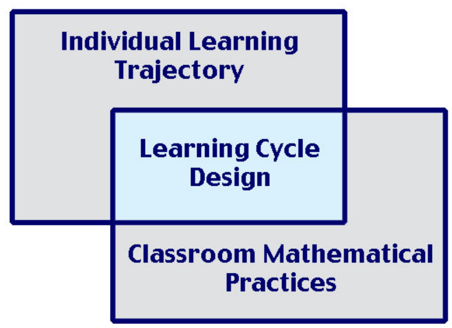
Measurement: Instructional Design and Approach

One of the primary goals in exploring the curriculum and learning implication of measurement is to identify tangible means of translating foundational research and theory (as applied at the early ages, see Measurement: Developmental Research and Theory) into classroom practice—the research-based design of a flexible learning cycle. In doing so, we look toward those aspects necessary for constructing the design, including the standards and objectives to be met, the expected trajectory or potential paths along which we anticipate that students' learning will progress, and the general heuristics supporting our design. First, however, we look toward the very philosophy of the "flexible" design that must, if the teaching and learning is to be excellent rather than "good enough," form the umbrella under which all other components reside.

Flexibility: Developmental Theory Meets Classroom Mathematical Practice



As with our other analyses of design and the heuristics guiding those designs, the importance of "flexibility" in a sequence cannot be overstated. *No group ever "learned."* As such, an effective cycle acknowledges that the developmental research (in this case with regard to measurement) applies to the *individual child* (Piaget & Inhelder, 1956; Piaget et al., 1960). However, it must also simultaneously recognize that the shared mathematical practices that evolve in the social setting of the classroom over the course of a unit *affect* the learning of the individual in a general sense. A useful cycle must therefore attempt to foresee how the various learning increments experienced by individual students will influence the mathematical practices that are taken-as-shared by the class as a whole, and vice versa (Simon, 1995). In other words, what we as teachers or facilitators do at various junctures is determined by two often conflicting realities—what we need to do to address the needs of individual students where they are in their measurement learning trajectory (discussed in terms of younger children in PreK-2 Measurement Learning Trajectory), and what we need to do to establish certain common practices and understandings that will allow us to move the class forward with some stability. Contrary to the instructional process predominant in most classrooms—teachers far too often determine even the step-by-step procedures students will "learn" and apply in order to solve problems—the cycle and the sequences within should serve as a road map which, though we may deviate, makes the trip so much more sound. Before discussing a cycle design that meets these criteria, it is helpful to identify certain heuristics we consider of importance for promoting measurement understanding and abilities, as follows.

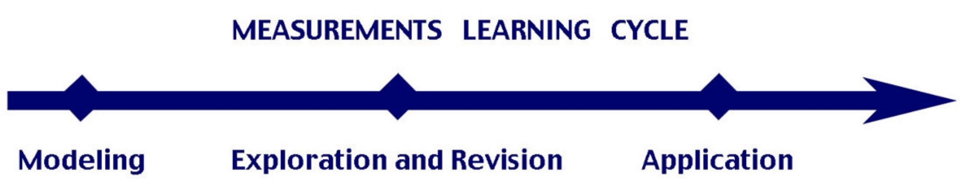
Realistic Application Heuristic: In this heuristic, due largely to the nature of measurement and its applicability to the world around us, we significantly raise the bar set by NCTM's general recommendations that students be provided with relevant situations within which they are expected to apply and hone their mathematical skills. A student's learning experience is significantly enhanced when instruction and learning are grounded in a realistic scenario—so much so that certain forms of instruction (e.g., Realistic Mathematics Education) are based principally on this heuristic (Gravemeijer, 1994a; Streefland, 1991; Treffers, 1987). Note that by "realistic" we do not mean that situations posed must be real in the strict sense of the word, but rather that they form a backdrop with which students can relate and (hopefully) have some base of experience, and through which they can imagine their work has real value and purpose.

Numerical Reasoning Heuristic: True measurement understanding involves other mathematical content and process, especially understanding and use of numerical relationships and systems—unavoidable if students are to go beyond the act of measuring to using measurement with insight and in a way that demonstrates real understanding. As such, these aspects of numerical reasoning are an essential component of operational measurement, the last developmental stage. However, they also play a role in earlier stages. From the outset of a student's growth in measurement understandings and skills, integral connections include counting and use of models to connect numbers to quantities and the base-ten system, strategies for adding and subtracting, and the capability to reason and modify activity based on the effects of such computations. At later stages these same aspects are reflected in the student's use of fractions and decimals on number lines and within the base-ten system, and strategies for multiplying, dividing, and using relationships and properties of numbers (inverse, associative, commutative, distributive) to simplify computations in a meaningful and reflective manner.

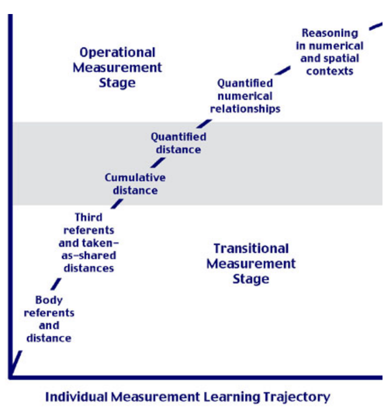
Tools as Models Heuristic: Tools function as a reliable and effective means for modeling many of the essential components of measurement. Through their effectiveness in integrating seemingly disparate components and clarifying relationships between these components, accepted and research-supported strategies for introducing, studying, applying and revising models become the cement that allows students to form multidimensional understandings (Designed Instruction, 2003 - see Modeling for Student Learning: A translational meta-analysis of scientifically based education research evidence). Reaching beyond the content considered as part of the Number and Operations Standard in *Principles and Standards for School Mathematics*, modeling provides an integrative mechanism by which the process standards of representation (creating, translating among, and using representation to interpret meaning), reasoning and proof (especially making and investigating conjectures), and problem solving (adapting and applying strategies, monitoring their effects, and revising accordingly) also become essential components of an appropriate and effective instructional approach to measurement.

Learning Cycle Design: Consistent Approaches for Meeting Individual and Age-Specific Needs

As discussed, an effective approach is determined equally by analyses that are microscopic—individual student needs—and macroscopic—taken-as-shared classroom mathematical practices. The resulting approach describes a learning cycle that addresses both sets of needs. From a large picture view, the cycle describes general phases of instruction and learning. Across and within each phase, sequences and events, both by teachers and students, are tailored to support the expected individual learning trajectory to the extent possible. The non-grade-specific heuristics discussed in the last section form a foundation for the design of a learning cycle that, when taken from this broader view, provides an effective framework for organizing an approach that can take into account age-specific subtleties within and across each phase of the cycle. This is in keeping with our measurement learning design philosophy, because in fact, close inspection reveals that each heuristic itself spans various levels of complexity (see for example the growth in measurement understandings from early to later stages described in the Numerical Reasoning Heuristic). The following cycle phases provide a general framework for addressing both instructional and learner needs toward acquiring measurement understandings and abilities.



Though the sequence of instructional activities must remain flexible within each phase and across a unit of instruction, the expected learning trajectory may and should be fitted to the phases of the cycle before instruction begins. The trajectory—the individual change in measurement concept understandings and abilities—and therefore the actual events of the overall instructional sequence support the heuristics throughout, and do so in different ways and through different means for each grade- or age-level addressed.



Review the PreK-2 Measurement Learning Trajectory. See the cycle and the trajectory blend as mathematical practice meets individual learning development.

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