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# RMT

## RASCH MEASUREMENT TRANSACTIONS

**Notes:**



**Transactions of the Rasch Measurement SIG**
**American Educational Research Association**

# Using Parallel Processing to Speed Up JMLE

The familiar Winsteps and Facets softwares rely on the JMLE algorithm for parameter estimation (formerly called UCON, see Wright and Masters, 1982, or Linacre, 1998). The following describes an experiment using Python 2.7 and the *Numpy* module aimed at improving JMLE's performance. The focus is a program part that is executed most often and that therefore contribute heavily to JMLE overall performance, that is *P(x,y,z)* – i.e., the probability that a person with trait level *x* when presented with an item of difficulty *y* will give rating *r*. *P(x,y,r)* needs to be computed once for each rating scale category during each JMLE iteration. JMLE also requires access to items' cumulative step values *cum ={c0, c1, …cs}*, where *cr* is the sum of all step values with index *0, 1, …, r*. A simulation study was performed to determine the impact of using *Numpy* on the CPU time needed to compute *P(x,y,r).* This study considers none of the other JMLE steps.

*Numpy*. The *Numpy* matrix-oriented software allows inefficient "sequential" program loops to be replaced by far more efficient vector operations (see e.g., Rossant, 2014). For instance, assume we are multiplying two 1-dimensional arrays element-wise. Then, multiplying vectors with 2 values each requires about the same CPU time as multiplying two vectors with 50 elements each. Thus, *Numpy* implements a limited form of "parallel" computing that is strictly limited to suitable vector operations. Unfortunately, it also requires additional internal CPU staging before any actual operations can be done, thus *Numpy* operations on small vectors may actually be *less* efficient than conventional "sequential" looping. Also, CPU time will vary across different computer designs and setups.

*Sequential Processing*. The following pseudo-Python code is an outline of the standard implementation of *prob(x,y,r)* as needed for JMLE.

*Assume:*

- *t = <predefined as an array with s elements>*
- *cum = <precomputed array as described in text>*

*def prob(x,y,r): d = y – x*
*for v in range(0,s): **t**[v]= exp(v * d - **cum**[v])*
*return **t**[r] / sum(**t**)*

That is, the program determines *t[0], t[1], …* from which the probability *P(x,y,r)* can be computed. The program is referred to as *Sequential*. Array variables (vectors) are in boldface type.
*Parallel P(x,y,r).* After the *cum* vector is converted to *Numpy* format and letting *v* play a similar role as above, then the program simplifies to:

*Assume:*

- ***v*** *= <predefined numpy array with elements 0.0, 1.0, 2.0, … as needed>*
- ***cum*** *= <precomputed numpy array as described in text>*

*def prob(x,y,r):*
***t*** *= np.exp(**v***(y-x) – **cum**) return **t**[r] / **sum**(**t**)*

For clarity, the *Numpy* vectors and operations are shown underlined and array variables are in boldface type. Note that the sum operation in the return statement is not underlined to reflect that the standard (sequential) Python version is used.
The preceding version is called *Parallel: sum(….)* because the exponentiation operation is vectorized via *Numpy*, but not the sum operation in the return statement. A variant was created where the sum operation in the return is done via *Numpy* as well, i.e.,
*return **t**[r] / np.sum(**t**)*

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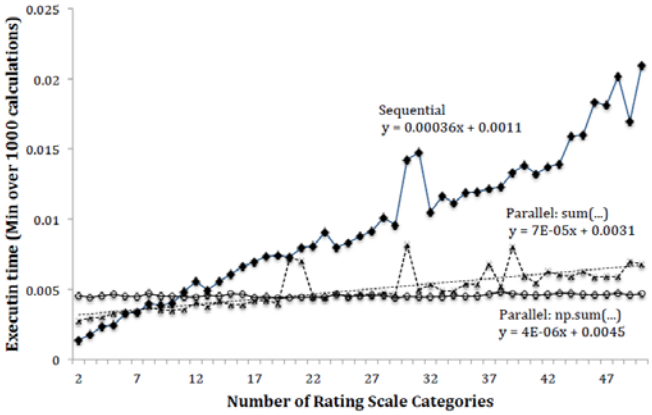
This program version is referred to as *Parallel: np.sum(…)*, the use of *Numpy* in computing the sum is the only difference with *Parallel: sum(…)*. *Simulation Results*. Figure 1 plots time in seconds needed to compute *P(x,y,r)* 1000 times (*Y-axis*) as a function of the number of rating scale categories ranging from 20 to 50 (*X-axis*). Ignoring some outliers due to unrelated CPU and OS activities, execution time for the *Sequential* program increases about linearly with the number of rating scale categories, as adding one more rating scale category increases execution time by about 0.0004 seconds per 1000 calculations (to avoid clutter, the regression lime is not shown).




As expected, the increase for *Parallel: sum(…)* for greater numbers of categories is much smaller, the slope of its' regression line (dotted line in Figure 1) being only about 7 x 10-5. Finally, the slope of the regression line for *Parallel: np.sum(…)* is more than 10 times smaller yet, being essentially flat (slope ≈ 0). Thus, it is indeed possible to compute *P(x,y,r)* using parallel processing such that the execution time remains essentially constant over the number of rating scale categories. It is further noted that the processing time for *Parallel: np.sum(…)* doubles to about 0.09 seconds of CPU per 1000 computations only after well over 1100 rating scale categories are used. At that point *sequential* needs nearly half a second of CPU time before eventually crashing due to numerical range issues.

Unfortunately, it takes considerable CPU time to initialize *Numpy* processing, especially for *Parallel: np.sum(…)*. Accordingly, Figure 1 shows that its processing time is superior only for rating scales with more than 8 categories. Rating scales with 9 or more categories are rarely used, and thus there is no immediate benefit to the *Numpy* approach. Of course, this might change as

improved *Numpy* versions become available, or when different vectorizing software is used. Also, this conclusion is limited the current setup based on Python 2.7, running on a standard 2014 Macbook Pro (OS 12.6). Conclusions will also likely differ between environments (e.g., using Java or Fortran) as well as across varying hardware designs and configurations.

It should be stressed that the preceding conclusions apply only to computing *P(x,y,r)* and *not to JMLE as a whole*, and that further parallelizing JMLE requires more than *Numpy*. The present findings encouraged me to investigate whether other aspects could be done in parallel, and it appears that other aspects of JMLE estimation can be parallelized as well using Python's "*rq*" and "*redis*" modules.

*Rense Lange*

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## SEM and Rasch Measures

Response variables in the human sciences are often binary or ordinal rather than interval. Item response theory (IRT) models have been developed to describe the nonlinear relationship between them, because the relationship between categorical item responses and their underlying latent traits is not linear. When the relationships are nonlinear in the measurement part of structural equation modeling (SEM), the resulting SEM can be called nonlinear SEM (NSEM) ( Su & Wang, 2010).

The relationship between indicators and their underlying latent traits in the measurement part of standard SEM is often assumed to be linear. The consequences of treating categorical item responses as continuous are problematic (Muthén & Kaplan, 1985; Olsson, 1979). How to establish a linear relationship between latent continuous responses and their underlying latent traits or convert observed categorical item responses to a latent continuous one is required.

SEM and Rasch measures were warmly discussed and talked in the PROMS 2017 pre-conference workshops on 6th August at Universiti Malaysia Sabah in Kota Kinabalu, Sabah. A single Rasch measure denoting a subscale score is proposed (Yan & Cheng, 2015). The plausible-value approach is introduced when original item responses are not acceptable (Mislevy,et al., 1992). A Rasch model can be estimated when holding loadings equal across items (Schweizer, et al., 2015).

In this paper, I construct three scenarios based on holding loadings equal across items. There are those using (i) raw ordered category data (Fig. 1), (ii) Rasch average measures on raw scores of each item (Fig. 2), and (iii) the combination of (ii) and their domain measures (Fig. 3) against the way of the traditional parameter estimation (Fig. 4). The path coefficients between two relevant domains using the method of partial least squares structural equation modeling (PLS-SEM) were examined.

See the difference in estimated factor loading in Fig.4, and we found that both Rasch methods in Fig. 2 and Fig.3 earn a higher R-square (0.72 and 0.71) in comparison with the other two counterparts. An illustration with a MS Excel format is at http://www.healthup.org.tw/marketing/course/marketing/Understanding PLS V01.xls. Interested readers are recommended to practice it and know the implication and meaning of using Rasch average measures to develop the approximately linear relationship between categorical item responses and their underlying latent traits. Likewise, the average measures across item categories can be applied to the standard SEM.


Figure 1. PLS with raw ordered category data and equal item weights to its domain


Figure 2. PLS with average measures and equal item weights to its domain


Figure 3. PLS with average measures, Rasch measures on each domain and equal item weights to its domain


Figure 4. PLS with raw ordered category data and different item weights to its domain

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## PROMS 2018

The Pacific-Rim Objective Measurement Symposium (PROMS) will be held July 25-27, 2018 in Fudan University, Shanghai, China. Preconference workshops will be held from July 23-24. The theme of the meeting is *Applying Rasch Measurement in Language Assessment and across the Human Sciences.*

PROMS 2018 will feature three keynotes:
Tim McNamara, University of Melbourne
Yan Jin, Shanghai Jiao Tong University
George Engelhard, University of Georgia

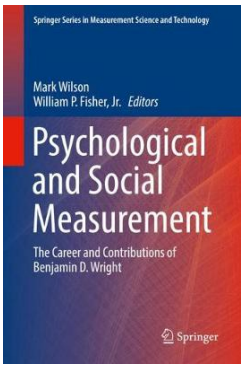
The PROMS 2018 website is available at: https://proms.promsociety.org/2018/.

PROMS 2018 will also feature workshops on the application of the Rasch model in both English and Chinese. PROMS invites presentations on the theory and practice of applying the Rasch model across the human sciences, including business, education, health and psychology.

Following the usual PROMS practice, accepted papers will be allocated to presentation strands with similar focus. The deadline for abstract submissions is April 1, 2018; Notifications of abstract acceptance will occur before May 5, 2018; Early bird registration is available until May 30, 2018.

"And with 10 being the highest, you're sure you're only at a 6?"

## New Book Honoring Ben Wright




*Psychological and Social Measurement: The Career and Contributions of Benjamin D. Wright* is now available online as a Springer eBook in their Series in Measurement Science and Technology. The hard copy is scheduled for release on January 20, 2018. The book is edited by Mark Wilson and William P. Fisher, Jr and can be found at: http://www.springer.com/us/book/9783319673035.

In this tribute to Benjamin Wright, former students and colleagues recall the foundational contributions he made to the theory and practice of measurement in a career spanning over five decades. Wright is recognized as the foremost proponent of the psychometric approach of Georg Rasch, a Danish mathematician, whose ideas continue to provoke controversy. Wright's colleagues and students, and students of their students, are leaders in educational research and practice around the world. This volume relates the extent of Wright's influence far beyond education and psychology, where his work in measurement began, into health care and the social sciences at large. The editors and contributors—all leading measurement scholars—trace the development of themes in Wright's work, identifying the roots of today's formative assessment methods, the integration of quantitative and qualitative data, and the contrast between scientific and statistical methods. These previously unpublished papers reflect on Wright's lifelong passion for making measurement both more scientific and more meaningful. They recount how Wright's insight, energy, and gregarious nature led him to produce multiple innovations in computing, estimation methods, model development, fit assessment, and reliability theory, stimulating practical applications in dozens of fields, serving on over 120 dissertation committees, and founding several professional societies. The volume includes three reprinted articles by Wright that provide insights into his early engagement with Rasch's ideas.

*Psychological and Social Measurement* will be welcomed by the broad international measurement community of professionals and researchers working in such diverse fields as education, psychology, health sciences, management, and metrology. Scientists working in any field involving measurement science and technology will appreciate an inside look at this seminal figure and a new perspective on the expanding conversation across the sciences about measurement and the communication of meaningful, transparent information.

## Rasch SIG Business Meeting

On Sunday, April 15 the Rasch SIG Business Meeting will take place from 6:30 to 8:00pm at the Westin New York at Times Square, Ninth Floor, Pearl Room. After a presentation of SIG business, lead by Chair Leigh Harrell-Williams, the audience will be treated to a presentation entitled "Power, Invariance, and Measurement" by George Engelhard, Jr. from the University of Georgia. Below is an Abstract of Dr. Engelhard's presentation.

Measurement serves numerous purposes in the social sciences. For example, test scores in education are used to guide decisions (diagnostic, formative, summative and strategic) that are made about students. In this presentation, I focus on measurement as a powerful technology that has great potential for both positive and negative consequences in education. Next, I describe the principles of invariant measurement, and their use to guide the construction of stable and useful assessment systems. Invariant measurement refers to assessments that yield test scores that "stay put while the user's back is turned". Finally, I introduce Rasch measurement theory as a psychometric model for creating stable systems of educational assessments. Rasch models offer an approach for developing invariant measures that can support the intended uses of educational assessments. This presentation provides an overview of these concepts, as well as the implications for research, theory and practice related to educational assessments.

# List of AERA Rasch-Related Presentations

The Community Readiness and Participation Scenario Scale: Unidimensional or Multidimensional? - *Tong Shen, Boston College; Larry H. Ludlow, Boston College; Sally Rogers, Boston University; Uma Millner, Boston University; Zlatka Russinova, Boston University*

Evaluation of Rater Accuracy in the Context of Music Performance Assessments in Malaysian Higher Education - *Pey Shin Ooi, The University of Adelaide; George Engelhard, University of Georgia*

Using Rasch to Develop and Validate an Assessment of Students' Progress on the Energy Concept - *Cari F. Herrmann-Abell, American Association for the Advancement of Science; Joseph Hardcastle, American Association for the Advancement of Science; George E. DeBoer, American Association for the Advancement of Science*

Validation of the Math Anxiety Scale With the Rasch Measurement Model - *Safiye Bahar Olmez; ibrahim burak olmez, University of Georgia - Athens*

Is PROC IRT a Viable Option for Rasch Model Calibration for Research and Large-Scale Assessment? - *Ki Matlock Cole, Oklahoma State University; Insu Paek, Florida State University*

Specification of Priors in Bayesian Estimation Under the Rasch Model - *Seock-Ho Kim, University of Georgia; Allan S. Cohen, University of Georgia; Minho Kwak, University of Georgia - Athens; Juyeon Lee, University of Georgia - Athens*

Using Functional Data Analysis to Analyze Unfolding Models - *Kyle Turner, University of Georgia - Athens; George Engelhard, University of Georgia; Jue Wang, University of Georgia - Athens*

Examining the Practical Consequences of Rater Errors and Rater Misfit in Performance Assessments - *Stefanie A. Wind, The University of Alabama - Tuscaloosa*

How Small Is Too Small? Sample, Item, and Correlation Size in Rasch Out-of-Sample Classification Error - *Anthony Raborn, University of Florida*

Similarities Between Cross-Sectional and Longitudinal Growth in Large, Rasch-Scaled Reading Achievements - *David Andrich, University of Western Australia; Ida Marais, The University of Western Australia*

An Investigation of a Rater-Mediated Medical Licensing Performance Examination Equating Quality With the Rasch Model - William L. Roberts, National Board of Osteopathic Medical Examiners

Appropriate for All? Rasch Analysis of a Scale for Teachers' Perceived Challenges - *Audrey Conway Roberts, University of Kentucky; Shannon O. Sampson, University of Kentucky*

Survey Validation From the Rasch Measurement Framework: An Empirical Demonstration - *Myrah Rose Stockdale, Campbell University; Kenneth Royal, North Carolina State University*

Comparing School Leadership Perceptions Using Rasch Measurement in Hong Kong and the United States - *Sijia Zhang, The University of Alabama; Stefanie A. Wind, The University of Alabama - Tuscaloosa; Mitchell Porter, The University of Alabama - Tuscaloosa*

A Case for Item-Level Examination of a Quality Rating Improvement System Tool Using Rasch Analyses - *Vasanthi Rao, University of South Carolina - Columbia; Kelvin Terrell Pompey, University of South Carolina; Herman T. Knopf, University of South Carolina*

Measuring Middle-Grades Teachers' Reasoning About Fractions With the Mixture Rasch Model - *Ibrahim Burak Olmez, University of Georgia - Athens; Andrew G. Izsak, Tufts University*

Investigating Response Profiles Using a Constrained Mixture Rating Scale Model -

*Perman Gochyyev, University of California - Berkeley; Mark R. Wilson, University of California - Berkeley*

A Deeper Look at Deeper Learning: Detecting Differential Item Functioning Using Explanatory Item Response Theory Models - *Meihua Qian, Clemson University*

Confidence to Perform in the Global Marketplace: Constructing and Validating a Survey Instrument for Community College Students - *Snejana Slantcheva-Durst, University of Toledo; Mingyang Liu, University of Toledo*

Using Many-Faceted Rasch Measurement (MFRM) to Evaluate a Teacher Observation Instrument - *Evelyn Johnson, Boise State University; Angela Rae Crawford, Boise State University; Yuzhu Zheng, Boise State University; Laura Moylan, Boise State University*

Assessing Multiple Mini Interviews: Practical Ways the Many-Facets Rasch Model Can Better Inform Pharmacy Admissions Processes - *Myrah Rose Stockdale, Campbell University; W. Mark Moore, Campbell University; Kenneth Royal, North Carolina State University*

A Validity Argument for an Innovative Assessment System Based on Learning Trajectories - *Jere Confrey, North Carolina State University; G. Gianopulos, North Carolina State University; Meetal Shah, North Carolina State University*

Measuring Reading Strategy Use in a Multilingual Context - *Daniel Katz, University of California - Santa Barbara; Albert Anthony Clairmont, University of California- Santa Barbara; Diana J. Arya, University of California - Santa Barbara; Andrew Maul, University of California - Santa Barbara*

Contrasting Micro-Interaction Processes During Online Assessment of Collaborative Problem Solving: Case-Based Portraits of Two Dyads - *Johanna Pöysä-Tarhonen, University of Jyväskylä; Esther Care, University of Melbourne; Nafisa Awwal, University of Melbourne; Päivi Häkkinen, University of Jyväskylä*

Implementing Exams Based on Item Response Theory in Higher Education - *S. Franziska C. Wenzel, Goethe University; Sabine Fabriz, Goethe University; Holger Horz, Goethe-Universität Frankfurt*

Examining the Dimensionality of Torrance's Figural Creativity Tests Through the Principal Component Analysis of Residuals - *Süreyya Yörük, Marmara University*

Refining Instruments for a Formative Assessment Intervention: Item Response Theory Modeling and Differential Item Functioning Analyses - *Susan E. Rowe, University of California - Davis*

Theory-Based Automatic Item Generation of Elementary and Middle School Area and Surface Area Problems - *Mary Ann Simpson, MetaMetrics; Lisa Bickel, MetaMetrics; Ian F Hembry, MetaMetrics; Ruth Price; Cassandra Totten; Eleanor E. Sanford-Moore, MetaMetrics; Heather Hughes Koons, MetaMetrics; Pan Qianqian*

Extent and Variation of Lower Secondary Students' Civic Knowledge and Changes Since 2009 - *Julian M.S. Fraillon, Australian Council for Educational Research; Eveline Gebhardt, Australian Council for Educational Research; Wolfram H. Schulz, Australian Council for Educational Research*

A First Look at the Impact of Selecting and Supporting Cooperating Teachers on Preservice Teachers - *Kavita Kapadia Matsko, National Louis University; Matthew Ronfeldt, University of Michigan; Hillary L. Greene, University of Michigan - Ann Arbor*

The Measurement of Sociocultural Integration in Schools With Culturally and Linguistically Diverse Student Populations - *Maria Eugenia Baez Cruz, Boston College; Larry H. Ludlow, Boston College; Martin Scanlan, Boston College; Colleen E. Chesnut, Indiana University - Bloomington*

Tale of Two Mathematics: Hybrid Pedagogies in Grades 3 and 5 Mathematics Teaching and Learning - *Siti Hawa Jonid, National Institute of*

*Education - Nanyang Technological University; Divya Bhardwaj, National Institute of Education - Nanyang Technological University; Rifhan Noor Miller, National Institute of Education - Nanyang Technological University*

The Business Influences on Teachers' Work - *Emily Winchip, University of Nottingham*

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The Effects of Item Placement in the Young Schema Questionnaire - *Victoria K. Moir, Christopher W. Lee, and Ida Marais*

Stability of INFIT and OUTFIT Compared to Simulated Estimates in Applied Setting - *Kari J. Hodge and Grant B. Morgan*

Approximate Functional Relationship between IRT and CTT Item Discrimination Indices: A Simulation, Validation, and Practical Extension of Lord's (1980) Formula - *John T. Kulas, Jeffrey A. Smith, and Hui Xu*

Social Desirability Amongst Chinese Teachers - *Randall E. Schumacker and Cathy Ka Weng Hoi*

I'm scared to go to School! Capturing the Effects of Chronic Daily Fears on Students' Concept of Self - *Rense Lange, Cynthia Martínez-Garrido, and Alexandre Ventura*

Confidence to Perform in the Global Marketplace: Constructing and Validating a Survey Instrument for Community College Students - *Snejana Slantcheva-Durst and Mingyang Liu*

Measuring Anger Types among Malaysian Adolescents using the Rasch Model - *Ahmad Zamri Khairani, Nor Shafrin Ahmad, and Mohd Zahuri Khaira*

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The Impact of Missing Values and Single Imputation upon Rasch Analysis Outcomes: A Simulation Study - *Carolina Saskia Fellinghauer, Birgit Prodinger, and Alan Tennant*

Methods for the Comparison of Differential Item Functioning across Assessments - *W. Holmes Finch, Maria Hernández Finch, Brian F. French, David E. McIntosh, and Lauren Moss*

Equating Errors and Scale Drift in Linked-Chain IRT Equating with Mixed-Format Tests - *Bo Hu*

Validation of Response Similarity Analysis for the Detection of Academic Cheating: An Experimental Study - *Georgios D. Sideridis and Cengiz Zopluoglu*

Rasch Analysis of the Teachers' Knowledge and Use of Data and Assessment (tKUDA) Measure - *Courtney Donovan*

Psychometric Properties and Differential Item Functioning of a Web-Based Assessment of Children's Social Perspective-Taking - *Beyza Aksu Dunya, Clark McKown, and Everett V. Smith*

Assessment of Test Items with Rasch Measurement Model - *Patrick U. Osadebe*

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## Rasch-related Coming Events

April 10-12, 2018, Tues.-Thurs. Rasch Conference: IOMW, New York, NY, www.iomw.org.

Apr. 13-17, 2018, Fri.-Tues. AERA, New York, NY, www.aera.net.

# In Memoriam

*In mid-February, The Pacific Rim Objective Measurement Society noted the passing of their colleague Professor WANG Wen Chung*

**Vale: Professor WANG Wen Chung** 王文中教授

It is with a deep sense of sadness and regret that the Chair and Board of the Pacific Rim Objective Measurement Society advise of the death of our esteemed Board member and dear colleague, Professor WANG Wen Chung, Chair Professor at the Education University of Hong Kong. Prof Wang quietly passed away on February 15th, 2018 surrounded by his family after a long and painful battle with cancer. His funeral service in Hong Kong on 1 March, was followed by a memorial service at EDUHK, the next day, during which Wang's daughter, Janice was presented with a plaque acknowledging the PROMS Lifetime Achievement Award honouring her father.

The award was made in recognition of the outstanding contribution to Rasch Measurement made by Professor Wang Wen Chung. The citation reads: "PROMS applauds the sustained effort Professor Wang has made over many years as a theoretician, researcher and teacher. His work has been highly original and at the cutting edge of Rasch Measurement world-wide." We know from the speech given by Wen-Chung's son, Peter, that Prof. Wang valued PROMS, and regarded the PROMS Lifetime Achievement Award as one of his most significant achievements.

Prof WANG was too sick to attend PROMS last year, and found out that he had been nominated for the first PROMS Lifetime Achievement Award when he read the Minutes from the 2017 Sabah PROMS Board Meeting: "When I read the PROMS minutes, I am very surprised and grateful to find your nominating me as a recipient of Life-time Achievement Award. I am deeply honoured and appreciate the board", he modestly messaged. Prof Wang was told that, "We thought our exceptional award should go to our exceptional Rasch scholar." Wang planned to come to our PROMS 2018 Shanghai meeting to receive the award: "It is my motive to get better."

Alas, Prof Wang will not make it, and our future meetings will be the sadder and the poorer without him. He will be missed by the broader Rasch measurement and psychometric communities, and by those who worked closely with him in Taiwan and Hong Kong. We will miss his brilliant intellect, his inventive problem-solving, his crystal clear teaching and his generous mentoring of grad students and young academic colleagues.

Wang's Professorial appointment in Hong Kong, in 2008, was virtually a *fait accompli*, even before his interview was completed. The interview panel was dazzled by his impressive academic achievements, his open, honest manner, along with his modest personal style. Wen Chung, Rebecca and their children moved onto the campus; and Wang continued his brilliant career as the Associate Vice President (Research and Knowledge Transfer), Chair Professor of Educational Measurement and Co-Director of the Assessment Research Centre at The Education University of Hong Kong. Wang's distinctive contribution to the measurement world has been the development of Rasch-based models for multidimensional tests, multilevel data structures, higher-order latent traits, testlet items, rater effects, examinee-selected items, wording effects, response styles, differential item functioning, computerized adaptive testing, ipsative data, and so on. Prof Wang has published more than 185 journal articles mostly on Rasch measurement, IRT, cognitive diagnostic models, and related fields.

We have been delighted to have had Wang as our close colleague; his contributions to our field, and his participation in PROMS have been seminally important. PROMS members, his past students and colleagues around the world, will miss Prof Wang Wen Chung now that he is released from his exhausting fight to survive. PROMS Board members extend their heartfelt condolences to Rebecca, Peter and Janice.