
Digital Module 04: Diagnostic Measurement: Modeling Checklists for Practitioners

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Available in the ITEMS Portal at <https://ncme.elevate.commpartners.com>

Module Overview

In this ITEMS module we provide a didactic overview of the specification, estimation, evaluation, and interpretation steps for diagnostic measurement / classification models (DCMs), which are a promising psychometric modeling approach. These models can provide detailed skill- or attribute-specific feedback to respondents along multiple latent dimensions and hold theoretical and practical appeal for a variety of fields. We use a current unified modeling framework - the log-linear cognitive diagnosis model (LCDM) – as well as a series of quality-control checklists for data analysts and scientific users to review the foundational concepts, practical steps, and interpretational principles for these models. We demonstrate how the models and checklists can be applied in real-life data-analysis contexts. A library of macros and supporting files for Excel, SAS, and Mplus are provided along with video tutorials for key practices.

Key words: Diagnostic measurement, diagnostic classification models (DCMs), Log-linear cognitive diagnosis modeling (LCDM) framework, checklists, attributes, Q-matrix, model fit, Excel, Mplus, SAS

Prerequisite Knowledge

This ITEMS module assumes no prior knowledge of diagnostic measurement models. However, for the more statistical data-analysis sections it might be helpful to have a working knowledge of foundational assessment and statistical concepts such as:

- basic assessment components (e.g., assessments / tests, items / tasks, total scores / scale scores)
- basic variable types and scales (e.g., continuous, discrete, dichotomous, polytomous)
- basic summary statistics (e.g., mean, variance, standard deviation, correlation)
- basic model parameter types (e.g., latent variables, item parameters, measurement error)
- basic ideas of related frameworks (e.g., item response theory, classical test theory, structural equation modeling)

Specific prior experience with specialized estimation software is not required. However, we use macros for SAS, code files for Mplus, and populated spreadsheets for Excel to support worked examples. We point to introductory videos for how to work with these documents for data analyses whenever possible.

Learning Objectives

Upon completion of this ITEMS module, learners should be able to:

- describe the benefits of diagnostic measurement models
- describe the key outputs and interpretations associated with diagnostic measurement models
- describe the key structure, parameter meaning, and operational uses of the LCDM framework
- describe the key benefits of quality-control checklists in general and for the LCDM framework
- specify and estimate several key diagnostic measurement models within the LCDM framework
- perform basic model-data fit checks within the LCDM framework

- interpret parameter estimates from best-fitting models and translate them into a diagnostic score report

After completion of this module, learners might wish to take additional ITEMS modules on parametric item response theory, classical test theory, or other diagnostic measurement frameworks. Check out the ITEMS Portal webpage for up-to-date information on available ITEMS modules!

Module Structure

The module is divided into the following sections, which can be reviewed sequentially or independently [*approximate completion times in parentheses*].

- Module Introduction [*10 Minutes*]
- Section 1: Conceptual Foundations [*20 Minutes*]
- Section 2: LCDM Framework [*10 Minutes*]
- Section 3: Other Diagnostic Models [*10 Minutes*]
- Section 4: Checklist Development [*10 Minutes*]
- Section 5: Checklist Usage [*30 Minutes*]
- Section 6: Data Activity [*20 Minutes*]
- Section 7: Quizzes [*10 Minutes*]

Module Components

This ITEMS module includes the following components, which are delivered within a unified design shell that is compatible across platforms (i.e., laptops, desktops, tablets, cell phones) and was created with modern course development software (*Articulate 360*):

- integrated content slides that provide a structured walk-through of the content with suitable voice-over and video components
- interactive quiz questions with diagnostic feedback covering the key aspects of the module
- data activity with annotated solutions
- a glossary of key terms
- a library of supplementary Excel, SAS, and Mplus files
- a library of online resources that have been vetted for general scientific accuracy and instructional utility

Additional materials may be added over time so check back periodically!

Content Developers



Natacha Carragher, *Senior Statistician at the University of New South Wales*

Natacha is a Senior Statistician at the University of New South Wales (UNSW) as well as a consultant for the Department of Mental Health and Substance Abuse at the World Health Organization Headquarters in Geneva, Switzerland. She has 10 years of experience in the mental health field and, more recently, three years of experience in higher education assessment and behavioral addictions. Her research interests include the classification and structure of psychopathology, assessment

and measurement, comorbidity, and the application of latent variable modelling techniques to public health and educational data. Her work has been published in a range of prestigious peer-reviewed journals, which includes a co-written book chapter on self-report assessment for specific mental disorders published in the *Cambridge Handbook of Clinical Assessment and Diagnosis*. In 2014, she received the *Epidemiology and Public Health Section Young Epidemiologist Prize* from the UK Royal Society of Medicine. As an educator, Natacha has provided statistical advice and expertise to postgraduate students and staff at UNSW and colleagues at other universities.



Johnathan Templin, *Professor and E. F. Lindquist Chair of Educational Measurement and Statistics at the University of Iowa*

Johnathan's is professor and E. F. Lindquist Chair of Educational Measurement and Statistics at the University of Iowa. His research interests are focused on the development of psychometric and general quantitative methods, as applied in the psychological, educational, and social sciences. He teaches courses on advanced quantitative methodology with an emphasis on statistical modelling, model comparisons, and the integration and generalities of popular statistical and psychometric techniques. He is a co-author of the book *Diagnostic Measurement: Theory, Methods, and Applications*, which won the 2012 American Educational Research Association Division D Award for *Significant Contribution to Educational Measurement and Research Methodology*. He is the winner of the 2015 AERA *Cognition and Assessment SIG Award for Outstanding Contribution to Research in Cognition and Assessment* and the inaugural 2017 *Robert Linn Lecture Award*.



Philip Jones, *Professor Emeritus at the University of New South Wales*

Philip is Professor Emeritus at the University of New South Wales (UNSW) where he was the Associate Dean in Education for UNSW Medicine for 10 years until his retirement in 2016. He was a senior staff specialist in the Department of Infectious Diseases at the Prince of Wales Hospital and held a conjoint appointment to the Prince of Wales Clinical School. He was involved with the development of the Medicine program from the inception of its planning in 1998. In 2010, he received the *Vice-Chancellor's Award for Teaching Excellence* at UNSW.



Boaz Shulruf, *Associate Professor at the University of New South Wales*

Boaz is an Associate Professor who works in the Office of Medical Education at the University of New South Wales (UNSW) who is also an Honorary Associate Professor at the University of Auckland. His main research interests are in the area of psycho-educational assessment in higher education, particularly within the context of Medical and Health Sciences Education. He has expertise in quantitative research methodologies and educational assessment and psychometrics. He supervises Independent Learning Project students in medical education and educational measurement.



Gary Velan, *Professor and Associate Dean at the University of New South Wales*

Gary is a professor, Associate Dean, Head of the Department of Pathology, Director of Learning and Teaching Development, and Head of the Educational Research and Development Group in the School of Medical Sciences at the University of New South Wales (USNW). His research is based on educational innovations, including web-based assessments, virtual microscopy adaptive tutorials, concept and knowledge maps, and their effect upon learning outcomes in medical education.

Instructional Design Team



André A. Rupp, *Research Director at the Educational Testing Service (ETS)*

André is a research director in the psychometrics, statistics, and data sciences area at ETS. He is the co-author and co-editor of two award-winning interdisciplinary books entitled *Diagnostic Measurement: Theory, Methods, and Applications* (2010) and *The Handbook of Cognition and Assessment: Frameworks, Methodologies, and Applications* (2016). His research synthesis- and framework-oriented work has appeared in a wide variety of prestigious peer-reviewed journals. Among other things, he is passionate about improving processes for interdisciplinary collaborations during the development and implementation of scoring solutions for digitally-delivered assessments. Consequently, he is very excited to serve as the associate editor / lead instructional designer of the ITEMS portal for NCME whose mission is to provide free digital resources to support self-directed learning and professional development.



Xi Lu, *Doctoral Candidate at Florida State University*

Xi is a doctoral candidate in the Instructional Systems and Learning Technologies program at Florida State University. Her current research interest focuses on designing and developing optimal learning supports to facilitate STEM learning in digital interactive environments. She also works as a research assistant with Dr. Val Shute on an NSF project targeted at designing various learning supports for a 2D physics game called *Physics Playground* to help middle school kids learn physics. Before coming to FSU, Xi taught Chinese for six years in Monterey Bay, California.

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