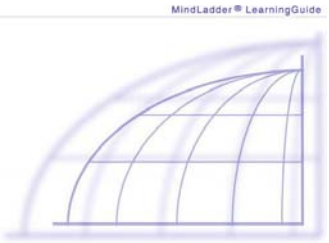

# Printout of MindLadder® Advisor Section B-5•

## T-19: Mathematical Operations

The MindLadder model is designed to catalyze the ability of schooling to achieve its objectives. As such the development of strong academic skills is among the foremost aims of MindLadder (see also T-18). To develop the mathematical operations educators and students together examine the contribution of the knowledge construction functions in the mathematics curriculum such as naming numbers, addition, subtraction, multiplication, division, place value properties, fractions, decimals, percent, comparing quantities, estimation, equations, geometry, measurement and money. A more detailed description of the mathematical operations is available in the Advisor section on Extended Definition: T-19. An example of the connection between the knowledge construction functions and the mathematical operations is provided here with the help of a 6th grade math standard.

Grade 6 Math (Standard 17): *Identifies effects of basic transformations on geometric shapes*

The following knowledge construction functions are needed for students to benefit from mathematics instruction and achieve the above academic standard:

Spatial orientation (R-3)
Interiorization (T-6)
Mental representations (T-7)
Generation of mental transformations (T-12)

In order to rely on the quick and efficient mechanisms of the mind the learner must first use the function of Spatial Orientation (R-3) to orient the given geometric shapes. Students need to use the knowledge construction functions of Interiorization (T-6) and Mental Representation (T-7) to make the shapes available for manipulation in the mind. Following that the function of Mental Transformations (T-

12) is needed to identify the effects of basic transformations on geometric shapes. With the help of these knowledge construction functions the learner mentally transforms a given geometric shape from its initial state by applying rules of transformation. This permits the learner to generate hypotheses with high levels of confidence and to use physical manipulation, if allowed, as a means of judging outcomes relative to specific expectations.

In the absence of these knowledge construction functions students are likely to resort to random, probabilistic, or trial-and-error approaches when confronting tasks that incorporate the above academic standard. If the geometric shapes can be physically manipulated such manipulation will typically lead to repeated unsystematic attempts to produce the required transformation. The student is forced to rely on luck or chance as more precise analytical approaches are precluded. Even if a correct solution is arrived at the learner is often unable to discern its correctness and may continue to rotate and manipulate the geometric shapes.

The mathematical operations can be effectively developed by mediating the underlying knowledge construction functions while engaging students in meaningful problem solving activities. While students actively engage in these types of activities, teachers are able to see the students' thinking processes in action and thus are able to strengthen students' knowledge construction functions even as they accomplish content objectives. For example, Anna, a fifth grader, is analyzing water samples collected upstream and downstream from a plant that discharges a series of chemical waste products into the river as it reaches town. As Anna explores sampling techniques and ways to present her findings, her teacher helps her apply and become insightful also about the function of precision and accuracy (R-9), comparative behavior (T-9) and ordering and grouping (T-10).

In mathematics, especially, teachers need to help their students move from the concrete to the abstract. One way to accomplish this is to encourage students to reason and communicate mathematically using diagrams, graphs, charts and other representations of the variables and problems they encounter. By mediating the functions that support the required mathematical operations teachers provide the cognitive foundations that students need to work from a mathematical understanding.

The development of mathematical operations enables students to bring growing mastery of the knowledge construction process to bear on such subject areas as arithmetic, geometry and calculus. The mathematical operations integrate and make visible the contributions

of the knowledge construction functions that support the science of numbers and their operations, interrelations, combinations, generalizations and abstractions. Once again, more detailed information about the mathematical operations is available under T-19 in the Extended Definition section of the Advisor.