Maximizing Teacher Candidate Performances Based on Internal Program Measures: Program Design Considerations

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Abstract

Using Structural Equation Modeling vis-à-vis path analysis, the authors tested models to understand the strength of relationships related to national recommendations of professional organizations and standards. The models explain much of the variance in Praxis-II and edTPA performances, respectively, with high power and medium to large effect statistics. This report provides implications for secondary mathematics teacher preparation with respect to the recommendations/standards of the multiple professional organizations. Program design and mathematics teacher preparation at local, state, and national levels should be of interest to readers.

Introduction

A national collaborative effort has focused on the transformation of secondary mathematics teacher preparation—the Mathematics Teacher Education Partnership (MTE-Partnership). Over 40 secondary mathematics teacher preparation programs (TPPs) in the United States began work in 2012 to create a framework with two goals: (a) establish a national research and development agenda and (b) produce well-prepared first-year mathematics teachers. While large-scale reform efforts, such as the work of the MTE-Partnership, that aim to evaluate TPPs with the intent to improve mathematics teacher preparation, critiques can be made for such efforts being costly, laborious, and lacking insufficient modeling with respect to measurement (Tatto, 2018).

The researchers recognize external critiques and examinations will continue to influence mathematics teacher education. Teacher candidates (TCs) ought to be well-prepared with a strong sense of self-efficacy and extensive knowledge from internal program measures to be easily ready for professional exams such as Praxis-II and edTPA.

Study Purpose

The purpose of this study was to examine how one secondary mathematics TPP design in the United States, in alignment with several professional organization recommendations and standards publications (e.g., Conference Board of the Mathematical Sciences' *Mathematics Education of Teachers (MET) II*, MTE-Partnership *Guiding Principles*, Association of Mathematics Teacher Educators' *Standards for Preparing Teachers of Mathematics*) demonstrates TCs' knowledge, skills, and teaching ability readiness as measured by internal measures and relationship to Praxis-II (Education Testing Service [ETS], 2020) and edTPA (Stanford Center for Assessment, Learning and Equity [SCALE], 2020) scores. The Conference Board of the Mathematical Sciences' (CBMS; 2012) MET II states: "Whatever the length of the program, the recommendations described here, particularly the 9-semester-hours of coursework designed for prospective teachers, are ambitious and will take

years to achieve. They are, however, what is needed" (p. 55). Furthermore, the standards of the Association of Mathematics Teacher Educators (AMTE; 2017) states: "Effective programs preparing teachers of mathematics at the high school level provide candidates multiple opportunities to learn to teach mathematics effectively through the equivalent of three mathematics-specific methods courses" (p. 141). Both professional organizations acknowledge that most TPPs do not offer the recommended coursework and experiences to meet these recommendations, demonstrating the need for comprehensive reviews of program design efforts in correspondence with the targeted goals for the preparation of mathematics teachers.

The authors developed a framework for constructing Structural Equation Models, vis-à-vis path analyses, to examine the relationship of multiple mathematics content and sequenced methods courses for TCs, as well as various internal measures used as part of our program's voluntary participation in the CAEP NCTM SPA review. Tatto (2018) stated:

> Recent reviews of [mathematics] teacher education reveal the need for more systematic exploration of programs and their intended outcomes, and for rigorous research directed at producing system-level evidence of program effects. Indeed, national-, state-, or even program-level evaluations of teacher education program [design] effects are rare. When they have been undertaken, evaluations have not shed much light on the acquisition of knowledge needed for teaching because they have not measured future teachers' knowledge outcomes and have, for the most part, relied on responses to satisfaction surveys. (p. 410)

While Tatto's chapter utilized the international comparison data from the Teacher Education and Development Study in Mathematics (TEDS-M), Tatto suggested that program alignment with accreditation demands are much more likely to generate graduates who are highly knowledgeable and well-prepared beginning mathematics teachers. This work directly addresses Tatto's (2018) call. That is, these authors aimed to provide empirical evidence that examines program relationships to performance assessments (i.e., licensure exams). Appendix A presents a cross-sectional analysis of the aforementioned national documents in relation to the research brief, while Figure 1 presents the program design sequence and related internal program measures.

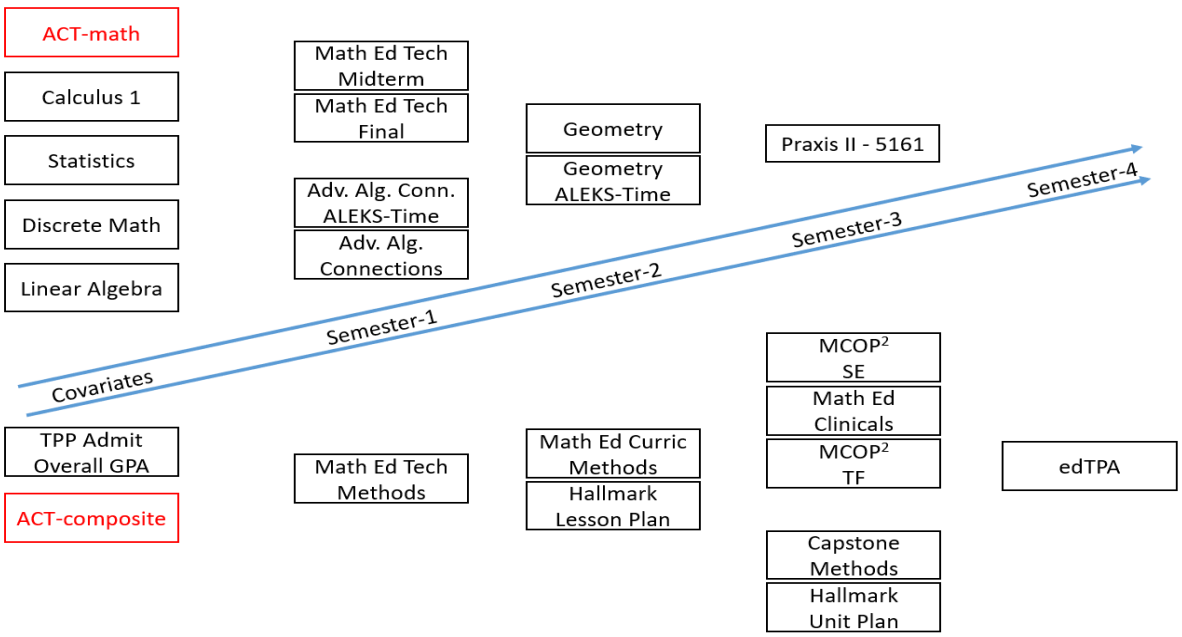

Figure 1. Sequential Program Design, Covariate Measures, and Common Measures.

Results

The path model explains 74.1% of the variance of Praxis-II exams and 49.2% of the variance in edTPA scores. For purposes of this research brief, we elaborate only the results of the full study in comparison to the work of the MTE-Partnership and national recommendations for secondary mathematics teacher preparation.

Discussions

Questions about National Recommendations

The CBMS MET II (2012) recommends mathematically, in addition to the 9 specialized credit hours in the long-sequence mathematics major, advanced calculus (analysis), introduction to proofs, abstract algebra, geometry or mathematical modeling, computer programming, two statistics courses, linear algebra, and a three-course calculus sequence. Findings from this report's analyses indicate that the *Specialized Content Knowledge* focus in the Advanced Algebraic Connections course to examine rings, groups, fields, and polynomials in relation to the high school curriculum and from a historical developmental approach could alleviate the need for abstract algebra, even analysis to some extent, as well as history of mathematics. Thus, the authors question whether the CBMS MET II long-sequence is well-beyond aspirational and beyond what is needed. Perhaps there should be a serious consideration of compromise between the long-sequence and short-sequence in how to integrate the pure mathematical major study within advanced perspective courses focused on *Specialized Content Knowledge* and *Horizon Content Knowledge* for teaching mathematics.

The AMTE Standards (2017) lack a direct focus on the developmental and pedagogical trajectory of TCs. That is, the sequencing of multiple methods courses likely has a greater impact than a single semester with multiple methods courses before student teaching—at least this study's findings suggest greater direct and indirect effects in relationship to higher edTPA performances.

A Validity Argument for Program Design

Considering the recommendations from multiple professional documents discussed herein, this report's path models and strength of the relationships of measures provide a strong case for beginning a validity argument for the program design presented. Bostic et al. (2019) and Krupa et al. (2019) presented summary chapters for validity of mathematics assessments of mathematical knowledge and frameworks for new directions in mathematics education predicated on the *Standards for Educational and Psychological Measurement in Education* (AERA, APA, & NCME, 2014). The authors define the path models as quantifiable tests for considering the validity of program design in relation to the recommended program experiences previously discussed in four nationally recognized publications. This report's analyses and models provide multiple sources of validity evidence. The validity argument on these works, as well as Kane (2001), is based upon considering the program model/design, the coursework, and the key assessment measures collectively within the path analyses of this study. Those four validity sources include (a) relationships between program measures and external measures, (b) evidence of consequences of TCs completing program experiences, (c) evidence of TCs' response processes on internal measures, and (d) validity evidence of program measures' test content.

Conclusion

Within the MTE-Partnership's Guiding Principles are high demands that differentiate the differences between a *well-prepared* beginning mathematics teacher and one who is *just-barely qualified.* Similarly, the AMTE Standards (2017) provide strong recommendations for developing *well-prepared* mathematics teachers in which we can endorse the recommendation of three methods courses, as well as that of advanced perspective

mathematics courses (vis-à-vis the CBMS MET II). However, the authors acknowledge that no TPPs, state departments of education, or accreditation bodies in the U.S. of which we are aware currently require TPPs to consider the MTEP Guiding Principles, AMTE Standards (2017), and/or CBMS MET II recommendations, although some states require CAEP NCTM SPA accreditation. The hope is that this research brief can aid other TPPs in leveraging transformational change.

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Appendix A.

Cross-Sectional Analysis of Recommendation and Standards Documents

	Mathematics Content	Mathematics Methods	Other Related to Study

CBMS MET II (2012)	A major in mathematics with at least:
	• Three-course calculus sequence
	• Intro to statistics
	• Intro linear algebra
	• **9 semester-hours focused on high school math from advanced standpoint**
	• 9 additional semester-hours
	  o Introduction to Proof
	  o Abstract Algebra
	  o Additional course
		High School Preparation
		• **Math methods courses (plural)**
		Middle School Preparation
		• **Two math methods courses**
		
		Preparation programs focused on both high school and middle school would need at least three given the plurality of both high school and middle school recommendations.
			• Engage in **Standards for Mathematical Practice** within coursework as learners
			• **Use technology and tools strategically** during preparation
			• Experiences with reasoning and proof
			• Modeling rich real-world problems
			• Historical development of math

CAEP NCTM SPA (2012)	Standard 1: **TCs have knowledge of** major math concepts, algorithms, procedures, applications in varied contexts, and connections within and among mathematical domains of Number, Algebra, Geometry, Trigonometry, Statistics, Probability, Calculus, Discrete Mathematics Standard 2: **TCs** solve problems, represent mathematical ideas, reason, prove, use mathematical models, attend to precision, identify elements of structure, generalize…	Standard 3: TCs apply **knowledge of curriculum standards for mathematics** and their relationship to student learning within and across mathematical domains. **They incorporate research-based mathematical experiences and include multiple instructional strategies and mathematics-specific technological tools**… Standard 4: TCs exhibit knowledge of adolescent learning, development, and behavior. They use this knowledge to plan and create sequential learning opportunities grounded in mathematics education research where students are actively engaged in the mathematics…	Standard 5: TCs provide evidence demonstrating that as a result of their instruction, secondary students' conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and application of major mathematics concepts in varied contexts… Standard 6: **TCs Engage in continuous and collaborative learning that draws upon research in mathematics education** to inform practice…(6b) Standard 7: **TCs engage in a planned sequence** of field experiences and clinical practice under the supervision of experienced and highly qualified mathematics teachers…
MTEP GPs (2014)	In reference to the **CBMS MET II:** Mathematical habit of mind, knowledge of the discipline, specialized knowledge of mathematics for teaching, and the nature of mathematics.	TCs can design instruction, use instructional methods and strategies, assess and reflect, use technology well, attend to diverse student populations, and **engage in embedded early and sequential intense** clinical experiences with expert supervision.	**Commitments by institutions** of higher education with shared responsibility across the administration, faculty, and partner schools, as well as supporting **partnerships with disciplinary [mathematics] faculty** and [K-12] schools… Institutional focus exists and faculty are supported and rewarded for leadership in preparation programs…
AMTE SPTM (2017)	**High School:** Math major equivalency, including statistics, with **at least three content courses** relevant to teaching high school mathematics incorporating sufficient attention to a data-driven, simulation-based modeling approach to stats. **Middle School:** Alignment to the **CBMS MET II** (2012) and Statistical Education of Teachers (2015)	High School Preparation • **Three mathematics-specific methods courses** Middle School Preparation • **Coursework** focused specifically on teaching middle level mathematics…	**Clinical experiences in both high school and middle schools** in which TCs have support to develop teaching practices that support learning of conceptual knowledge and engagement by students in mathematical practices.