# The WoodinMath Number System

**Develop number sense and math skills through integrated, whole-to-part, multimodal processing.**

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Like reading, math involves many cognitive processes or systems. Ideally, teachers should diagnose and treat math breakdowns with the same specificity and strategies they apply to language-based instruction. When math instruction is most effective and efficient, it employs the same best practices that are used to address reading struggles. Additionally, the best instruction utilizes student strengths to mitigate weaknesses, and uses context and the integration of multi-sensory techniques to help the student make meaningful, memorable connections. The ability to learn and express math facts involves perception, memory and output. Consider the encoding and decoding tasks demanded within the math domain. The number code must be perceived stored and expressed using the same dynamic processes that are involved in processing language.

The **visual system** provides the organizational structure necessary to quantify and compare numbers. Visual models or graphic organizers supply structured visual information in a static, simultaneous manner. Visual information is perceived in a whole-to-part format. Training that improves the ability to recognize visual patterns to develop cardinality has been shown to benefit poor math students by helping them process quantities more accurately and efficiently so they develop a relational understanding of numbers. The visual system is also necessary to perceive, produce and refine the written output necessary to perform computations.

Numerosities 1 to 4 displayed as random dot patterns or arrays of manipulatives are perceived immediately (subitized). Larger quantities are processed slower, as they are often counted. This disparity is greater with individuals with poor numeracy skills. These individuals process quantities larger than 4 slower and less accurately than controls (Butterworth et al, 1999). Subitization occurs with quantities larger than 4, however, when dots are arranged in canonical formations- perceived faster and more accurately than random arrays (Krajcsi et al. 2013). WoodinMath Icon arrangements use 10 as a gestalt, with numerosities 1 through 9 embedded as easily identifiable number form patterns that are subordinate to the structure of the 10. These dynamic visual models provide a way to extend the benefit of subitized efficiency to the base-ten system and multidigit computations.

The **language system** is needed to perceive instruction, express and communicate facts and processes, and relate computations to applications. Language is arranged in a linear, part-to-whole format. Language marks the linear sequence of processing that establishes a fact or procedure. Expressing information verbally takes time. The perception of this elapsed time of expression provides temporal cues as to the length of time necessary to perform a defined task.

The **sensory motor system** is necessary to articulate communication through speech, gestures, or writing. Touch and movement can also aid in perception to augment or compensate for visual or auditory perception or processing issues. The motor system, like language, is a part-to-whole system that can be linked to language production and inner voice. Sequential motor production tasks are stored in motor memory and can be recalled through episodic memory to help prompt and sequence verbal descriptions.

**Integration**

Both the visual and auditory domains are impacted by memory systems, executive functions and higher level reasoning skills. This dynamic process is well defined by Allan Paivio with his Dual Coding Theory. To excel at math, each of these systems needs to work efficiently and accurately, and these systems must work in an integrated manner. Integration occurs when visual images are expressed through the part-to-whole language system. Toggling focus between visual elements of a complex image directs the proper sequence of perception necessary to prompt the linear-sequential verbal expression of a written fact or process. The practices and strategies offered by the WoodinMath curriculum offer examples of how teachers can forge the integration of these systems.

Multisensory repetition is absolutely vital for effective learning- especially with students with learning disabilities. Experiential, gross-motor activities are the backbone of the program, and instrumental to the success of the curriculum. I lean heavily on the (CSA) theory developed by Cecil Mercer et. al. Later renamed CRA, (**Concrete, Representational, Abstract**) this paradigm stresses the progression from **concrete** manipulation of highly templated materials as modeled by an instructor. The multimodal interaction with the materials helps to impose a robust episodic memory of the students' experience that may be drawn on to support later independence.

During the **representational** stage, students are guided to use two-dimensional drawings to represent their previous interactions with three dimensional objects. Students must replace initial imposed visual and kinesthetic structure with their own production, coupled with language. At this point, students need to have practice understanding (decoding) written examples, as well as producing (encoding) these diagrams. Eventually, the student is asked to express concepts and problems using more **abstract** notation (base ten numbers and related algorithms).

Consistent graphic organizers that relate quantities to both 5 and 10 provide the structure necessary to establish one-to-one correspondence between numbers and discernible quantities and help students develop a relational understanding of the numbers 1 through 10. These visual models also provide a way to extend this knowledge to the base-ten system and multidigit computations. Number sense is developed through the process of assigning values to groups of objects and then making comparisons between these groups (Dehaene, S., 1996).

In mathematics, the cardinality of a set is a measure of the number of elements of the set. Rather than trying to establish cardinality by counting objects from part to whole in a linear fashion, consider the benefit realized by counting the elements of a recognized set from whole to part. For instance, envision counting a handful of cereal piece by piece to determine the quantity—"one, two, three, four, five," and so on—versus looking at a starfish and counting its five legs. Which process does a better job of establishing a cardinal understanding of the number 5? Whole-to-part processing models provide the ability to integrate parts within the context of a whole number to establish cardinality.

The acquisition of multistep written production tasks is usually mediated with (fine motor memory or language-based mechanisms (Ayres, A. J., 1979). Students with L.L.D. and sensory integration disorder are faced with a double deficit. These individuals are compromised by motor planning issues, as well as their difficulty with the naming and sequencing of language (Sokol, S.M., & McClosky, M., 1988). Working memory limitations also preclude students from sequencing multistep directions and processes. All of these students benefit from instructional methods that forge explicit relationships between motor planning, language-based mediation, and written output (Woodin, C., 2014).

**Gestalt Theory**

Graphic organizers that feature whole-to-part architecture can provide structure to mitigate the impact of cognitive limitations. Naming the concrete visual features of diagrams promote students' ability to perceive, process, and store related verbal and visual information in an integrated manner that may be retrieved in a more accurate and efficient manner (Paivio, A., 2006). It is easier to acknowledge the elements of a recognizable whole than it is to create a whole from a large number of discrete elements. A methodology based on this concept is powerful for all students—and for some, necessary.

Whole-to-part processing models provide structure that can compensate for deficits in working memory, expressive language mechanisms, and executive function. Pictures or images of familiar things present a great deal of information within a bundled package, or gestalt. These visual models are useful in that they provide learners with a means of retaining information long enough to name, organize, and describe the component parts within the context of the whole. For example, when assembling a toy, some people ignore the part-to-whole written directions. Instead, they choose to look at the picture of the completed toy on the front of the box and manipulate the components until they have matched the picture. After the toy has been assembled, these people may use episodic memory to document the part-to-whole assembly process.

Optimal graphic organizers offer a great deal of information in a simple, elegant manner, consistent with the law of pragnanz in that they present information in a manner that is regular, orderly, symmetrical, and simple (Koffka, K., 1935). People see relatively complex visual material in the simplest, most familiar patterns by relating their components within the scope of an organized gestalt or whole. Toggling focus from one component to another, or to the greater context of the whole can prompt a linear process that can be described with language. Additional benefit is achieved with the degree to which a graphic organizer relates to practical applications and connects to, or relates other, similar diagrams.

**Motor Memory as a Catalyst for Sensory Integration**

Like language, kinesthesia is a part-to-whole system that is easily linked to language. An effective method to synchronize the visual perception of a graphic organizer to written production steps of a process is to lead the student to verbalize each step as he physically interacts with it. Motor memory is one of the strongest and most primal memory retrieval systems. Children develop and refine gross motor movement patterns at an early age. People use these learned motor patterns throughout life to walk while talking, ride a bike while looking in store windows, and sign their names in the dark. Motor memory is a powerful ally when children are learning to use graphic organizers. Verbally narrating the steps of gross motor tasks allow students to develop a sensory integrated sequential, episodic memory that may be later be recalled to actuate the process with paper and pencil. In effect, students develop an synchronized, inner voice soundtrack to motor memories that help drive accurate sequential written output necessary to perform multi-step procedures. This therapy is especially valuable to those students with language-based deficits.

**The WoodinMath Number System in Practice**

The collection of resources on the Vertical Path are not intended to be used like a textbook. The materials presented with the intent that activities and worksheets will be reused and practiced more than once, and reviewed over time. Furthermore, this program is meant to be metered-out in a diagnostic- prescriptive regimen that is directed by a trained professional. Training is available through WoodinMath seminars.

At each operational stage, students should be given a graphic organizer with which they interact. Through guided practice students try problems and receive feedback on their process. Finally students independently practice the new skill(s). Experiential learning, often involving kinesthetic practice from within the students' primary reference frame sets the stage for learning to occur later on paper. Hands-on practice, followed by increasingly independent abstract worksheet practice is the recipe for success. Do not skip the activities. Though perhaps foreign to your understanding- remember, it is not all about you. Do every activity shown and do it multiple times over a period of days. I've found that students make steady progress if they can perform a new task three consecutive times during a session. Gauge the rigor of your progression by limiting the presentation of new material until this level is reached, and can be replicated on the next learning session with minimal cueing.

In terms of evaluating mastery of a stage on the Vertical Path, interaction with the student is imperative. Rather than defining mastery with a written quiz, a student should be able to demonstrate competence through independence with the activities and worksheets presented over a series of days with minimal prompting. This may take a great deal of repetition and review, where the teacher models a concept, watches the student practice similar examples, then explain the process or "teach the teacher" to perform the task. Learned tasks need to be reviewed over time using consistent directions and accurate terminology. After performing templated worksheet problems, ask the student to set up and perform similar problems without imposed structure on lined paper.

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