

Measurement and Learning

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Experimental measurement in psychology commonly refers either to psychophysics or psychometrics. The metrology behind psychophysics presumes that numbers—invariant to some plausible transforms—can represent psychological experience, and in this way display experience as functionally related to physical metrics. So, for example, experienced "loudness" can be systematically related to acoustical power. The success of this enterprise can be appreciated by the application of such metrics to various palliatives or other practical ends, viz: eyeglasses or hearing aids.

These methods give information about the psychological functions of single individuals. They can be made normative by the usual statistical procedures. The scatter of psychophysical measurement only represent the "noisiness" of the neurological processes that translate the physics into psychology. Theories of this neural driving often concern the ways that neurological systems, themselves composed of huge populations of synchronous and asynchronous neural activity, preserve highly reliable functional relations between physics and psychology. The main point of psychophysics is that non-physical psychological events and experience can be understood as quantitative and therefore more-or-less measurable.

Psychometrics on the other hand measures abstract, and purely psychological properties, capacities, or achievements that have no observable physical counterpart. These numbers applied to individuals, e.g., skill in reading, ability to calculate correctly, psychomotor skills, political attitudes, all derive from early attempts to metricize purely mental processes. The classic problem that drove these metrologies was the practical need to improve education. The foundation of such metrics, drawn as we shall see, in part from psychophysics, was first made quantitative by the purely empirical information collected by Binet & Simon (1909), and then metrized by Pearson's derivation of the correlation coefficient (Huber, 2004), Spearman's invention of factor analysis (1904), and Thurstone's (1927) scaling methods. Psychometricians construct their numbers to represent a particular individual within some statistically defined population without tying down "amounts" of the object of interest, say "intelligence," or even "differences between two amounts." The population is commonly represented by the distribution of "scores," often Gaussian. An individual is measured by his position on the abscissa of the distribution, with differences between individuals reflected by differences in standard deviation units. Note that this is also the central idea behind some modern forms of psychophysics, viz. Signal Detection Theory, although signal detection still references psychic events internal to the individual rather than across population samples.

S. S. Stevens (1968) explicitly argued against this approach. This view and the hope engendered by such variants as Kruskal/Shepard nonmetric scaling and conjoint measurement (Krantz, et. al. 1971) was thought to extend these concepts and actually measure things like loudness as quantities with differences that could be understood as

¹ I am indebted to Scott Parker for his critical and technical help in the preparation of this report.

differences between amounts of, say, loudness rather than as degrees of non-overlap of distributions. These formulations failed to find application—as discussed by Norman Cliff (1992) in his paper about "the revolution that never happened."

We must assert that these statistical conceptions, all designed to measure individual psychological quantities: intelligence, motor skill, mental competence, educational skill etc. have served as efficient management tools for the past century (Furr & Bacharach, 2007). Their implementation has made practical inroads to improve in some way teaching and learning by teacher selection, children's performance etc. However, they fail to advance educational practice in the way psychophysics has enhanced perceptual practice because theories of learning do not provide serious solutions to educational problems. Indeed, these very psychometric educational measures have continuously signaled a continuing decline in the schooling of children.

One may reasonably conjecture that part of the schooling problem resides in the failure of theories of learning to guide instruction. The problem with existing learning theories is that they arise in part from cross-species experiments (Terrace, 1963). We can divide learning theories into two major formats (Galanter, 1960); Stimulus-Response chaining mostly supported by animal experiments, and Cognitive Hierarchical Structures (Galanter and Miller, 1960) based on human experimentation (Neisser, 1980). In various contexts both theories appear plausible. However, we may need to find a solution by turning from learning theories to theories of human development, and some relevant neuropsychological imaging research.

How a child grows and develops physically and psychologically has occupied many experimentalists, and has led to a body of data that must be addressed by the questions we raise. There is some agreement that in the early life of children, physico-psychic growth divides conveniently into four segments that we name here proto-lingual (birth to age 3 plus), associative structural (age 3 to 6), hierarchical cortical pruning (age 5 to 10), intellectual-organizational (8 plus to puberty and beyond). These stages overlap, and often run in parallel. The central operative and practical question is how to take advantage of this structural model. There have been several views about such applications, but we may summarize them as Piagetian and Vygotskyian. Piaget (1972) believed that structural change during early development imposed limits on what a child could address intellectually at various stages. Vygotsky (1986) believed that any child had a range of possible intellectual capacities that could be aided or adjusted by external coaching (sometimes referred to as scaffolding, or hinting).

In 2003 the author received a patent on a new way to assess children's intellectual development, based in part on Vygotskyian principles (Galanter, E & Galanter, M. 1999). The primary idea is simple. The errors a child makes give more information about the child's mind, than do the correct answers. However, until the existence of broadband Internet and computers in schools, high-speed analysis and correctives were not feasible. As an example, consider a child confronted with the problem $7 - 5 = ?$ and, say, four possible answers: a.[75], b.[2], c.[12], d.[dog]. Each incorrect response tells us something about the child's lack of understanding; the first and second distinguishing concatenation from addition, or failure to recognize the problem as numerical. If Bill answers a, and Jean answers c, the teacher is aware of distinctive differences in each failure, and may proceed to help the children in appropriate ways. The design of our technology allows us to make the next posed

question contingent on the answer to the previous one. We make the next question a Vygotskyian hint, and so help the teacher, if the hint leads to a correct answer, or advice on how best practice suggests appropriate remediation. The structure of such a “test” becomes a tree as in Figure 1, leading not merely to a “score,” but also to teaching modules to address the problem the child has encountered.

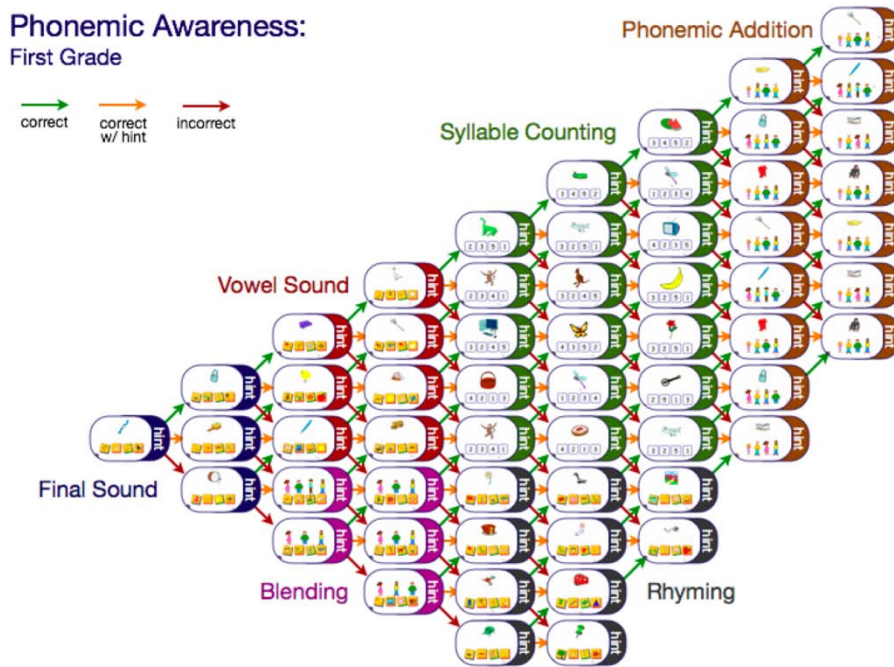


Figure 1

The ramifications of this technology lead directly to a new model of teaching, as shown in Figure 2. This tripartite structure requires an assessment technology that is ongoing. The child may pass through a technically equivalent structure, and thereby reveal to the teacher the need for further remediation, or the behavior may suggest new concepts, all designed to promote the development of organizational hierarchies, although they may have originally developed as simple associative (“rote” to use a hateful term) structures.

By offering the teacher suggested helpful remediation, we may take advantage of the corpus of educational research in language arts and mathematics that serve as the foundation for early schooling; age 4/5 to age 10, and so spanning the transformation of associative structures into hierarchical models that transcend the exemplars of the assessment. These reports, similar to what the teacher learns from each of his/her pupils are shown in Figure 3.

Not only have we changed assessment from a reporting tool, it now becomes part of the skill set of the teacher for advancing the rate of learning among her charges. Whereas we have minimized the role of the correct answer in learning, we cannot deprive management of the capacity to examine the competence of children for which she or he is ultimately responsible. Because the technology captures every keystroke of every child in every classroom, the responsible entity that oversees and supervises the school or schools, whether in a classroom, a school division or indeed in the national school network, can access summary data that is critical to his or her role. Because the

entire system is Internet based, special needs for special children can be identified, and every teacher, every appropriate school principal, educational specialist or special technologist, can call up with a few mouse clicks, summary data for entire the classroom, the school, the regions, indeed for entire nations.

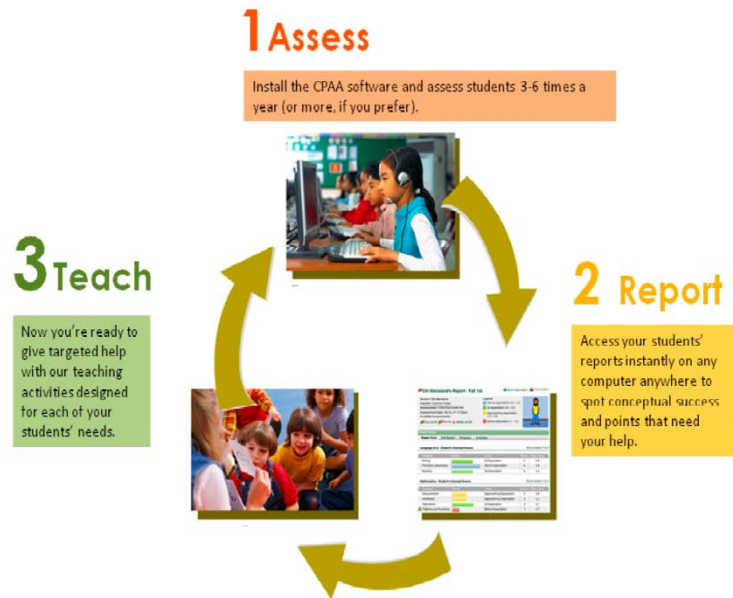


Figure 2

Report Areas
Report Card Full Report Activities Progress

Language Arts > Phonemic Awareness > Dissecting and Creating Words

Dissecting and Creating Words
Phonemic Addition Supportive Activity: Give the students a list of words and ask them to add or take away certain phonemes. Ask them to say the new word and recall what steps were taken. For example, give them the word shrink and ask them to they take away the "sh" sound or give them the word rink and then ask them to add the "sh." To adapt this activity for students struggling with phonics, use cards with common letter sequences already on them.

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Report Areas
Report Card Full Report Activities Progress

Mathematics > Numeracy > More of Less

More of Less
Number Comparison - Symbols Instructional Activity: Divide the students into pairs. Ask them to write their names on a piece of paper. If they struggle with writing, encourage them to copy their name from an already printed place. Next, have the students count the letters in their name and compare the quantities. Whoever has more proceeds to the child with the longest name in a nearby pair. Continue with the comparisons until the child(ren) with the longest name in the class has been determined.

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Figure 3

Figure 4 below shows an example of the composite information for a particular classroom. Note that various “buttons” allow the user to reconfigure the data for the appropriate needs of the moment. That capacity also ensures the timely attention to problems that may go unnoticed, while the causal issues for the children may establish inappropriate behavior in the face of their intellectual pursuits.

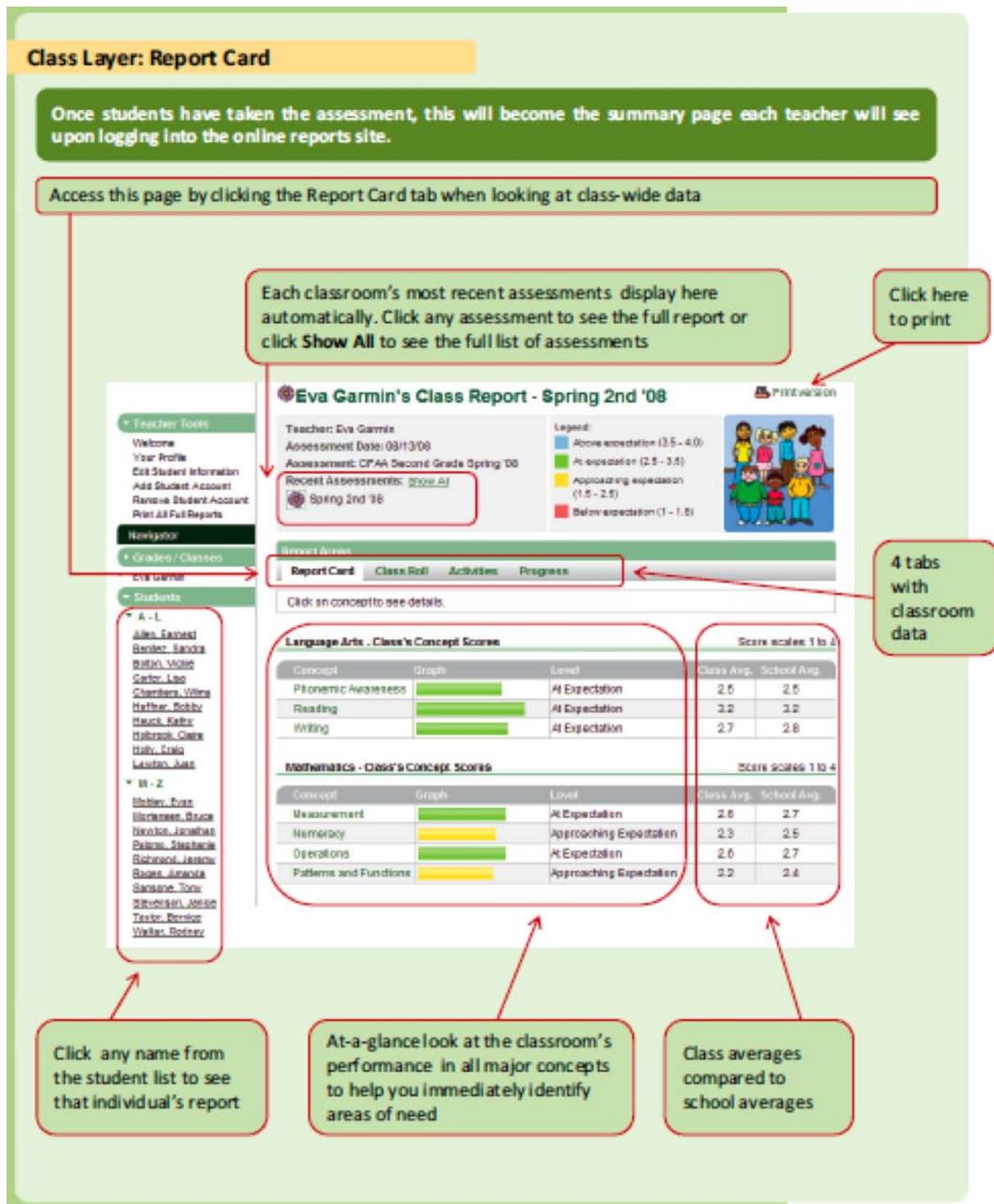


Figure 4

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