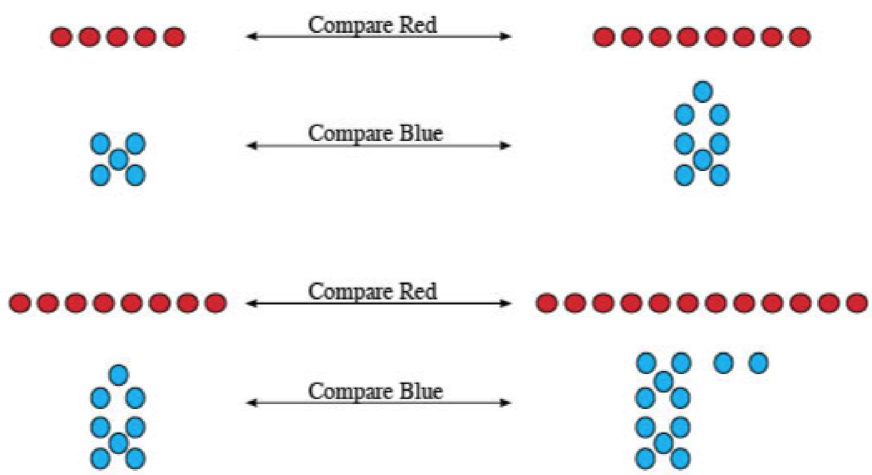
Develop Cardinality and Number Sense with Whole-to-Part Icons of Quantity

A student who is confused by typical math instruction may excel when instructed in a way that always shows the big picture first, uses visual-spatial images, and directly examines how the parts are connected to the whole. This program is quite different from how most of us were taught math, and it is different from most modern curriculum approaches as well. Number sense is developed by establishing a robust understanding of quantities so that their values may be compared. The methodology to be presented enables such comparison by limiting demands on language processing, working memory, and executive function skills. The techniques used in the WoodinMath Number System have been developed over a lifetime of working with children who have struggled with math. Countless students have come to this program with a limited, instrumental ability to conceptualize and compare numbers and emerged as numerate math students with a relational understanding of quantities.

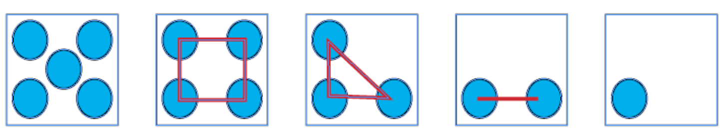
Learning and memory research tells us that multisensory integration is absolutely vital for children who have learning difficulties, as well as the best way to teach all students. Experiential, gross-motor activities provide a powerful approach to interact with recognizable whole-to-part visual models. Students develop language skills necessary to describe math concepts and relationships as they perceive and process them. In essence, students take patterns apart, then reassemble them while describing the process.

Number sense is developed through the process of assigning values to groups of objects and then making comparisons between these groups (Dehaene, S., 1996). Consistent graphic organizers that relate quantities to both 5 and 10 serve two vital purposes. They provide the structure necessary to establish one-to-one correspondences between numbers and discernible quantities, and they help students develop a relational understanding of the numbers 1 through 10 by facilitating their comparison. Subitization occurs with quantities larger than 4 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.



In mathematics, numerosity is the ability to discriminate arrays of objects on the basis of the quantity of items presented—for example, being aware that a quantity of two is different from a quantity of three. Cardinality of a set is a measure of the number of elements of the set derived from counting them. When counting the elements of a set, the student must tag each one with a unique number name in the standard order (1, 2, 3…). The last number named in the sequence enumerates the number of objects counted.

Rather than trying to establish cardinality by counting objects from part-to-whole in a linear fashion using language, 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 counting a familiar quincunx (5) dot pattern of the cereal, acknowledging the whole five dots, and the subordinate patterns that are embedded in it- as it is decomposed.



From the Five Icon, removing the center dot produces a recognizable square. Removing subsequent dots result in a triangle, line, then single dot. Whole-to-part processing models provide the ability to integrate parts within the context of a whole number to establish cardinality in a durable sense. Cardinality is derived by linking language to the structure of established numerosity.

Part-to-Whole (Red) Versus Whole-to-Part (Blue) Structure

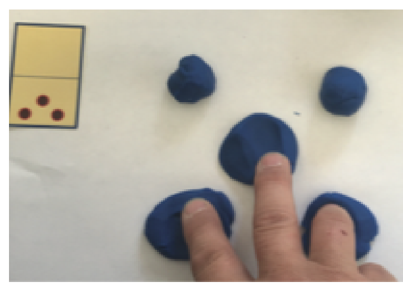
Whole-to-part processing models provide structure that can compensate for deficits in working memory, expressive language mechanisms, and executive function. Pictures or images of familiar items present a great deal of information within a bundled package, or gestalt. These visual models are useful in 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 are most efficient when they 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 assembly process.

Naming the concrete visual features of diagrams promotes the students' ability to perceive, process, and store related verbal and visual information in an integrated manner that may be retrieved with greater accuracy and efficiency (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. Graphic organizers that feature whole-to-part architecture can provide structure to mitigate the impact of cognitive limitations. When larger quantities are constructed from recognizable, subordinate, nested patterns it is easy to compare quantities. For instance, it is easy to see the X shape (five) within the six, and compare them (a difference of 1 red dot). A methodology based on this concept is powerful for all students—and for some, necessary.

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).

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). Canonical patterns, like the "X-shaped" quincunx pattern are processed substantially faster than random, noncanonical patterns (Wender et. al, 2000). By relating their components within the scope of an organized gestalt or whole, they can be used as a vehicle for prompting a process by toggling focus from one component to another, or to the greater context of the whole. Additional benefit is achieved with the degree to which a graphic organizer relates to practical applications and connects to or relates other, similar diagrams.

People with visual processing limitations may often benefit from interacting with the graphic organizer spatially through tactile-kinesthetic activities. Touching visual patterns evokes an integrated visual-spatial connection necessary for accurate perception that is then stored accurately in memory.
An established spatial appreciation for visual patterns of quantities can be used to establish cardinality, and thus promote number sense by enabling comparison between similar patterns.



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