* (CLT), initiated by Sweller in 1988. This theory is very important when it comes to learning as it tackles the issue of weak working memory and provides an effective solution for it. This theory assumes that the working memory has a limited ability compared to the long term memory (Kirschner, 2002) and in turn provides different instructional guidance to overcome the limitation of the working memory. This theory calls for the avoidance of unnecessary load on the working memory and focuses on creating schemata that can be easily retrieved from the long term memory (Ibid.). In turn, instructional practices should cater towards proper organization and storage of information in the form of schemata. The benefit of having schemata is that it holds complex and multiple elements of information,

however these elements are treated as one unit by the working memory. This in turn reduces the load of the working memory (Kirschner, 2002). This theory focuses on increasing the efficiency of complex tasks (Mostyn, 2012). which entails increasing the learner's effort to learn and to remember a given amount of information (Ibid.). This is achieved by teaching and planning for the acquisition of cognitive skills and competencies through different instructional practices and materials (Kirschner, 2002). This theory does not only depend on the working memory of the learner but on the long term memory as well (Mostyn, 2012), which reduces the working memory load Both theories believe that the working memory of an individual plays a dramatic role in learning and in achieving complex tasks.

Reasons for weak working memory/Nature versus Nurture

It is well known that weak working memory is common in many categories of children (Minear & Shah, 2006). Children with developmental disorders as well as those with specific learning disabilities show signs of weak working memory and people do not realize the real problem, but think that it is short term or long term memory deficiencies. Also children who undergo chemo-therapy suffer from weak working memory (Ibid.), not only during the phase of treatment, but also possibly extending for years after treatment (Schagen, et al., 1999). According to the National Cancer Institute, these effects that are encountered for years after treatment may be extended even into adulthood. This might be partially due to the reduced white matter volume and integrity of the brain which is induced by radiation, as stated by the National Cancer Institute as well. The white matter consists of brain fibers that connect the brain cells together, enabling them to communicate. Also the white matter contains myelin, a coating found around each axon and which acts as an insulator.

There are different groups or categories of children who have the problem of weak working memory, but they all suffer from poor working memory and hence disengagement and disinterest in the learning process.

Referring back to the Baddeley model of the working memory, there might be more than one origin for the deficits of working memory. One origin might be the size of the phonological loop or the visuo-spatial stores (Ibid.) – referred to earlier in this paper. Another cause of poor working memory might be the extent of the integrity and attention of the higher level processes of the central executive (Ibid.). Also the efficiency of the rehearsal processes of the phonological loop or the visuo-spatial stores might be an indicator of weak working memory as well (Ibid.). Many theories suggest that differences in individual performances result from the differences in the capacities of working memory of different individuals (Ibid.).

Nature versus Nurture:

There is always this conflict between researchers as to what is the main reason for the differences in the performances of working memory between individuals. Does it totally depend on the nature of the individual? Or can it depend on the individual's exposure to different strategies and techniques that might enhance it?

It is very unrealistic to have a concrete and definite answer for those questions, of course. After what we have known from Baddeley's model about the anticipated origins of weak working memory, it is usually brought back to thought by other researchers who state that working memory can be nurtured (Minear & Shah, 2006). Many theories state that practicing different strategies would enhance or train the working memory (Ibid.). This will partially confirm that working memory is not only nature – dependent, but also nurture plays a role.

In order to sum up the reasons for weak working memory among individuals, one should know that there are causes that are naturalistic, such as different sizes of the phonological loop or the visuo-spatial stores. There also might be localized damage to one of them or more general damage in the central executive (Ibid.). Within the phonological loop or the visuo-spatial stores, there might be reduced capacity, poor knowledge representations in the long term memory or lack of usage of efficient strategies (Ibid.). Poor representation of long term memory refers to poor retrieval of information that is already stored in the long term memory (Ibid.).

Working Memory and IQ:

This is one of the most frequently asked and thought of questions. People often ask if working memories and IQ are interdependent. As a start, let's differentiate between the tests that measure each of these two, the working memory and the IQ.

The IQ tests are mostly dependent on the person's prior knowledge and on pre-learned skills (Gathercole & Alloway, 2008). Unlike the IQ tests, the working memory tests do not depend on the person's prior knowledge or learned skills (Ibid.). Being dependent on pre-learned skills, the IQ tests are surely dependent on many factors such as the person's background knowledge and the quality of education s/he has received, including the quality of the day care and/or schooling (Ibid.). Achieving poorly in IQ tests usually is the result of failure to learn a specific skill or knowledge. On the other hand, failure or achieving poorly in working memory tests is usually due to memory loads that are higher than the working memory capacity of the individual (Ibid.).

Instead of measuring a single skill or set of abilities, IQ tests assess a range of mental abilities and processes that are added up to each other (Ibid.). The IQ score then is an overall holistic evaluation of many different mental abilities (Ibid.). In contrast, the working memory

measures a component of the working memory system that is well defined and explained (Ibid.) as the working memory has three main elements: the verbal working memory, the visuo-spatial working memory and working memory.

From the above two mentioned comparisons, it is made clear that working memory assessments give an idea about the child's ability to remember important information and hence the child's ability to learn and keep data (Ibid.). So this explains how a child's IQ scores depend on his/her working memory. The child needs his/her working memory to learn new things or to keep important information (Ibid.). Thus, impaired working memory definitely affects the IQ scores (Ibid.).

Effect of working memory on learning:

This will bring us to a very important aspect which is the relation between working memory and learning. It is said that working memory capacity is a great predictor of the academic performance of different children (Gathercole & Alloway, 2008). Children with poor working memory capacity are low academic achievers especially in Reading and Math (Ibid.). On the other hand, children who score high in working memory capacity are believed to be high achievers in Reading and Math (Ibid.). These results are not for the early years of learning only, but are actually relevant to later years as well (Ibid.).

There is a certain paradigm that recommends the assessment of the working memory of all the young children at the level of school entry (Ibid.). Assessing the working memory of the children during their early years is considered to be a very reliable way to identify the children that might be at a higher risk of being low achievers during their school years (Ibid.). It has been proven in previous studies that children whose working memory scores were weak when they first entered school, are the same students who failed to pass the national expected levels a few

years later (Gathercole & Alloway, 2008). Early identification of the children who are at risk of poor academic achievement is crucial as it allows an early and prompt intervention that can reduce the adverse effects of the poor working memory on learning (Ibid.) and in turn, implementing classroom intervention (that will be explained later in this paper) and teaching the students, at an early age, certain strategies that they can use to compensate for their weak working memory is of crucial importance. It is definitely better to cater to those children from the beginning of their learning journey during their first years to avoid them being left behind and hence losing a lot of learning opportunities which will in turn affect them in their future years. Also training the teachers on how to implement the classroom approach is mandatory and a key point in enhancing a well diverse and individualized approach that can be held accountable to cater for individual needs. I find the teachers have a huge responsibility as that might be the only guarantee, besides training of working memory, that would save those children from the short and long term effects of their weak working memory.

The reason behind the poor academic progress in children with weak working memory is mainly the working memory overload. The working memory of those children cannot cope with the working memory demands of the activities that they go through (Ibid.). In other words those children with weak working memory tend to lose crucial information that is necessary for them to complete a certain task or to follow a multi-step direction process (Ibid.). So they either abandon the task completely or they tend to guess what they should do next (Ibid.). Guessing leads to many errors. It is sad to say that the failed attempts and task abandonment represent missed learning opportunities for those children (Ibid.).

General characteristics of children with poor working memory:

More boys than girls have poor working memories (Gathercole & Alloway, 2008). Children with poor working memory show the same classroom behavior at all times (Ibid.). The severity of this problem of having a poor working memory does not change from day to day (Ibid.). The social relationships of those children are normal although they do not participate in any group activities (Ibid.). They do not volunteer to participate in any classroom discussions (Ibid.). It sometimes happens that those children might raise their hands showing their intention to participate in a group discussion, but once called on, they do not respond and they have nothing to say (Ibid.). We are not sure if they have forgotten what they wanted to say or they did not have anything to say from the beginning (Ibid.). These children would normally withdraw from group discussions or activities.

Children with poor working memories are never described by their teachers as suffering from weaknesses in their working memory capacities (Ibid.). They are often described as students with very short attention spans, who can be easily distracted and having very low self-esteem (Ibid.). They are often believed to fail in monitoring and evaluating their work and always accused of making carless mistakes (Ibid.).

Behavior profile for children with weak working memory

The behavioral profile in children with poor working memory is fairly even between both genders (Gathercole, 2008). This behavior is usually stable and lacks any impulsive and hyperactive nature that is found in children with ADHD (Ibid.).

Children with poor working memory often struggle with reading, math and science and the reason for the academic struggling is that the memory demands are overwhelming for them (Ibid.). In other words the learning strategies and activities that they encounter require many

memory demands, which they are unable to meet. As a result of that, the necessary information that is needed in a certain learning activity such as writing a sentence or keeping in mind certain directions to follow is lost (Ibid.). Thus the children with weak working memory are usually unable to proceed with the learning activity and usually unable to reach a successful conclusion. The reason for that is that the information is lost from the working memory and the only solution is to regain access again to the lost pieces of information (Ibid.). When the children cannot regain access to the information, or in other words when the children lose what has been said or the instructions that should be followed, they either start to guess which lead to a lot of errors or they would stop working and will avoid the task (Ibid.). Such experiences definitely delay learning and the more frequent the children encounter such incidents, the more negative they would become towards education (Ibid.).

Another behavior is always associated with poor working memory which is loss of attention (Ibid.). It is claimed that the inattentiveness that is encountered in children with weak working memory is due to what is mentioned above – the failure to complete a certain task and the unsuccessful trials to meet the requirements of different learning activities (Ibid.). This disengagement in the learning process result is what is called "zoning out", where the child loses attention or shifts his/her attention away from the overwhelming learning procedure (Ibid.).

Strategies or techniques to cope with weak working memory

There are believed to be many different strategies and techniques to enhance and cope with weak working memory.

As a start, we can differentiate between two ways of working memory training. Training might be implicit when it depends solely on the repetition of the same task, followed by feedback on the performance and finally adapting the training and the difficulty of the task according to

the performance (Klingberg, 2010). On the other hand, working memory training can be explicit if it depends on learning different strategies. The different strategies that can be used to enhance the working memory can be rehearsals, chunking and many different meta-cognitive techniques (Ibid.). What is common in these strategies is that the person with weak working memory usually exerts the effort to consciously learn and practice these strategies for the goal of empowering his/her working memory. Chunking refers to putting different pieces of information in a certain sequence by relating them to previously stored concepts or pieces of information in the long term memory (Ibid.). Chunking, also refers to the grouping of related items or words in order to be stored and processed as single concepts.

One specific well known working memory training is the Cogmed Working Memory Training. This is a computerized training for the working memory and it is referred to as "a computer – based solution for the attention problems caused by poor working memory" (Roche & Johnson, 2014). It is available for three levels. The Cogmed JM is for preschool children (age 4 – 6), Cogmed RM is for school aged children (age 7 – 18) and Cogmed QM is for adults (Ibid.). The Cogmed working memory training is based on the multiple component model of the working memory that is stated by Baddeley and at the same time, it depends on the theory of the brain's neuroplasticity which explains that the brain's performance can be developed and enhanced by tailored and continuous practice (Ibid.). The Cogmed working memory training consists of eight daily different tasks that are done in five consecutive days for 5 consecutive weeks (Ibid.). The daily training consumes from 30 to 45 minutes per day. However, the Cogmed JM for preschoolers (age 4 – 6) includes fewer tasks that take 15 to 20 minutes only (Ibid.). The Cogmed JM consists mainly of child – friendly bright colored themes which have different representations of roller coaster, Ferris wheel, bumper car and others(Ibid.). The

children should use the mouse or the touch-pad to click on the different representations in the correct sequence. By clicking on the different representations, the child will receive an immediate feedback in the form of giggles, smiley faces or cheers for correct responses and frowns or sad faces for false responses (Ibid.). At the end of the training, the program produces a report called Cogmed Progress Indicator (CPI) which gives a detailed evaluation of the individual's progress in three tasks which are working memory, following instructions and math challenge (Ibid.).

Can it be enhanced or trained?

Experiment:

It is stated that working memory deficits can be overcome through training programs. I would like to share the findings of one study which studied the impact of two interventions on the working memory performance of children. This study was examining the impact of the training program as well as the stimulant medication on the working memory performances of children (Holmes et al., 2010). This study included 25 children (21 boys and 4 girls) aged between 8 and 11 years old. The children selected were either diagnosed of combined type ADHD for 6 months or longer or having a prescription of psycho stimulant medication for ADHD. Each child had to go through 4 sets of assessments during individual testing sessions (Ibid.). For children under medication, the medication was withdrawn at least 24 hours prior to the assessment at time #1 (Ibid.). At the second and all other assessments, children were taking their medications regularly. As for the children taking the training program, Cogmed Working Memory training started within 1 week of time #2 assessment (Ibid.). Each child completed 20-25 training sessions. After the completion of the training program, a post training assessment was administered to the children (Ibid.). Another assessment was done on each aspect of memory 6

months after training. That is the fourth assessment that the children have to go through throughout the course.

Results:

The working memory training resulted in significant gains in all of the 4 memory components (verbal short term memory, visuo-spatial short term memory, verbal working memory, visuo-spatial working memory) scores (Ibid.). However neither the medication nor the training resulted in any gains in the verbal IQ or in the performance. Six months after the training program, there was no significant deterioration in the visuo-spatial short term memory, verbal working memory or visuo-spatial working memory scores. The medication resulted in significant gains in the visuo-spatial working memory (Ibid.). But overall, the training program led to greater gains in working memory than the medication alone (Ibid.).

There are different possibilities and interpretations for the above findings. One of these interpretations might be that working memory might be enhanced by intense training because of the plasticity of neural cells and in turn their functions become better (Ibid.). Another possibility might be that the intense nature of the training program will result in either the production of working memory strategies that will compensate for the weaknesses or the subjects' conscious control of attention during the performance of complex tasks (Ibid.). The significant effect of the medication of ADHD on the visuo-spatial working memory might be the result of its strong influence on the right hemisphere in specific which contains the areas responsible for the visuo-spatial working memory (Ibid.).

Principles of the working memory intervention:

This section of this paper introduces the classroom-based approach designed to help and support the children with weak working memory as well as their teachers. The teachers need to

understand the nature of those children with weak working memory. They need to understand what strategies can work and what trials might simply lead to more failures. It is of crucial importance for the teachers to know that the information once lost, cannot be retrieved again and that the only solution is to administer the information again in a more suitable manner. Additionally, this intervention helps the teachers to know more about the strengths and weaknesses of students. Thus the teachers will know what will the students be able to do and what tasks would add to the difficulty of the situation. Teachers will be encouraged to engage the children with weak working memory in certain activities and to refrain from other activities.

This intervention aims at minimizing or avoiding the failures that might happen to the children due to their weak working memories (Gathercole & Alloway, 2008). One of the strengths in this approach is that it can be applied with any curriculum (Ibid.). It provides the necessary modifications that will enable the child to complete the tasks and activities that s/he normally fails to see through completion (Ibid.). Another main strength is that this intervention consists of a set of principles/strategies that all aim to avoid working memory failures (Ibid.). It is not only one strategy that might work one time and fail in the other. This provides the child with a rich source of strategies that can compensate for the working memory failures and hence the child's confidence is enhanced and gets better (Ibid.). Below is a list of the different principles that constitute the classroom approach and the different steps that should be carried out by the teachers to avoid the failures of the weak working memory of some children:

1. Recognize working memory failures:

   There are four warning signs that all adults related to children's learning should know and be able to identify once one or more of them happen (Ibid.). The warning signs are:

   - Incomplete recall:

Partial or complete loss of information is likely to happen with children with poor working memory. (Ibid.).

- Failure to follow instructions:

  Children with weak working memory, can remember the first few instructions, but then fail to remember what is next (Ibid.).

- Place-keeping errors:

  Children with poor working memory cannot tell which steps were done and which steps have to still be done in activities that include several steps. As a result, they, sometimes, go through some steps twice or more and in other times, they omit or skip some steps (Ibid.).

- Task abandonment:

  Children with weak working memory, tend to forget what exactly needs to be done. As a result, they stop working on a specific activity and abandon the task completely (Ibid.). What makes this sign really destructive is that sometimes it happens that those children not only abandon the task themselves, but also distract their colleagues' attention and focus towards off-track activities and discussions (Ibid.).

2. Monitor the child:

   Teachers and other adults related to the child's learning should usually monitor the child and his/her activity in different mental processes (Ibid.). There are two main ways to monitor the child:

- Check the presence of any of the warning signs: The warning signs (as mentioned above) need active and alert teachers as they may pass unnoticed by busy teachers (Ibid.).
- Ask the child: The teacher or any adult related to the child's learning should regularly ask the child about the next step that s/he will do (Ibid.). It is also believed that such a strategy acts as a "repetition" method which in itself is an activity that can keep the information for longer periods of time (Ibid.).

3. Evaluate the working demands of learning activities:

   The teacher should usually evaluate the working memory demands of different steps in different activities. If at any point the work memory demands were evaluated to be excessive, the activity could be modified in order to reduce the working memory load (Ibid.).

   Some factors that affect the working memory:

   - Excessive length: lengthy sequences often place high working memory demands especially if the things in sequence are unrelated. (Ibid.).
   - Decontextualized content: Content that is unfamiliar or unmeaningful places heavy demands on the working memory of children with weak working memory (Ibid.).
   - A demanding mental processing activity: If the working memory is involved in a mental process besides the storage, that would add up to the working memory load (Ibid.).

4. Reduce working memory loads:

To ensure that children with weak working memory succeed in the completion of different learning activities, the working memory loads should be reduced. (Ibid.). There are two ways to reduce working memory demands. First is *lesson planning* (Ibid.). A class activity or the technique of instruction might need to be modified to suit children with weak working memory. The second way of reducing working memory demands is the modification of the tasks that students are asked to perform to suit children with weak working memory (Ibid.). Repetition of the task after modification is of great importance to the child as it makes him/her to be more familiar with the task and with what is to be expected (Ibid.). Reduce the amount of material: The huge amounts of information can be reduced by shortening the sentences and by dividing the multi-step activity into smaller one step at a time tasks (Ibid.).

- Contextualization of the content: As is mentioned earlier in this paper, familiar content contains knowledge that already exists in the child's long term memory, so retrieving this knowledge will not depend solely on the working memory, but also on the long term memory (Ibid.).
- Simplify mental processes: Most of the activities that the children are engaged in in their classrooms include some mental processes other than just storage of the information (Ibid.). These mental processes might be reading a word, spelling a new word, solving a mathematical equation or comparing between the sounds of different letters (Ibid.). Mental processes consume the child's working memory. In other words, reducing the mental processing demands can preserve the working memory.

Restructure complex tasks: complex and multi-step tasks are often advised to be broken down in simpler independent tasks. This separation of tasks will prevent the errors of skipping or repetition that the children tend to make (Ibid.).

5. Be prepared to repeat:

   It is of crucial importance to repeat information to those children with weak working memory (Ibid.). Repetition of instructions, general classroom rules and routines and content specific information is of great benefit (Ibid.).

6. Encourage the use of memory aids:

   Memory aids provide a great help to children with poor working memory (Ibid.). Memory aids provide information that can be lost and/or reduce the working memory loads (Ibid.). Children will use these external memory aids if they are found nearby. Shifting from one place to another would consume the working memory and would not help the children to seek the benefit of the aids, but if they are nearby, children will find it feasible to use them (Ibid.).

   Some of the memory aids that can be of great benefit:

   - Writing aids: Spelling charts, flash cards, word strips and dictionaries are very important writing aids.
   - Mathematical aids: The use of mathematical memory aids can be of great help. For young children in their early years, the children can use concrete objects that they can use to count (Ibid.). Children can use their fingers andnumber lines (Ibid.). Older children who have passed the level the primary level of mathematics, can rely on more advanced mathematical aids such as calculators, multiplication grids and memory cards (Ibid.).

- Audio devices: This is another kind of memory aid that can be of great help. Besides the other aids that are mostly visual, this audible aid can serve as a back-up for any instructions that are given to the children (Ibid.).
- Computer software: Technology provides an opportunity for children to be active learners by having to choose certain icons or clicking on them to receive a certain piece of information (Ibid.). This interesting memory aid grabs the students' attention and helps them retrieve the information independently in an exciting way especially for young learners.

7. Develop the child's strategies for supporting memory:

   This last principal in the intervention aims at teaching the children with weak working memory some strategies that they can use themselves to help them when they forget crucial pieces of information (Ibid.). Some of these strategies are:

   - Request help: this is a strategy that should be fostered and taught to children with weak working memory. These children should understand the importance of this strategy as it can help them avoid the failures that result from working memory over load (Ibid.).
   - Rehearsal: rehearsal is referred to as the strategy in which the child rehearses verbal information for a brief period of time (Ibid.). Repetition of the verbal information keeps information intact for a brief period of time.
   - Note-taking: writing down basic information that would support the performance on different tasks and activities would be of great help to the students (Ibid.).
   - Using long-term memory: depending on information that is in the child's long term memory makes it a lot easier to retrieve (Ibid.).

- Place-keeping and organizational strategies: this strategy needs a lot of metacognition from the child's side (Ibid.). The child needs to be aware of the multiple steps that s/he has to go through to the completion of a certain activity.

Methods:

Overview

This study was a single-subject kind of experiment where the principles of the working memory intervention, that are mentioned in the previous section, were implemented in different kindergarten classrooms in an international school Homeroom teachers were introduced to the intervention and it was explained in detail to them. Afterwards, they implemented the strategies included in the intervention in their classrooms with the students that showed one or more signs of weak working memory. Students' attitude, behavior and performance in different activities were monitored and the effect of the intervention was studied and observed. Only kindergarten children showing signs of weak working memory were selected for this study over a period of 4 months. The selection of the students was done by their homeroom teachers as they are the teachers with whom the children interact most, in many contexts and different activities. Homeroom teachers in this school have a good standard base of qualifications. All teachers have a good number of years of experience in this school or others. They show their concern and feeling of responsibility for the well-being of their students. Qualifications vary among the different teachers in this school. Some only have a certificate, others have a teaching diploma and others had pursued or are in the process of pursuing their Master's degree. That being said, it was surprizing that none of the teachers had known before about the working memory intervention. Some teachers used to implement some strategies that are included in the working memory intervention as their means of differentiation and of having different teaching and instructional practices, but they did not know its benefit for children with weak working memory. Most of the teachers could identify one or a few students in their classes with warning signs of weak working memory which signifies the common presence of those children.

Teachers were interested to implement the intervention showing how important it is to find a way to cater to such students. However, few teachers had successfully implemented it. The main reason for not implementing it by other teachers was the amount of time and effort needed to plan and implement it.

Kindergarten students range from 4 to 6 years old. They are selected based on an interview assessing the child's behavior, knowledge of basic information, ability to respond to questions and the general appearance. Another separate interview is conducted with the parents to have an insight about their philosophy of raising up their child, if they punish the child, and if so how. It is an interview that seeks to gain an insight about the mentality of parents and if it matches the school's philosophy, mission/vision or not.

The school tends to be strictly selective in the admissions process. It seeks a certain level of social standard and open minded parents. It is a strict school which is concerned with the academic progress of the students as well as the attitude and behavior aspect. This is an important part of the school culture which is fostered in all and every occasion. It is considered to be a school with a high level of expectations in all aspects. Students who cannot cope with its high expectations eventually leave the school during their early years. In some occasions, this happens in the kindergarten stage!

This fact has a moral responsibility on the teachers working in this school. Teachers should try all practices and interventions that can help them reach different learners. Children might just need individualized or tailored teaching practices such as the working memory intervention. Additionally, teachers should believe in the importance and benefit of student diversity, but must be capable of dealing with it. So this intervention might be a good addition

that can help the teachers to keep more students included in this school and avoid their admission to a school with lower expectations.

I asked kindergarten teachers of the international school if they have children who show one or more signs of weak working memory. This school has an American and a British division. I shared the warning signs of weak working memory with the teachers to help them identify those students who might have problems with their working memory.

The aforementioned warning signs, that I asked the teachers if they encounter in one or more of their students, are:

- Difficulty in recalling what has been said – sequence of sentences, words in a sentence
- Failing to follow instructions, ability to remember only parts of a sequence of instructions.
- Place – keeping errors
- Giving up on tasks completely, especially those that include multiple steps.

To avoid the violation of the internal validity of this study, proper controls were exercised. As a start, stable baseline measures were obtained in order to provide a description of a certain target behavior before starting the intervention. The goal was to obtain a well-defined and specific baseline measure for each of the selected children before the intervention began. It is surely clear that instrumentation used to measure single-subjects' performances might so easily violate the internal validity of the experiment. To avoid that, repeated measures of children's performances were as consistent as possible. Observations of participants' behaviors was standardized as much as possible in terms of the location, time and setting of the observation.

New experiences and unexpected incidents or situations were totally avoided as they could have ruined the validity of the design.

Another very important point is the possible replication of the treatments used. The treatment relied on the same procedures each time it was used. Same sequence, duration, conditions, feedback and support ensured the possible usage of such a treatment many times in the same way. The stability and standardization were the key to the generalizability of the design of this study.

I depended in my study on many observations of the selected sample. The weather conditions were ensured not to be in either of the two extremes. Primary needs, in terms of food, water and the need to use the bathroom were met before observing the response to different working memory tasks. The duration of these pre-treatment observations were extended till a stable baseline measure was obtained for each of my participants. The aim of reaching a stable baseline was to have a basis of comparison to evaluate the effectiveness of the intervention.

In this study I opted to use the *Classroom guide Framework,* which was developed by the University of York in 2007. In this experiment, I will use the classroom support framework, which includes many teaching strategies or techniques that the teachers can use in their classrooms with those students who show one or more of the warning signs that were mentioned earlier in this paper.

The Classroom support Framework for children with working memory problems:

It is of crucial importance to note that such intervention is not meant to improve the working memory of the children, but it is an approach that can be conducted by different

teachers to minimize the chances that the child will fail to get engaged in different learning activities. Minimizing the chances of failure or disengagement occurs through managing the children's working memory loads. The goal is to avoid the disappointing consequences of excessive working memory loads.

Such intervention will help the teachers while preparing their lesson plans for their students with working memory problems. Monitoring such students and their engagement will definitely be of help to the teacher as well.

Framework of classroom support:

The detailed principles of the working memory intervention was explained earlier in this paper, but just to remind the reader, find below a quick summary

1. Identifying the children who show signs of poor working memory:

   Warning signs, as mentioned earlier, are:

   - Difficulty in recalling what has been said – sequence of sentences, words in a sentence
   - Failing to follow instructions, ability to remember only parts of a sequence of instructions.
   - Place – keeping errors
   - Giving up on tasks completely, especially those which include multiple steps.

2. Monitor the child:

   The teacher should look for:

   - Warning signs (point #1)
   - Checking directly with the child if s/he knows what should be done next.

If the child is confused, does not know or forgets, the teacher should:

- Repeat information as required
- Break down multi-step tasks into a one-step-at-a-time manner

3. Encourage the child to ask for help when s/he does not know what to do. Evaluate the working demands of the learning activities
4. Reduce working memory loads whenever needed

   This can be achieved by:

   - Reducing the required material to be stored. Increasing the contextualization of the material taught.
   - Simplifying the language of instruction. Dividing multi-step tasks to small and simple tasks.
   - Using memory aids.
5. Be aware that processing demands increase the working memory loads
6. Repetition is of crucial importance

On a side note, the *extrinsic* method – which is not tested in this study, is a way of training the working memory through certain strategies that are taught to the student to help him/her retain important pieces of information so that s/he becomes able to manipulate and process them.

Repetition also includes:

- General classroom rules and routine that are expected.
- Instructions that are specific to a certain activity (Dividing multi-step tasks into simple individual tasks).
- Instructions for that one task that is a part of a multi-step activity.

7. Support the use of memory aids
8. Train the child to develop memory retrieving strategies such as:
    - Rehearsing to keep important information
    - Asking for help when there is difficulty recalling important information
    - Ability to break down tasks

As a kindergarten teacher, I think that this last step of the framework (#8. Train the child to develop memory retrieving strategies) is a bit advanced for children between 4 and 6 years old. I believe it would be helpful for older children who are more self-aware of their weaknesses. I do agree that it is a very important strategy and I do know how important it is, but for kindergartners, it may need a lot of practice until it is learned.

This intervention was explained to different teachers who could identify students who show one or more of the warning signs in their classes. Initially, there were five teachers with eight students willing to implement the working memory intervention. Those teachers who managed to fully work with it were three. They used the intervention for four weeks. After four weeks, I started collecting data from the teachers about the intervention. Teachers' interviews were conducted to know their feedback about the intervention, its efficacy and if the students had shown any progress.

Teachers who implemented this intervention exerted a lot of effort with the children who showed signs of weak working memory. They consumed much time as well. I have noticed that they were so busy even in their free time, they were busy planning or preparing extra resources for those children. They needed to spend one on one time with the children whom they are working with. On the other hand there were teachers who intended to implement the intervention

but were not able to work on it. The incapability was mainly due to the much effort and time that it demands. Most of the teachers are busy at all times, so introducing this intervention and asking them to implement it right away was not practically easy. They did not find it easy to plan and prepare resources for those children with weak working memory besides the normal planning of their classes. They expressed their wish whenever we met in the hallways or in our meetings in the school, to start implementing the working memory intervention. They did want to find a way to deal with those children who are most of the time left behind, but they expressed their tight and busy time and schedules. In our conversations, we mentioned that first time implementers of the intervention will definitely consume more time and effort, but by time and more practice, teachers can get used to it and will have already prepared resources and this in turn might make it a bit easier for the teachers. Another point was mentioned that preparation for the first time implementers should take place before the beginning of the school year. This will make it a lot easier and will help the teachers focus on the strategies themselves and not on the preparation of the resources or the memory aids.

The overall feedback that I got from the teachers was productive and positive. The effect of this intervention was proved to be very successful. Children who showed signs of weak working memory were not left behind as was the case before the implementation of the intervention. Teachers, successfully knew different strategies that helped them to reach those students.

A very important advantage in this design is the absence of the withdrawal phase which is found in most of the other single-subjects experiments. The withdrawal phase is that phase when you have to stop a certain treatment even if it was proved to be beneficial for the participants. I consider it to be very unethical to stop implementing a certain strategy or

technique when you are certain that it is mandatory and beneficial for the participant's learning. Dealing with kindergarten students makes it more difficult as they are not like older students who can help themselves or who would choose to keep implementing a certain strategy on their own even after the discontinuation from the teacher's side. This requires a greater ethical responsibility and commitment.

Further research could be carried out to explore different kinds of replication, but as a start, direct replication will add to the generalizability of the findings. Replication or the repetition of the study adds also to our confidence of the treatments that are implemented.

Findings:

Overview:

As stated above, this research study is a single subject experiment. Children who show signs of poor working memory were those who are selected for this study. Kindergarten teachers in an international school were asked if they encounter children in their classes that show one or more warning signs of weak working memory and they were told about this classroom approach. There was a great interest to participate in this study. These teachers had a great need to find solutions for these students with weak working memory who were always lagging behind and never engaged in classroom activities that take place. Children with weak working memory tend to forget the different steps in a multi-step tasks or activities. They are not able to recall different instructions that are given to them. This difficulty to recall either leads to wrong guesses or complete task abandonment which in turn leaves this child behind, not knowing what to do and unable to be engaged in whatever is going on in the class.

The teachers who found one or more warning signs in children in their classes were told about the intervention. Communication of the intervention was a crucial step as the teachers were able to understand the reason behind this attitude in learning. They got to know that the students cannot help this attitude and that it is their job to modify and change their teaching technique to suit these students. The teachers have known how the intervention really helps those children.

Experienced teachers might have already used one or more of these strategies but maybe were not persistent enough, which might have hindered an obvious progress in the children's learning performance.

Results of this intervention were promising and successful, for both the students and the teachers Children who showed signs of weak working memory were not left behind as before. Those children were able to participate in different classroom activities. It is true that they had their own pace which might be a bit slower than their colleagues, but it is a progress for these students. Students are no longer totally dependent on the teacher or another source of guidance as was the case before implementing the working memory intervention when the child used to sit inattentive and unfocused in any activity that used to take place until the teacher or another adult came and told him/her what should be done. By time and practice, the students got to know certain strategies that they could resort to by themselves. Some of those students had better self-confidence and self-esteem as a result of the diminished failure trials. As they were able to successfully complete the different tasks and activities, such as successfully finishing a specific craft or project, writing a complete sentence or working on a worksheet, their self-confidence and hence their self-esteem improved which in turn led to more error free trials.

Although parents did not know that an intervention was going on, they noticed the progress that happened in their children. They noticed that their children could now gain skills that were not found before. The school administration did not see it mandatory to inform the parents about the intervention. The reasons behind this decision were: the intervention was carried solely by the child's homeroom teacher and the intervention only includes different teaching strategies and practices that any teacher can freely opt to use in her/his class. One parent noticed that her child had dramatically improved in his reading skills. The school sends a leveled reader book with the students every week, and this child was never able to read to his mother. After implementing the intervention, the mother told the teacher that she was astonishingly listening to her child while he read the books that were sent home earlier. Teachers were

thanked for the effort and time that was invested in their children. Another parent in another class also noticed a great improvement with her daughter's academic progress. This parent sent an email to the teacher to express her thankfulness for the teacher's efforts. The parent mentioned that she had noticed that her daughter is more aware of what is being taught at school. The student goes home and talks about things that happen at school and the parent has noticed the difference.

This approach is believed to consume the teachers' time and effort as mentioned by both teachers who have worked by the intervention and those teachers who were unable to implement it. Several teachers have expressed their desire and interest to implement this approach with students in their classes, but were not able to, because of that reason. Teachers have mentioned that to implement this approach, they needed to do extra planning for those students who showed signs of weak working memory and they needed to prepare extra resources and memory aids for those students as well. Additionally, the teachers need to spend much one on one interaction with the children. This extra planning, preparation and one on one interaction besides the normal planning and preparation for the rest of the students, made it not an easy approach to be followed. They mentioned that they were too busy and did not have enough time to consume on implementing this approach. They could not have the time to give primary one on one attention and to prepare extra resources or memory aids for those specific children with weak working memories. It was mentioned by one of those teachers who used this classroom approach that it is very tiring, as well, with all the repetition of instructions and information that had to take place. However, she mentioned that this effort that is exerted and the time consumed were worth the results and progress that were achieved.

As a summative wrap up for the results of this intervention, it is believed that this classroom approach is of great help to those students with weak working memories. They show great signs of improvement and progress which is a very satisfying outcome for the teachers who consumed a lot of time, effort and resources. On the other hand, it is not considered an easy to implement approach as it needs a proper and detailed planning of instruction and resources ahead of time. It is not one kind of approach that can be once decided to work with, implemented on the spot. The teacher cannot just decide to implement it without having a detailed and well prepared plan.

Detailed findings of this study:

Teachers were interviewed after a month of communicating this classroom approach to them. In their book *Working Memory and Learning: A Practical Guide for Teachers*, Gathercole and Alloway (2008) used the following interview questions to ask the teachers who implemented the intervention with one or more children with weak working memory.

Below are the interview questions and the teachers' answers:

- Have you noticed any differences in the child/ren as a result of the intervention?

  Teachers, who implemented this classroom approach, all agreed that definitely they have noticed big and dramatic differences in the child/ren as a result of the intervention. One teacher was confused as the child whom she used the intervention with was not steadily progressing. The child showed signs of improvements one day and returns back to his first state the other day. That is to say, that this child did not show a stable and regular progression, but was fluctuating all the time between signs of progression and back to his initial state. This child's teacher mentioned that "Repetition and one on one interaction were the most beneficial for him".

- Were there any other benefits of taking part in the intervention?

  One teacher mentioned that this approach benefitted the child's self-esteem. The child's self-confidence got better and this enabled him to participate in different activities that he was not engaged in before. He started to sing, talk and raise his hand, activities that he deferred from before implementing this approach.

  Another benefit was mentioned that was of great help to the other students in the class. The teacher in this class prepared a table that had all the memory aids and resources for this child and it was called the "reference table". "This table became a reference table for all the students, not just for this child with a weak working memory only", said one of the teachers. Children knew that they could go to this table whenever they wanted to check for the spelling of a certain word or for the missing number and for other reasons as well. This modification in the use of the reference table to be used by all the students has made it a lot easier for the teacher because students did not have to ask her all these questions and they became more independent. They could just go to the reference table to know a certain piece of information that would help them complete a certain task or activity without having to go to the teacher and ask her. This was not only a benefit for the teacher but for the students themselves as they would not have to wait for the teacher to be free or to finish answering one question before she answers the next one.

  Another teacher said that this intervention helped the child in her class in a variety of ways. First the child learned how to depend on herself most of the time. At the beginning, the child needed the teacher to be next to her all the time, but now the child can work on tasks independently. Before implementing the intervention, the child used to sit down

focusing on nothing and not engaged at all. Now this child knows what to do and she learned that it is always possible to ask for help.

- Do you think that your colleagues have benefitted from you taking part?

  Teachers were not sure if other colleagues have benefitted from them participating in the intervention.

- What difficulties have you faced in implementing the intervention?

  All teachers agreed that this intervention needs a lot of well prepared and detailed planning. It consumes time and effort and it needs a lot of resources. All resources that are used generally in the classroom need to be replicated for the child with weak working memory to serve as a memory aid in addition to other resources that these children would need to focus on different tasks and activities.

- Do you think that taking part in the working memory intervention will continue to influence your classroom approach once the study has finished?

  Teachers mentioned that they would definitely continue taking part in the working memory intervention as it is of great help to the children and to themselves as teachers as well. The teachers felt that there are things that could be done with those children with whom they previously thought nothing could be done. Those children previously believed they could not learn in a regular classroom. The teachers have mentioned that this intervention has different strategies that can be used in their normal instruction practice and can benefit other children as well, not necessarily those who signs of weak working memory. Even the teacher, whose child did not show much progress, still believes that this intervention is of great benefit. The progress was not dramatic in her case, but there was a benefit from knowing the different strategies that can be used.

- What further information would you have found useful in helping you to implement the intervention?

  One teacher said "What exactly do I need to tell the parents to do at home with their child in order to supplement the effort that is exerted at school?". This teacher believes that the child needs to continuously work on and practice the introduced concepts in order not to forget what has been introduced. That is why the teacher sees it mandatory that the parents know what exactly should be done with their children.

- Would it help to provide the parents/carers with more information about the approach?

  Teachers did not agree on a common answer to that question. One teacher said that it would be of great benefit to talk to the parents not only about the intervention, but on the specific situation of their child as well. She believes that it would be of great benefit if the parents knew what the problem that their child is, how it affects their child's learning and what should be done from their side at home to help with this intervention at school. Another teacher had a totally different answer to the above question. She finds it very hard to communicate to the parents the exact problem of their child. She also finds no reason for telling the parents about this approach especially that they might deny the whole issue.

  Conclusively, this study was a very beneficial way that was tried and implemented to deal with children with weak working memory. It is an intervention that proved to be successful and effective with those children who cannot keep information for a long period of time. Kindergarten teachers in an international school were asked if they have students who show one or more warning signs of weak working memory. It was very common to encounter one or more student in each classroom. The principles of the

working memory intervention were communicated to the teachers and the teachers started implementing it right away. Data collection started one month later to gather the teachers' feedback and to know about the efficacy of the intervention.

The feedback from the teachers was a positive and productive one. Teachers who implemented the intervention all agreed that it is very efficient and students have improved academically. Students' engagement was noticed to be higher after the implementation of the intervention. Teachers had finally found a way to reach those inattentive students. However, there were another group of teachers who wanted to work with this classroom approach, but found it very difficult to have the time to plan and prepare the necessary resources. I agreed with them that first time implementers need enough time to plan ahead. However, teachers who have implemented this approach before might find it a bit easier as they will already have all the resources and the memory aids.

I find that this intervention provided a practical means for teachers to solve the problem that some children might be suffering from. It is not a means to diagnose and go through the possible hassle of convincing the parents with their child's problem. It is also not a program for training the working memory of children to enhance it or make it better, but it's a practical solution for the teachers who might have one or more child in the class with this condition. It's also a practical solution for the children who are a lot of times, uninterested and cannot proceed with activities and tasks that take place in the class.

Discussion:

Working memory has been proven to be crucial in the learning process of young children. Working memory is the ability to hold certain information while working on and manipulating it. It is the working memory which helps us to store pieces of information in mind and manipulate them at the same time. Therefore, if a child has a problem in his/her working memory, the important information that should be kept in mind which would enable him/her to work on a specific task or activity till its completion would be lost. The child will fail to finish the assigned task either due to task abandonment or due to false guessing which leads to errors. The child will not only be unable to complete different tasks or activities but also will be unable to follow instructions or be engaged in multi-step tasks. That being said, it is clear and obvious that the learning process of such children is not an easy or smooth one. Children are often lagging behind. Academically they are weak and have the tendency to be left behind. Teachers in many cases just assume that those children are stupid or lazy and they do not know what exactly should be done to help them progress. The main reason behind the weak academic progress is the working memory overload. This means that the capacity of the working memory of some children cannot cope with the working memory demands of different tasks. The main and most important solution for such cases is the reduction of the working memory overload. Working memory load should be reduced for children who have poor working memory in order to avoid working memory failures. This study provides an intervention that includes many principles that guide teachers when dealing with children with weak working memory. It is an intervention that provides a solution for the teachers and the students as well.

It is not an intervention to train the working memory or to improve it as it is normally not the teacher's responsibility to train the working memory of students in the class, but it is the

teacher's responsibility to find a way to reach those children and to find the suitable teaching practices and strategies that would help them to learn and progress. This intervention once known and communicated to the teachers, it can be implemented and successful results are often achieved. This is not the case with training of the working memory which needs professionals. That is why, this intervention is considered to be practical, doable and provides real solutions for the problem of weak working memory. Another strong aspect in this intervention is that no one has to go through the hassle of convincing the parents that their child has a problem of a weak working memory and that he should have a working memory training. This intervention includes instructional and teaching strategies and techniques that are carried out by the students' teachers without any intruders which adds to the feasibility and convenience of this approach.

Teachers who implemented this classroom approach have achieved great success. Students have dramatically improved. Teachers knew how to deal with their working memory capacity and they have reduced the loads. This in turn helped the students to see it through the completion of different tasks and activities. The students have learned to use different strategies independently and this has developed their self-esteem and self-confidence. The aim of all the principles of this intervention is to reduce the working memory load. This can be achieved mainly by breaking down different tasks into small simple steps and students should deal with each step as a separate independent task and should shift to the next step when the first step is totally done completely. Another way to reduce the working memory load is through the repetition of different concepts. Repetition is a crucial strategy that has a great benefit on children with weak working memory. Working on information that can be retrieved from the long term memory is also of great help. In this case, the load is not solely on the working memory to keep information that should be manipulated afterwards, but also on the long term

memory from which information can be retrieved. Retrieval of information from the long term memory reduces the working memory load. That is why activating and building on the child's prior knowledge is of great help as the child depends partially on the long term memory to retrieve information and partially on the working memory to manipulate such information. This in turn reduces the load of the working memory.

It should be noted that this classroom approach consumes much time, effort and resources and that is the main point which hindered some teachers from the implementation of this approach. The teacher needs to spend much one on one time with the student especially at the beginning till s/he gets used to the different strategies. Copies of all resources are prepared and used as memory aids together with other resources that are prepared specifically for that child in the class with weak working memory. Therefore it is of ultimate importance that the teachers know how this approach works and that it consumes this excessive amount of time and effort. The teacher's willingness is the main guarantee of the implementation of this classroom approach. Detailed planning ahead of time will definitely ensure a smooth and successful daily practices for the teacher and an engaged and interesting learning experience for the student.

The above point might be one of the limitations of this study as the teachers were not well prepared for this approach. The intervention was communicated and explained to them and they were asked to implement right away. They did not have enough time to plan or to prepare additional resources or memory aids and this was the reason for the difference in the number between the teachers who were interested to implement the approach and those who have really implemented it. I believe teachers need much time to plan for this approach especially if it is the first time to implement it. However, it should be noted that the teachers who implemented this approach have all agreed that it is worth the time spent and the effort exerted.

Conclusion:

This study is of crucial importance for teachers dealing with children who show signs of weak working memory. Teachers would be able to help and reach those students who are normally judged to be lazy and unable to learn. As for the children, they are not supposed to be left behind anymore. Children will be engaged in different activities and tasks but in their own and different way. This study shows the principles which aim at reducing the working memory load and hence reducing the failures that happen due to working memory overload.

This classroom approach does not train or improve the working memory of children, but it is a clear, helpful and practical guide for teachers whose responsibility is to find a way to reach all the students and to tailor their instructional practices to cater for each one of those students who might have weak working memories.

One of the inquiries that need further research and exploration is that if it is helpful and beneficial to put more than one child with weak working memory in one class or it is better to separate them. This inquiry arose after hearing one of the teachers who implemented this classroom approach. This teacher mentioned that the child with weak working memory has complained and needed an explanation at the beginning of the intervention on why specifically he was withdrawn from his group of classmates. Later on, the child was fine and got used to this special and individual interaction. So is it beneficial that the child finds that s/he is being treated differently than other students? Is it beneficial to know that there is a problem and that is how it is solved? Or is it better not to make the child feel different by having a group of children showing signs of weak working memory in one class?

The above inquiry will bring us to the idea of screening all the children at the level of school entry which was introduced earlier in this paper. The idea of screening was for the sake of

having an insight about the academic progress that the child is expected to show later during his/her learning process, but now another benefit can come out of the screening which is the placement of those children in different classes: separating them in different classes or having groups of them in the same classes? It is worth mentioning here that the intervention has benefitted both the children with and without weak working memories.

Another point of inquiry is whether the teachers need a sort of professional development on how to implement this classroom approach or not. It is true that once the intervention is communicated, teachers can work on the principles that it includes and it is true that several of these principles might have been used by experienced teachers, already. May be not in the same manner of persistence and may be they did not use all the principles at the same time, but they might have had an idea. However, this intervention was found to be very time and effort consuming to the extent that hindered some teachers from implementing it. So would it be of any benefit to have a training for teachers that would give them tips and general practices or cues that would enable them to implement the intervention? As a teacher, it would also be important to know more about how to train the students themselves to use different strategies. The strategies are clearly mentioned in the intervention, but how to train the students, whether or not and what to communicate to the students is a point that I find of crucial importance. I believe the teacher is in great need to know the previously mentioned aspects. That is why a training on this working memory classroom approach should be mandatory for adults especially teachers dealing with children with weak working memory.

Conclusively, this research study served the knowledge that children with weak working memory should not be left behind anymore. A practical classroom approach was tried and experimented and the results were dramatically successful for those who implemented it.

However, knowing more practical tips and training the teachers might help save their time and effort. Additionally, well prepared and detailed planning will definitely be of ultimate help and support.

References

Baddeley, A. (2003). Working memory: Looking back and looking forward. *Nature Reviews. Neuroscience*, *4*(10), 829–39. doi:10.1038/nrn1201

Baddeley, A. (2012). Working memory: theories, models, and controversies. *Annual Review of Psychology*, *63*, 1–29. doi:10.1146/annurev-psych-120710-100422

Gathercole, S. E. (2008). Working memory in the classroom. *President's Award*, *21*.

Gathercole, S. E. & Alloway, T. P. (2007). *Understanding working memory. A classroom guide*. London: Harcourt Assessment, Procter House.

Gathercole, S.E., & Alloway, T.P. (2008). Working memory and learning: A practical guide for teachers. London: Sage Publications.

Holmes, J., Gathercole, S. E., Place, M., Dunning, D. L., Hilton, K. A. and Elliott, J. G. (2010), Working memory deficits can be overcome: Impacts of training and medication on working memory in children with ADHD. *Applied Cognitive Psychology*, 24: 827–836. doi: 10.1002/acp.1589

Just, M. A., & Carpenter, P. A. (1992). A capacity theory of comprehension: Individual differences in working memory. *Psychological Review*, 99(1), 122-149. doi:10.1037/0033-295X.99.1.122

Kirschner, P. A. (2002). Cognitive load theory: Implications of cognitive load theory on the design of learning. *Learning and instruction*, *12*(1), 1-10.

Klingberg, T. (2010). Training and plasticity of working memory. *Trends in Cognitive Sciences*, *14*(7), 317–24. doi:10.1016/j.tics.2010.05.002

Late effects of treatment for childhood cancer (PDQ). Retrieved from http://www.cancer.gov/cancertopics/pdq/treatment/lateeffects/HealthProfessional/page4

Minear, M. & Shah, P. (2006). Sources of working memory deficits in children and possibilities for remediation. In S. P. Editor & G. P. Editor, *Working Memory and Education* (pp. 273–307). Burlington: Academic Press.

Mostyn, G. R. (2012). Cognitive Load Theory: What it is, why it's important for accounting instruction and research. *Issues in Accounting Education*, 27(1), 227-245. doi:10.2308/iace-50099

Roche, J. D., & Johnson, B. D. (2014). Cogmed working memory training product review. *Journal of Attention Disorders*, *18*(4), 379–84. doi:10.1177/1087054714524275

Schagen, S. B., van Dam, F. S. A. M., Muller, M. J., Boogerd, W., Lindeboom, J. and Bruning, P. F. (1999), Cognitive deficits after postoperative adjuvant chemotherapy for breast carcinoma. Cancer, 85: 640–650. doi: 10.1002/(SICI)1097-0142(19990201)85:3<640::AID-CNCR14>3.0.CO;2-G