

Proceedings of the Forty-Fifth Annual Meeting of the
North American Chapter of the International Group for
the Psychology of Mathematics Education

Engaging *All* Learners

VOLUME 1: TEACHING

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PME-NA HISTORY AND GOALS

PME-NA History and Goals

PME came into existence at the Third International Congress on Mathematical Education (ICME-3) in Karlsruhe, Germany, in 1976. It is affiliated with the International Commission for Mathematical Instruction. PME-NA is the North American Chapter of PME. The first PME-NA conference was held in Evanston, Illinois in 1979. Since their origins, PME and PME-NA have expanded and continue to expand beyond their psychologically oriented foundations. The major goals of the International Group and the North American Chapter are:

1. To promote international contacts and the exchange of scientific information in the psychology of mathematics education.
2. To promote and stimulate interdisciplinary research in the aforesaid area, with the cooperation of psychologists, mathematicians, and mathematics teachers; and
3. To further a deeper and better understanding of the psychological aspects of teaching and learning mathematics and the implications thereof.

PME-NA Membership

Membership is open to people who are involved in active research consistent with PME-NA's aims or who are professionally interested in the results of such research. Membership is open on an annual basis and depends on payment of dues for the current year. Membership fees for PME-NA (but not PME International) are included in the conference fee each year. If you are unable to attend the conference but want to join or renew your membership, go to the PME-NA website at <http://pmena.org>. For information about membership in PME, go to <http://www.igpme.org> and visit the "Membership" page.

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Preface

The Forty Fifth Annual meeting of the North American chapter of the International Group for the Psychology of Mathematics Education was held PME-NA 45 in Reno, Nevada, Oct. 1-4, 2023. The conference theme is listed below:

Engaging All Learners

Math learning should be a joyful experience for all students. When students are engaged and inspired, they are motivated to learn. Instruction that targets the learning needs and interests of our students makes it possible for students to excel in learning math. Participants in the conference explored how to create conditions to support learning that build on student engagement and interest in addition to other research engaged by the PME-NA community. The specific conference theme questions explored as part of the conference was:

- How can we engage all students to learn math content by building on their interest and motivation to learn?
- How do we design learning environments that take students and learning into account?
- What are the design features of tools and curricula design features considering student engagement and interest in supporting learning?
- How do we build partnerships with schools and the community to support student engagement and math learning?
- What research agendas should we pursue to ensure that all students reach their potential by paying attention to engagement and learning needs?

The acceptance rate for Research Report was 45%, the acceptance rate for brief research reports was 70 %. The acceptance rate for posters was 90%. Note: some papers were accepted in alternate format than originally proposed. The total number of participants who submitted proposals as co-authors was 1083.

Plenary Speakers

Motivation and Embodied Cognition

- Mitchell J. Nathan, Ph.D., University of Wisconsin at Madison
- James Middleton, Ph.D., Arizona State University

Connecting Math to Real-world Experiences, Culture and Technology

- Lisa Lunney Borden, Ph.D., St. Francis Xavier University, Canada
- Jose Luis Cortina, Ph.D., National Pedagogical University, Mexico City
- Theodore Chao, Ph.D., Ohio State University

Play Experiences and Math Learning Panel Presentation, "*What Do You See in Mathematical Play?*"

- Nathaniel Bryan, Ph.D., Ed.D., The University of Texas at Austin
- Melissa Gresalfi, Ph.D., Vanderbilt University
- Naomi Jessup, Ph.D., Georgia State University
- Amy Parks, Ph.D. Michigan State University
- Tran Templeton, Ed.D., Teachers College Columbia University
- Anita Wager, Ph.D. Vanderbilt University

Preparing Teachers to Engage Students (closing the plenary sessions)

- Robert Berry III, Ph.D., University of Arizona

The local organizing committee would like to thank the steering committee for all their support and everyone who helped make this conference a success.

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QUANTITATIVE INSTRUMENT REPOSITORY FOR MATHEMATICS EDUCATION RESEARCH WITH VALIDITY EVIDENCE

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The paper reports on the developments of a repository of quantitative assessments used in mathematics education contexts. This repository centralizes assessments and the associated validity evidence. The repository is public and freely available and has potential to inform future quantitative mathematics education scholarship.

Keywords: Assessment, Measurement

Finding and selecting quantitative instruments to use in mathematics and statistics education can be difficult for scholars for many reasons. First, it is not always easy to ascertain if there is a suitable instrument to measure a desired construct. Second, many published articles report results based on analyses of data from instruments they used, but they do not always publish the full instrument used. A third reason is that some manuscripts describe an assessment but do not provide details about the validity evidence related to the assessment's intended uses or score interpretations. Broadly speaking, validity describes the degree to which evidence supports an intended claim (AERA et al., 2014; Messick, 1989). A goal to fostering scholarship is building a strong knowledge base that uses assessments with strong validity evidence (Authors., 2022A; Kane, 2013). A searchable database of mathematics education assessments may help to address that goal, which is the objective of this research project. The purpose of this submission is to describe the creation of a new database of mathematics and statistics education assessments that will be broadly available to scholars. A result of addressing this purpose is to provide the mathematics and statistics education scholarly community with a tool that may help individuals locate possible assessment for use, review validity evidence about the assessment, as well as review available literature associated with the respective assessments.

Literature

Prior to 2014, there was scant discussion of validity and quantitative assessment within mathematics education scholarship (Author, 2017). In the last decade, there has been a substantial increase in scholarship exploring the degree to which validity and validity evidence is discussed in mathematics and statistics education as well as scholarship focusing on how those validity arguments are communicated (e.g., Pellegrino et al., 2016; Walkowiak et al.,

2019; Wilhelm & Berebitsky, 2019). As more assessments are described in journal articles, it can be time intensive to search journals for instruments that match a desired construct as well as their validity evidence. Moreover, there are documented differences in the journals that institutions access, which is an equity issue as well as an issue of building robust research (Authors, 2022B). With a greater attention paid to the quality of information collected on quantitative assessments

in mathematics and statistics education scholarship, there is a pressing need for providing the fields of mathematics and statistics education scholars with a means to efficiently and effectively explore available measures used.

Methods

In the spring of 2020, 41 participants attended a BLINDED conference in Las Vegas. Participants of the conference included mathematics education faculty, researcher scientists, psychometricians, assessment developers, and graduate students. The goal of the conference was to create an understanding of validity within mathematics education contexts and solicit recommendations from experts about information necessary to build a repository of quantitative mathematics education instruments. Based upon the recommendations from the experts who attended the conference, a synthesis procedure was developed for identifying and categorizing validity evidence, interpretation statements, and use statements of quantitative instruments. This conference participants were divided into six synthesis groups: (1) Elementary (K-6) Tests and Instruments; (2) Secondary (7 - 12) Tests and Instruments; (3) Undergraduate and Graduate Mathematics Tests and Instruments; (4) Statistics Education (K - 20) Tests and Instruments; (5) Teacher Education Tests; and (6) Teacher Education Instruments.

Each group searched for instruments that fell within their group's parameters, identified if the instruments should be included into the repository, searched for validity evidence associated with the included instruments, and identified and categorized the existing validity evidence for each instrument. The validity evidence was categorized using the sources outlined in the *Standards for Educational and Psychological Testing* ([Standards] AERA et al., 2014). The *Standards* describe five validity sources: test content, response process, relations to other variables, internal structure, and consequences from testing/bias. Reliability is a related component of the *Standards* but is not one of the five sources. These sources and resulting evidence types (Figure 1) provided the foundation for our categorization. In addition, each instrument that was found by each synthesis group was tagged with key features, such as, the population being tested, the construct measured by the instrument, the types of items present in the instrument, etc. These instruments and the associated evidence are what were used to create the repository.

Product Development

From the work of the six synthesis groups, we created a free online digital repository for the categorization of instruments that also describes their associated validity evidence. To access the repository, users will create a log-in and briefly acknowledge the user agreement. Once logged in users have access to instruments, validity evidence, and training modules about

validity. The website was designed to be user friendly, accessible, and evidence in the repository is aligned with the *Standards* (AERA et al., 2014). The repository has several important design features explained below: search features, researcher portal, and ease of adding new instruments.

Design Feature: Search Features

The database will have a search feature that will allow users to input any desired text and search for instruments based on that text entry. In addition, they will be able to search by any of the tagging features. We intentionally created tagging features consistent across all six synthesis groups, and ones customized to each group, so researchers can easily sort and search for instruments. Tagging features were common to all six synthesis groups and include: Synthesis Group, Population, Grade Level, Construct, Type of Instrument, Mode of Delivery, and Item Type.

Consequences of Testing	Internal Structure	Relations to Other Variables	Reliability	Response Process	Test Content
Appropriate cut score	Bayesian Network Models	Alignment with expert opinion of test user (e.g. teacher, therapist)	Alternate form	Cognitive interviews	Alignment with frameworks/standards/theory/learning trajectory
Bias as one consequence of testing	Cluster analysis	Convergent Association or Divergent Association	EAP/PV test reliability	Error related to response patterns/CTT	Construct Definition
Cost-benefit analysis	Factor Analysis- Bifactor	Correlation analysis	Generalizability theory- D-studies	Eye tracking/physiological data	Data from experts
Documentation of unintended behavior changes based on test use	Factor Analysis- Confirmatory Factor Analysis (CFA)	Discriminant validity	Generalizability theory- G-studies	fMRI (functional Magnetic Reasoning Image)	Fairness of content
Explicit intended uses and interpretations and warn against inappropriate uses	Factor Analysis- Exploratory Factor Analysis/Exploratory Structural Equation Modeling	Discrimination power	Inter-rater reliability- Kappa	Focus groups	Field Work
Impact of assessment is similar under clinical and practical implementations	Factor Analysis- Multi-trait Multi-method matrix (MTMM)	Hierarchical Linear Modeling	Inter-rater reliability- Percent agreement	Generalizability-theory (G-theory) related evidence	Literature Review
Item functioning such as DIF - unknown subgroups had to know	Factor Analysis- Not specified	Multi-trait Multi-method matrix (MTMM)	Internal consistency or alternatives- Alpha	Log data	Participant-generated content
Motivational consequences	Factor Analysis - Parallel Analysis	Statistical Testing (e.g., t-test, regression, and chi-square)	Internal consistency or alternatives- IRT or Rasch reliability	Predicted response patterns/processes based on Learning Trajectories	Revision Process
	Factor Analysis- Principal Axis Factoring (PAF)	Structural Equation Model	Internal consistency or alternatives- Omega	Rater agreement/reliability	Standard Setting
	Factor Analysis- Principal Component Analysis (PCA)	Treatment/control study	Internal consistency or alternatives- Raykov	Rater training and calibration	
	Item difficulty	Triangulation/Crystallization with qualitative data	Item remainder correlations	Sorting tasks	
	Item Scale Correlations		Kuder-Richardson formula 20	Student written work	
	Item Response Theory (IRT)		SEM measurement	Studies of respondent's speed of task completion	
	Latent Class Analysis (LCA)		Sensitivity analysis	Think alouds	
	Latent Profile Analysis (LPA)		Split-half reliability		
	Multidimensional scaling		Test - Retest		
	Rasch modeling				
	TETRAD				

Figure 1: Validity Evidence Types

Design Feature: Researcher Portal

There will be a researcher portal that will have training modules, both written and video based. These will provide users of the repository with educative content pertaining to ideas related to validity and validation and on the proper use of the repository and instruments the user may want to use for their own purposes. Once logged into the researcher portal, instruments can be saved to users' "favorites" or shared. Users will also be able to provide feedback on the results of an instrument or download the search results for a particular search.

Search

Design Feature: Ease of Adding New Instrument

Initially, assessments were added by the project leaders based upon the work of the synthesis groups. However, users can now submit a request electronically to include an instrument in the repository, along with the associated validity evidence and tagging features. Once an instrument is submitted, a repository curator will vet the materials to ensure the inclusion criteria have been met. Once the criteria have been met, the instrument will be included in the repository. If it cannot be included, then the project leader will communicate what additional information is needed to include the instrument.

The image displays two side-by-side screenshots of the EdEx platform interface, illustrating the process of uploading and tagging documentation.

Left Screenshot: Upload documentation

- Header:** "Upload Doc"
- Section:** "Submit an instrument for review" (with a close icon).
- Text:** "Once we receive your file we will review and add to our database. The process takes roughly 1-2 weeks. We will be in touch."
- Form:** "Instrument name" (text input) and "Provide feedback" (text input).
- Section:** "Attach documents" (with a dashed border and a close icon).
- Drag and Drop Area:** A large dashed box containing a placeholder icon (a square with an 'X') and the text "Drag and drop here or Browse files". Below the box, it states: "Accepted file types JPEG, PNG, PDF with a max file size of 15MB".
- File Uploads:**
 - Instrument 1.PDF (426 KB) [Progress bar: 100%]
 - Instrument 2.PDF 1.23 MB [Progress bar: 100%]
 - Instrument 3.PDF [Status: Document failed to load]
- Buttons:** "Cancel" and "Continue".

Right Screenshot: Tagging with Validation

- Header:** "Upload Tagging Doc"
- Section:** "Tagging your submission" (with a close icon).
- Text:** "Please take a moment to choose which tags best apply to your submission."
- Form:**
 - Synthesis group:** "Elementary instruments & tests", "Secondary instruments & tests" (selected), "Stat Ed K-20 Instruments & tests", "UQ/Grad Instruments & test", "Teacher education instruments", "Teacher education tests".
 - Population:** "Student", "Inservice teacher" (selected), "Preservice teacher".
 - Grade level:** "K-6", "7-12" (selected), "Undergraduate", "Graduate".
 - Type of instrument:** "Criterion-referenced & Diagnostic" (selected), "Formative", "Likert/Rating Scale", "Norm-referenced", "Observation", "Summative", "Survey".
 - Validation:** "Do you have any supporting validation evidence?" (Yes selected, No unselected).
 - Type(s) of validation (Select all that apply):** "Instrument", "Test Content", "Response Process", "Relations to other variables", "Internal Structure", "Consequences of testing", "Reliability".
- Buttons:** "Cancel" and "Submit".

Figure 3: Adding a New Instrument Conclusions

A goal of this project was to produce a repository that could be used by scholars seeking a quantitative instrument for use in mathematics or statistics education contexts. Through developing the repository, it may be easier for scholars to locate assessments for a given

construct or evaluate two viable instruments considering their validity evidence and claims.

Moreover, this repository has a propensity for others to locate an instrument and improve it, or to gather greater or more robust validity evidence. As a result of the repository, we argue it offers a start to promote equity through using assessments aligned to a desired construct and suited for an appropriate population. Engaging all learners in mathematics education and assessing whether we are engaging all learners in mathematics, should be based on research conducted from high- quality studies. Foundational to such studies are instruments with proper validity arguments.

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