The MDPI Research Basis

Introduction

The Mathematics Diagnostic/Prescriptive Inventory (MDPI) is a unique tool for the assessment of a student's strengths and difficulties with mathematics. Its features include the use of a clinical interview format to obtain the data, the examination of process associated with performance, the incorporation of a neuropsychological framework for interpreting the results, and the use of criterion referenced scoring. All of these aspects of the program are based on, and supported by, the research of a wide range of mathematics educators, psychologists and neuropsychologists.

The end-products of the MDPI program have been found to be of high-value to math educators in determining the fine-structure of a particular student's difficulties with mathematics and then generating an effective prescription for an intervention program. The MDPI contributes to a deeper understanding by the concerned professionals of the student's specific learning issues in mathematics and helps to design the most appropriate instructional approaches.

The Clinical Interview

A key element of the MDPI is the clinical interview to obtain qualitative insights into a student's learning. Following in the steps in the work of seminal theorists such as Piaget, Vygotsky and Freud, Herbert Ginsburg has become a leader in noting the utility and superiority of the clinical interview over traditional standardized measures on mathematics thinking.[1] He contends that the clinical interview is the best vehicle for understanding how children "construct their personal worlds, how they think, how their cognitive processes operate, and how their minds function" in any academic domain.

Examination of Process.

The MDPI goes beyond standardized, "paper and pencil" achievement tests, which focus only on solutions. Instead, it includes an examination of the processes that the student uses in *arriving* at solutions. As a result, the examiner has a more definitive understanding of the child's learning issues and can prescribe a more effective intervention program.

[1] "The Clinical Interview in Psychological Research on Mathematical Thinking: Aims, Rationales, Techniques, Herbert Ginsburg, For the Learning of Mathematics, Vol. 1, No. 3 (Mar., 1981), pp. 4-11

Prior to the development of the MDPI, students with problems in math learning were identified by poor performance on a standardized achievement test, such as the Woodcock Johnson III (WJIII) or the Wechsler Individual Achievement Test (WIAT). Though these instruments enjoy widespread use, they reveal little information as to the nature and quality of the student's poor performance or the reasons why a child is experiencing difficulty.[2] Therefore, they shed little light on the most effective intervention strategies for the student.

About seventy-five years ago, developmental theorist Heinz Werner cautioned that conclusions about a student's performance that were based entirely upon achievement scores could be quite misleading.[3] A central tenet of Werner's criticisms of standardized assessments was his observation that individuals can arrive at a solution to a given task via a variety of distinctly different processes. And that these different processes, which are observable at the behavioral level, are, in fact, manifestations of underlying differences in the central nervous system. And these differences are, therefore, relevant in any assessment of an individual's learning ability and achievement.

These more general observations by Werner were later extended to evaluation of mathematics and endorsed by statements from the National Council of the Teachers of Mathematics.[4]. They noted the importance of "moving beyond a superficial 'right or wrong' analysis" to the consideration of the various factors that give rise to a particular performance.

Neuropsychological Framework

Edith Kaplan, and others, expanded on the basic concept that different processes are manifestations of underlying differences in the central nervous system. As a result of her work, she developed a methodology for neuropsychological assessment.[5] It was called the Boston Process Approach (BPA). The approach focuses on the qualitative aspects of performance with the goal of understanding the underlying neuropsychological mechanisms that contribute to the observed performance, including the individual's strategic approaches, error patterns, and response latencies.[6]

Boiselle, Ellen. "Assessment of Students with Learning Difficulties in Mathematics: Apply Neuropsychological Analyses to Standardized Measure of Arithmetic Achievement", 2007, Tuft University

[3] Werner, H. (1937). Process and achievement. Harvard Educational Review

[4] NCTM, 2000, p.24

[5] Kaplan, Edith, "The process approach to neuropsychological assessment", Aphasiology Volume 2, Issue 3-4, 1988

[6] Baron, Ida Sue, " Neuropsychological Evaluation of the Child," Oxford Press, 2004

More recently, Deborah Waber [7] argued for the rethinking of learning disabilities in terms of a Child / World system, which she, and her colleague, Jane Holmes-Bernstein, have developed. Their work is consistent with the work of Kaplan and others. Rourke and Conway[8], for example, argued that patterns of behavior relate to neuropsychological assets and deficits. And that brain-behavior relationship may interact with, or affect, the learning situation.

Waber and Bernstein's work reinforces the notion that the key to meaningful assessment practices rests in the examination of the interaction between the child and the environment. The question is whether the child's complement of skills and dispositions are such that he or she can reasonably adapt to the demands that the particular child encounters. The goal is to adjust the "Child-World" system to make the adaptation more successful.

The Child -World System construct was extended to mathematics learning by Marolda and Davidson[9]. The "World" in which they considered the "Child" was the world of mathematics. In their work, they defined ***mathematics learning styles*** (inherent intuitions and processing strategies brought to the circumstance of mathematics) and incorporated additional neuropsychological parameters (language, working memory, integration skills, pace/precision) into the assessment of students' performance in mathematics. The understanding and definition of mathematics learning styles emanated from clinical experiences over a thirty year period[10], with almost five thousand children who participated in a Comprehensive Learning Disabilities Evaluation at the Learning Disabilities Program, Department of Neurology, Boston Children's Hospital. The definition of mathematics learning styles, which are revealed in the MDPI, were confirmed by the research of Patricia Davidson[11]. In that work, statistical analyses confirmed the constellation of features that contributed to each learning style as well as the relationship of mathematical learning style to neurological and neuropsychological features.

The ***qualitative aspects of performance*** incorporated by Marolda and Davidson were examined by Ellen Boiselle[12]. Boiselle confirmed associations between achievement (Woodcock Johnson, III: Numerical Operations) and qualitative aspects of performance in mathematics (precision, pace, management of complexity in math, self-efficacy in math) as well as associations between qualitative aspects of performance and neuropsychological measures (visuo-spatial/perceptual abilities, processing speed and automaticity of rapid naming).

---

[7] Waber,D. (2010) Rethinking Learning Disabilities: Understanding Children who Struggle in School. Guilford Press.

[8] Rourke,B. & Conway, J. (1997) Disabilities of arithmetic and mathematical reasoning: Perspectives from neurology and neuropsychology. Journal of Learning Disabilities, 30, 34-46.

[9] Marolda,M. & Davidson, P. (1994)***Assessing Mathematical Abilities and Learning Approaches,*** in ***Windows of Opportunity***: National Council of Teachers of Mathematics Yearbook, NCTM, Reston, VA,

[10] Marolda, et al.

[11] Davidson, Patricia, Mathematics Viewed from a Neurobiological Model for Intellectual Functioning, (Davidson,1983: #NIE-G-79-0089)

[12] Boiselle, Assessment of Students with Learning Difficulties in Mathematics: Applying Neuropsychological Analyses to Standardized Measures of Arithmetic Achievement

Criterion Referenced Scoring

The MDPI is a criterion referenced assessment instrument as opposed to a norm-referenced assessment. Linn and Gronlund[13] define these two types of assessments:

1. "Norm-Referenced Assessment: A test or other type of assessment designed to provide a measure of performance that is interpretable in terms of an individual's relative standing in some known group.
2. Criterion-Referenced Assessment: A test or other type of assessment designed to provide a measure of performance that is interpretable in terms of the specific knowledge and skills each student can demonstrate. [14]

The MDPI finds that referencing student performance to specific expectations that students face in the classroom is more meaningful for success in supporting a student's challenges in mathematics and intervention rather than simply reporting whether the student's skills are like or unlike their cohort of peers, some of whom may also be feeling challenges in meeting curriculum expectations in mathematics.

The knowledge and skills used as criteria for the MDPI scoring reflect the curriculum expectations delineated by national initiatives, which, in turn, drive most of the mathematics texts and programs in which students participate. The MDPI is aligned with the curricular emphases delineated in Common Core Standards[15]. It is also consistent with the "focal points"[16] of the National Council of Teachers of Mathematics (NCTM). Curriculum focal points, according to NCTM, are the important mathematical topics for each grade level, pre-K–8. The goal of the criterion-referenced MDPI is to obtain a description of how a student meets the objectives of their grade's curriculum and whether the student as the prerequisite skills to participate in that curriculum.

MDPI Validity and Reliability:

The validity and reliability of the MDPI items has been established in a variety of research efforts. Patricia Davidson used the MDPI to identify clusters of behaviors that define specific Mathematical Learning Styles.[17] Within the course of the NIE study, the reliability and validity of the clusters of behaviors were established, as well as the validity of the scoring procedure as

[13] Linn, R. L., & Gronlund, N. E. (2000). Measurement and assessment in teaching (8th ed.). Upper Saddle River, NJ: Prentice Hall.
[14] Ibid, page 43
[15]
[16]
[17] Davidson, Patricia, Mathematics Viewed from a Neurobiological Model for Intellectual Functioning, (Davidson,1983: #NIE-G-79-0089)

well. Ellen Boiselle's work[18] focused on validating the seven qualitative features of performance used in the MDPI.

In sum, the research of the authors as well as the work of notable research psychologists and math educators, confirm the approaches and interpretive definitions used in the MDPI.

[18] Boiselle, Ellen, "Assessment of Students with Learning Difficulties in Mathematics: Apply Neuropsychological Analyses to Standardized Measure of Arithmetic Achievement", 2007,. Tufts University

