Quasi-Longitudinal Trends of Mediators and Asian Female Mathematics Performances: TIMSS Perspectives*

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Abstract

Mathematics performances of Taiwan and Asian female students will be compared thoroughly based on specific mathematics problems solving abilities, including understanding, planning, executing and monitoring. In addition, their performances on routine and non-routine mathematics problems will be examined and compared. In other words, performances on standardized (multiple choices) items and alternative items (performance assessment) will be separated and examined.   Quasi-longitudinal or stage-wise educational developments or changes in Taiwan educational systems and other Asian environments with respect to the changes of educational achievements across years will be modeled.   Specifically, categorized mathematics scores and their scaled overall achievements will be analyzed.   Developments of specific mathematics learning for TIMSS participants (countries) can be recorded individually and analyzed across different survey years.   The changing trajectories are useful for educational interpretations and policy refinements.

Introduction

Cognitive developments of mathematics learning will be modeled and evaluated extensively according to corresponding substantive theories of mathematics learning. Specifically, advanced statistical methods, e.g., structural equation models are used to analyze TIMSS databases.   The content of mathematics achievement of TIMSS is focused on knowing basic mathematics facts, using basic arithmetic strategies, word/performance problem solving, and reasoning and communicating.   In addition, detailed quantitative comparisons on mathematics among Taiwan and Asian female

students will be proceeded with respect to educational environments, curriculums, educational expectations, student OTL, etc.   Complex relations among mathematics and their influential educational contributors will be examined by structural equation models (SEM) and other recent developed statistical analysis methods, e.g., robust SEM for categorical test outcomes, multilevel SEM, SEM for complex sampled/weighted datasets.   In addition, trends of Taiwan and other international participants can be discovered by using the repeatedly measured TIMSS samples and SEM techniques.

The educational achievement mediators to be analyzed will include educational policy, curriculum, instructions, opportunity to learn (OTL), parents expectation, and other significant factors. In addition, gender Effects, cultural differences, and quasi-longitudinal trends, classroom effects, school effects, school district effects (rural and urban area) as well as country differences are to be analyzed.

Methods

TIMSS was intended to investigate trends of international educational achievements in Mathematics and Science.   In addition, excessive important factors potentially influential to educational achievements were also surveyed.   The TIMSS surveyed (1994 ~ 1995) five different grades of students (i.e., 3rd, 4th, 6th, 7th, and 12th graders) while TIMSS-R (1998 ~ 1999) adjusted test and questionnaire contents and also recruited new subjects in different countries. TIMSS (Trend of International Mathematics and Science Study) datasets have complex sampling designs (e.g., Gonzalez, & Smith, 1997; Gonzalez, & Miles, 2001); therefore, corresponding proper weighting procedures have to be engaged in any levels of statistical analyses to establish correct inferences.   For example, the TIMSS questionnaires were finished by more than 500,000 students and thousands of thousands of parents, teachers and principals.   Assisted by more than forty countries scattered around the world, the sample datasets were to infer trends of mathematics and science achievements in these international/gigantic populations.   Without proper weighting procedures, biased statistical analyses on the samples can lead misleading conclusions and/or inferences of populations.

Statistical literature (e.g., Lohr, 1999; Kish, 1965; Asparouhov, 2005) suggested that unequal probability of selection is an inevitable feature of complex sampling surveys, for example, as those in all TIMSS surveys.   In addition, it was proved (Asparouhov, 2005; Yang & Tsai, 2006) that if the unequal probability of selection is not

incorporated in the analysis, a substantial bias in the parameter estimates may arise. This bias is called as selection bias. However, if the probability of selection is known and incorporated in the analysis, the selection bias can be eliminated or reduced (Asparouhov, 2005; Yang & Tsai, 2006; Tsai, & Yang, 2007). Analyses performed for complex sampling procedures, therefore, have to incorporate with designated sampling weights to adjust selection biases.

The structural equation models to be used includes: categorical SEM: robust weighted least square, multigroups confirmatory factor analysis, multiple indicators multiple causes (MIMIC) models (Jaccard, Turrisi, & Wan, 1990; Bollen, 1995; Bollen, & Paxton, 1998; Moustaki, Jöreskog, & Mavridis, 2004; Huber, Ronchetti, & Victoria-Feser, 2004). Related SEM model evaluation techniques (Dudgeon, 2004; Marsh, Hau, & Wen, 2004; Spiegelhalter, Best, & Carlin, & van der Linde, 2002) will be used. In particular, because of the complex TIMSS sampling procedures, special weighting procedures need to be used in order to produce correct parameter estimates representing the population of a country (Martin, Mullis, & Kennedy, 2003). Moreover, structural equation models need additional weighting procedures (Muthén & Satorra, 1995) to perform correctly.

Because TIMSS were not longitudinally designed, subjects recruited for one surveyed year may not be recruited again for the next survey. Analyzing educational trends in the survey years from these non-longitudinal studies is an important yet difficult task. We developed a specific analysis procedure (Yang, Yang, & Yeh, 2005) to deal with the problems. The algorithms in Yang, Yang, and Yeh (2005) were proven theoretically correct and practically feasible.

Conclusion and Implications

Comparisons among Taiwan and Asian female participants in TIMSS studies will generate critical information for educational reforms. In particular, the curriculum and other educational revolutions currently carried out in Taiwan can learn much from these comparisons and reflections. Educational policies, achievements and environments can be benefited from the study. In addition, new thoughts and creativities will be generated for several research disciplines. Specifically, the study verifies cognitive models for mathematics learning and localizes cognitive models for mathematics learning for Taiwan. Identifications of cultural and gender differences of mathematics achievements and developments are achieved and discussed.

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