

Definition: Ability to hold information in immediate awareness and use it within a few seconds including the ability to store information long enough to manipulate it. Short-term auditory memory is the span or length of time one can capture oral information and send it to working memory. The longer short-term memory is the more language a student can hold in mind in preparation for working memory to code it with visual symbols or other sensory information. Working memory provides opportunities to record new learning, connect new and existing knowledge, transform and manipulate information, as well as hold information while memories are being retrieved from long-term (semantic memory). Strong working memory allows for cumulative rehearsal, elaboration, categorizing, chunking, and consolidating. Working memory provides the this ability to follow multi-step directions, do mental math, complete in sequence multi-step mathematical procedures, comprehend over extended passages or readings, associate new and known information rapidly, create organized sentences and passages.

Cognitive theory suggests there are four types of working memory (verbal, visual, executive, and episodic). The brain processes most information through episodic memory first and through repeated exposure recodes it into semantic (a form of long-term memory). Student's memory difficulties may be related to lack of exposure or due to normative weaknesses in this cognitive ability or result from emotional coping or provocation. Dependent on the demands of the memory task, language proficiency (e.g.: central auditory processing, linguistic differences) may negatively affect performance on auditory memory tasks. Experiences that prompt emotional regulation and coping may compromise both attention and working memory as well as executive functions resulting in lack of ability to consolidate learning into long-term memory or performance. Teams should use multiple sources of evidence to parse contributing factors that impact working memory and continuing lack of achievement.

Remediable: No. However, strategies, mnemonics, chunking, and over learning may give the appearance of improved capacity but are more compensatory strategies.

Related areas of processing: auditory working memory, visual working memory, auditory and visual short-term memory,

Impacts: Language development as well as phonological and visual spatial coding. Students with normative weakness in short-term auditory memory cognitive ability are most likely to present at ages 6-9 with weak language and foundational reading skills. There is moderate correlation with achievement up through age 14 which may be more associated with multi-step, sequencing and increased demands on working memory. Presentation of normative weaknesses in short-term and working memory in the classroom manifest during the following activities: following oral multi-step directions, rote memorization, sequencing or ordering items presented once, mental math, comprehension activities such as summarizing, predicting, recalling facts, etc. Students may frequently ask for directions to be repeated, talk to peers to confirm expectations, use visuals as aides or reminders, or appear inattentive. More targeted areas of academic impact follow and should be useful in interpreting student work samples, observations, teacher interview, and test results.

READING Achievement

Sight-word vocabulary

Applying phonemic awareness and phonetic coding to decoding unknown words (especially multi-syllabic words)

Reading comprehension recall of facts to making predictions

Oral retell and paraphrasing

Following multiple-plot lines or characters (would likely be present in movies, audio, and written works unless visual working memory is stronger than auditory working memory).

MATH Achievement

Memorizing basic facts

Regrouping and multi-step problems

Extracting information from word problems for recoding into mathematical sentences

Remembering and sequencing mathematical procedures

WRITING Achievement

Difficult with spelling (specifically multi-syllabic words)

Essay development

Managing and coordinating multiple demands of writing when time or assignment constraints limit the use of step by step writing process.

Redundancy in writing (word and concepts)

Organizing of thoughts into a sequence

Note taking and copying (due to divided attention)

Additional Indicators across other environments and contexts

- **At home, with peers, in the community**
- **Observed behaviors during assessment**
- **Other indicators in performance or vocational readiness**

Research-based Implications for Instruction, Curriculum, Environment (ICE):

Instruction:

- Provide directions that are short, syntactically simple, and use familiar language so that the task is what is processed not comprehending the directions.
- Give student only one direction at a time that the student can do immediately; provide second step of direction only after student has completed first step successfully. A directions routine may look like the following: the teacher gives one direction and shows example, the student either repeats the directions or demonstrates understanding, the student or peer asks a question, then steps or picture cues are provided as reminder later on.
- Build in repeated opportunities to rehearse or practice and review directions and tasks Use think-pair-share, peer tutors, peer note-taker, segmented instruction (technology provides) or study buddy to provide clarifying directions when the teacher is busy.
- Explicitly require the student to connect the known with the new through elaboration (to be beneficial the elaborations must be as specific as possible). Teachers must teach elaboration strategy to automaticity. Additional research-based strategies include use of anticipatory sets or guides, pre-teaching terms and concepts, SQ3R, QAR, semantic mapping, goal directed reading, self-questioning, teaching story grammar, etc.
- Reduce the cognitive load by breaking-down instructional steps and tasks. Allow time to process and practice frequently during an instructional session. Include activities that require active engagement with material so that students are using higher level thinking skills and practice with the material multiple ways. This allows for multiple ways of holding and consolidating learning for long-term memory.
- Peer assisted learning to increase opportunities to interact with smaller chunks of content.
- Teach word attack and math facts to automaticity as well as strategies for reconstructing knowledge for example use meta-cognitive phonics programs.

Curriculum:

- Organize and scaffold course material to reduce working memory load (include opportunities to record known with the new, the relationships and connections between items and concepts, etc.). Create instructional routines that provide review, multiple opportunities to rehearse, and summarize frequently within a class session.
- Build strategy instruction into curriculum so that steps of strategy instruction are over generalized and transferred. Most important aspects are that the student understands the reason for the strategy, how use of the strategy will be beneficial, see the steps applied in context, practice the strategy until it is internalized and application is automatic. The student has to be automatic with the use of the strategy before the benefits will be realized with respect to mastering content. It is critical to recognize and reward the student for attempts to use the strategy as well as explicitly providing data on the success of the strategy. The final step requires continuing to support the student in monitoring, anticipating, applying and evaluating the effectiveness of the strategy in new situations. This last step will reduce the likelihood that the strategy will be abandoned or not transfer forward into future coursework.

Environment:

- Provide supports to minimize competing inputs or simultaneous demands on memory such as required when a student has to listen and take notes. For example, provide lecture notes and require activation of prior-knowledge before beginning a lecture.
- Encourage and support use of memory aides such as number lines, step-by-step procedures, journals, visual cues, sub-vocalization, etc. Reduce background discussions or music that is of similar phonology as this is more disruptive than white noise.
- Position a student such that sub-vocalization or other memory strategies are not disruptive to peers. Any compensation strategies should be recognized and reinforced to promote independent learning.

Recommendation for Differentiation in the General Classroom for Short-Term and Working

Memory: (includes changes in methods, Universal Design for Learning, process, compensatory strategies, accommodations, assistive technology, etc.)

Content	Process	Product
<p>Use research-based strategies for organizing and teaching such as those produced by University of Kansas e.g. Content Enhancement Routines: (teaching routines for planning & leading learning; routines for exploring text, topics, details; routines for teaching concepts).</p> <p>Look for content to be prioritized, chunked and organized in materials such that the student can demonstrate comprehension and have multiple opportunities to practice.</p> <p>Instructions are linguistically simple and clear. The vocabulary should be familiar, redundant, and wording precise so that the focus remains on the content, not on comprehending the task at hand.</p>	<p>Use research-based strategies for teaching a process such as those by Graham and Harris (POWER and TREE writing strategies) University of Kansas Strategic Instruction Model Strategies and Content Enhancement Routines (LINCS, Paraphrasing, Inferencing, teaching routines to improve performance)</p> <p>Provide visual supports and memory aids that reduce cognitive demands and place instructional focus on most critical aspect of task or content to be learned. For example, put comprehension questions on sticky notes where student can place them next to the paragraph where the answer is found which will also provide a resource for the student to refer to when asked to provide written responses to stories.</p>	<p>Break projects down such as writing or research projects and provide frequent check points to assess progress with smaller chunks.</p> <p>Encourage use of assistive technology coupled with writing process tasks to increase a student's focus on ideation and organization of written work. Use of graphic organizers to generate and organize ideas and to understand presented or written content.</p> <p>Text to speech tools assist students in determining the need for revising and editing written work by providing a multi-media aid for memory.</p> <p>Adjust grading as to not penalize student for lack of ability to multi-task.</p> <p>Recognition tasks indicate higher levels of achievement than recall and produce tasks.</p>

	<p>Multi-media presentations and use of interactive whiteboards provide visual supports for students. Allow use of sticky notes, color coding or highlighting to facilitate comprehension of important information and note-taking.</p> <p>Provide templates or guided notes (it is critical that students are not only familiar and automatic in using them so the focus remains on learning the content. When requiring higher order thinking (analyzing, synthesizing, evaluating, meta-cognition) provide visual, memory (mnemonics, rehearsal, chunking, etc.), and assistive technology supports where there are simultaneous task demands, language and content are unfamiliar, or when rehearsal is not an option.</p> <p>Study Guides assist in focusing attention on important concepts</p>	<p>Allow use of or train the student to use memory aides, templates, or visual supports during testing as to reduce the demands on working memory.</p> <p>Examples of memory aids include portable ios devices, smart phones, voice reminders, PDAs, calendars, planners, color coding, timers, and alarms. Recording tools include smartpens, digital voice recorders, smartphone and other handheld devices.</p> <p>For students who have difficulty remembering how to spell, the use of word prediction, grammar checkers, spell checkers and voice recognition are helpful.</p> <p>For students who have difficulty remembering detailed information or facts, use of paper and electronic flashcards can be helpful.</p>
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Implications for Achieving Proficiency on State Standards

Samples of English Language Arts content standards, if unsupported, which may exceed a student's working memory capacities or compensatory strategies:

- Grade 2 Recount or describe key ideas or details from a text read aloud or information presented orally or through other media.
- Grade 3 Compare and contrast the themes, settings, and plots of stories written by the same author about the same or similar characteristics.
- Grade 3 Determine the main ideas and supporting details of a text read aloud or information presented in diverse media formats, including visually, quantitatively, and orally.
- Grade 3 Write opinion pieces on topics or texts, supporting a point of view with reasons.
 - Introduce the topic or text they are writing about, state an opinion, and create an organizational structure that lists reasons.
 - Provide reasons that support the opinion.
 - Using linking words and phrases (e.g. because, therefore, etc)
 - Provide a concluding statement or section.
- Grade 4 Refer to details and examples in a text when explaining what the text says explicitly when drawing inferences from the text.
- Grade 4 Write narratives to develop real or imagined experiences or events using effective technique, descriptive detail, and clear event sequences.
- Grade 5 summarize a written text read aloud or information presented in diverse media and formats, including visually, quantitatively, and orally.
- Grade 5 Recall relevant information from experiences or gather relevant information from print and digital sources, summarize or paraphrase information in notes and finished work, and provide a list of sources.
- Grade 5 Analyze multiple accounts of the same event or topic, noting important similarities and differences in the point of view they represent. Grade 5-8 Standards for Reading Science and Technical Content: Analyze the author's purpose in providing an explanation, describing, a procedure or discussion an experiment in a text.

Sample of Mathematics content standard, if unsupported, that may exceed a student's working memory capacities or compensatory strategies

- Grade 3 Add and subtract multi-digit numbers, using efficient and generalizable procedures based on knowledge of place value, including standard algorithms.
- Grade 3 Order and compare unit fractions and fractions with like denominators by using models and an understanding of the concept of numerator and denominator.
- Grade 5 Add and subtract fractions, mixed numbers and decimals to solve real-world and mathematical problems.

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