Toward the Integration of Cognitive Diagnosis, Diagnostic Item Analysis, and Internet-Based Instruction

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Education

M.A. Degree (Education), 1967, Committee on Measurement, Evaluation, and Statistical Analysis, The University of Chicago.
Ph.D. Degree (Education), 1969, Committee on Measurement, Evaluation, and Statistical Analysis, The University of Chicago.

Experience

1969-Present, Faculty Member, Educational Psychology, University of Minnesota
1974-75, Fulbright Research Scholar, Max Planck Institute for Psychiatry, Munich, West Germany.
1977-78, Senior Fellow, Laboratory for the Study of Adolescence, Michael Reese Hospital and Medical Center.
1980–Present, Professor, Department of Educational Psychology, University of Minnesota.
1984-85, Fulbright Research Scholar, Max Planck Institute for Psychological Research, Munich, West Germany.
1998, Visiting Research Scholar and Professor, Faculty of Education, Hiroshima University, Higashi-Hiroshima, Japan.

Selected Publications

Bart, W., & Williams-Morris, R. (1990). A refined item digraph analysis of a proportional reasoning test. *Applied Measurement in Education*, *3*, 143-165.
Bart, W., & Orton, R. (1991). The cognitive effects of a mathematics in-service workshop on elementary school teachers. *Instructional Science, 20*, 267-288.
Bart, W., Post, T., Behr, M., & Lesh, R. (1994). A diagnostic analysis of a proportional reasoning test item: An introduction to the properties of a semi-dense item. *FOCUS on Learning Problems in Mathematics 16*, 1-11.
Bart, W. (2000). Connecting cognitive theory to instruction and testing: Learning and understanding the concept of torque. *Journal of Learning and Curriculum Development, 1*, 107-110.
Edman, L., Bart, W., Robey, J., & Silverman, J. (2004). Psychometric analysis of the Minnesota Test of Critical Thinking. *Psychological Reports, 95*, 3-9.
Yuzawa, M., Bart, W., Yuzawa, M., & Junko, I. (2005). Young children's knowledge and strategies for comparing space. *Early Childhood Research Quarterly, 20*, 239-253.
Bart, W., Hong, S., & Shin, T. (2007). Inquiry on the role of contemporary chess software to enrich human learning and cognition. In O'Neil, H., & Perez, R. (Eds.). *Computer games and human learning* (pp. 247-268). New York, NY: Erlbaum.

Professional tasks include teaching courses in learning, cognition, intelligence, creativity, and measurement. Research foci are cognitive diagnostic testing and the improvement of basic cognitive abilities and higher reasoning skills, especially critical thinking skills, among learners.

Summary

A major challenge facing the educational enterprise is the integration of the domains of measurement, cognition, and instruction. It is becoming increasingly commonplace for teachers and school administrators to be held accountable for the academic progress of their students. Teachers are thus requesting information to guide their instructional activities from the voluminous amounts of testing that occur in the schools.

To render testing more useful to the educational enterprise, tests need to provide teachers information as to how students think and information as to what to teach students so that they make academic progress. As a result, tests are needed that are cognitively diagnostic and instructionally prescriptive. To accomplish those outcomes for tests, a fresh alternative perspective is needed to examine how tests can be better integrated with cognition and instruction.

The purpose of this presentation was to introduce the concept of semi-dense item as the basis for a fresh alternative view of test analysis. A semi-dense item is an ideal cognitively diagnostic item in that one can make distinct inferences to cognitive rules from the item responses of students. Within this perspective, a cognitive rule is the sequence of cognitive steps that permits one to proceed from the stem of an item to an answer choice.

Five indices are presented to determine the extent to which a multiple choice test item is a semi-dense item. The indices measure the following properties of a semi-dense item: (1) response interpretability; (2) response discrimination; (3) rule discrimination; (4) rule set usage; and (5) semi-density,

Two of those item diagnostic item properties are response interpretability and response discrimination. Response interpretability refers to the extent to which each of the answer choices provided in an item is interpreted by at least one cognitive rule in the set of cognitive rules posited for the item. Response discrimination refers to the extent to which each of the responses to the item is interpreted by only one cognitive rule in the set of cognitive rules posited for the item.

For each of the five item diagnostic properties, there is an index that ranges in value from 0 to 1 with the value of 0 indicating that the test item totally lacks the item diagnostic property and with the value of 1 indicating that the test item has the item diagnostic property. The five item diagnostic properties and their indices permit the analysis of test items to determine how diagnostic test items are. If the cognitive rules posited for a test item are computable, then the computation of the five item diagnostic property indices constitutes an *a priori* analysis of the diagnostic properties of a test item. Such an *a priori* method of item analysis could be done on a computer without the use of actual item response data.

A type of item even more useful than a semi-dense item is a dense item, which is any item that permits distinct instructional inferences as well as distinct cognitive inferences from the responses to the item. This presentation was limited to an exposition of indices associated with the properties of semi-dense items.

One consequence of this approach to diagnostic item analysis is that cognitive research that identifies cognitive rules used when solving test items will need to be considered when constructing and analyzing test items. A second consequence is that the analysis of the diagnostic properties of test items is possible, without the use of actual item response patterns from students. A third consequence is that sophisticated internet-based instruction will be possible that results from the judicious coordination of computer technology, cognitive research, diagnostic testing, and instructional science.