Programmatic Effects of Capstone Math Content and Math Methods Courses on Teacher Licensure Exams

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Abstract

This chapter reports on how well coursework, design, and implementation of our secondary mathematics programmatic changes have influenced teacher candidate performances on teacher licensure exams (Praxis II, edTPA: educative teaching portfolio assessment). Our goal is to provide empirical evidence for the Mathematics Teacher Education Partnership (MTE-Partnership) to leverage institutional change where institutional commitment to programmatic investments of coursework and faculty load may be difficult. The data used for analysis consists of all program completers in the last four graduating cohorts (2014–2017) and their associated data collected as part of our Council for the Accreditation of Educator Preparation (CAEP) National Council of Teachers of Mathematics (NCTM) Specialize Professional Association (SPA) accreditation review. Our findings highly suggest that well-designed, rigorous capstone mathematics courses and sequenced mathematics methods courses focusing on developmental trajectories for instruction have a large effect size on licensure exams. This research intersects the work of the Research Action Clusters; MODULE(S^2) and Clinical Experiences, as well as the Program Transformation working group.

Keywords: Praxis II Exam, edTPA, capstone math courses, math methods courses, clinical experiences

Introduction

In the past 10 years, the critical shortage of certified middle and high school mathematics teachers has grown more critical (U.S. Department of Education, 2016). One factor associated with this increase in the critical shortage has been the high-stakes testing environment derived since No Child Left Behind (NCLB) in the early 2000s. While K–12 schools have been heavily influenced by NCLB testing requirements, high-stakes testing has moved rapidly into teacher preparation programs as a result of the NCLB requirement of producing *highly qualified* teachers. State departments of education were quick to adopt specific testing measures external to universities and colleges to warrant the highly qualified status.

Since early 2012, the Association of Public Land-grant University's (APLU) MTE-Partnership has been using a Networked Improvement Community (NIC) model to develop a framework of guiding principles for preparing teachers of mathematics. In 2013, a set of Research Action Clusters (RACs) were organized to carry forward research projects designed to solve particular problems in secondary mathematics teacher preparation. The use of the NIC model (Bryk, Gomez, & Grunow, 2011) has a very specific purpose for the MTE-Partnership. That is, the RACs focus on solving problems by joining academic research, clinical practice, and faculty expertise to create a profound shift in knowledge for both researchers and practitioners that finds solutions to distinguish best paths (plural assumption) for developing well-prepared, highly knowledgeable beginning teachers of mathematics.

Problem and Purpose of Study

Given the increasing shortage of certified mathematics teachers and high stakes licensure exams for teacher candidates (TCs) in higher education programs, mathematics teacher preparation programs need to know if investments in new or modified courses, additional faculty, and hours of observation are investments that will pay off with TCs well-prepared to pass high stakes licensure examinations. That is, these examinations should essentially be formalities without reducing the number of well-prepared mathematics teachers that higher education institutions develop. Keeping attrition low in programs is a goal, but not at the expense of watering down the preparation to *teaching to the test*. Rather, we focus more on the development of positive beliefs and dispositions, mathematical knowledge for teaching, and pedagogical skills that provide foundational learned knowledge to succeed on licensure exams without a test-prep mentality.

Our purpose is to provide the outcomes of a near-fully transformed programmatic design that aligns to the Conference Board of the Mathematical Sciences (CBMS) and the Association of Mathematics Teacher Educators (AMTE) recommendations while keeping the MTE-Partnership Guiding Principles as foundational to all programmatic changes. By providing our programmatic outcomes on licensure exams as they related to two capstone mathematics courses and a sequence of three mathematics methods course semesters with clinical experiences, we provide programmatic effects on these licensure exams.

Conceptual Design of Program

The design of our program consists of a two-year cohorted model in upper division courses. Prior to the start of their junior year, TCs must have completed the calculus sequence, an introductory business statistics course, an intro to education 1-hour seminar, and discrete mathematics where proof techniques are learned. Linear algebra is a co-requisite with the first capstone *advanced perspective* course though prior experience and data shows higher levels of success if linear algebra is finished before the first capstone course. We define capstone mathematics courses as those that examine the secondary (Grades 6–12) mathematics from an advanced perspective.

Mathematics Capstone Courses

During the penultimate year in the program, the TCs enroll in a two-semester sequence of mathematics courses designed around the recommendations of *The Mathematical Education of Teachers I and II* reports (CBMS, 2001, 2012). These courses focus on connections across different branches of mathematics, grade-level standards, and expectations. The first semester primarily focuses on polynomial and rational functions and their connections to integers and rational numbers, rings and integral domains, short-term and long-term graphical behavior of functions, and unique prime factorizations. The second course centers on studying geometric transformations through synthetic geometry, functions of the complex plane, linear algebra and vectors, and multivariable functions with two-independent and two-dependent variables. The course additionally explores group theory through the study of the group of transformations, families of functions via connections with transformations of the plane, and calculus optimization problems focusing on geometric properties.

The classroom culture in these capstone courses involves a mixture of student exploration, whole-class and small-group discussions, proof of mathematical theorems, applications of mathematical ideas, and some lectures. Appropriate uses of technology such as graphing calculators, GeoGebra, and spreadsheets are used throughout the courses for exploration, modeling, and mathematical justification.

Embedded within these two mathematics capstone courses, TCs complete web-based learning modules from Assessment and LEarning in Knowledge Spaces (ALEKS). This tool allows TCs to practice procedural skills and to review or learn the secondary content standards while honing their conceptual understanding within the capstone courses. The assessments for the web-based learning module reflect the content standards for secondary mathematics students. TCs are required to master 95% of the content to pass the course. They spend on average 30 hours mastering the required content for the first capstone course and 17 hours for the second capstone course.

Author #2 had the unique opportunity of participating in the capstone sequence as a graduate student. In his observation, ALEKS reinforces mathematical skills for TCs and fills their knowledge gaps from the 6–12 curriculum. This is necessary for preparing TCs not only to succeed on the teacher licensure exam but also to relearn necessary skills for teaching 6–12 mathematics.

Mathematics Methods Courses

Over the course of three semesters before the full-time student teaching semester, TCs complete five courses specific to their preparation for the student teaching internship. In semester one, a STEM-focused introduction to secondary education integrates math and science TCs to explore issues of equity, diversity, collaboration, and professional practice. Alongside this course in semester one, TCs complete a math methods course focused specifically on the use of different technologies for enhancing mathematics teaching and learning. By the end of semester one, basic lesson planning ability is assessed.

In semester two, a second math methods course focuses specifically on the 6–12 curriculum standards and resources and mathematical tasks embedded in lesson planning. A final hallmark lesson plan is submitted at the conclusion of the semester. We use an advanced rubric for this hallmark lesson plan as one of the major assessments for our NCTM SPA review.

In semester three, two specific courses are completed in addition to generalist coursework. First, a math methods course focuses on unit planning (8-10 days of instruction) and includes an assessment of the unit plan using a rigorous rubric that is one of the NCTM SPA assessments. Next, a clinical experience course focuses on the reflective nature to improve based on the evaluation of lessons implemented in the schools. This course includes: (1) a two-week seminar to start the semester that includes the MTE-Partnership Clinical Experience Methods sub-RAC Mathematical Practices Module, (2) three formal observations of teaching in the schools with the Mathematics Classroom Observation Protocol for Practices (MCOP^2; Gleason, Livers, & Zelkowski, 2017), (3) scored lesson plans based on the enactment and questioning, and (4) attending the state Alabama Council of Teachers of Mathematics annual fall forum. The standards set forth on the hallmark lesson plan rubric, unit plan rubric, MCOP^2, and final course grades determine if the standards have been met to move into the internship. We encourage readers to refer to the MTE-Partnership proceedings paper for our scoring criteria with the MCOP^2 (Zelkowski & Gleason, 2016).

Methodology

We examined the full cohorts to have completed the restructured, transformed sequencing of coursework in preparation for the student teaching internship. Because our programmatic changes were implemented in 2012, we analyzed the cohorts who graduated in 2014 through 2017 resulting in a total of N=52 TCs who all completed the same assignments and coursework and were scored on all our NCTM SPA rubrics and the MCOP^2. Also of note, the 2014 cohort was the first to be required to pass the new Praxis II exam #5161, as well as complete our programs' predecessor to edTPA, the Teacher Work Sample (TWS). In cases where any TCs used a grandfathered score on the Praxis II #5061 or #0061 due to summer testing after the capstone sequence (August 1, 2013, was the state's cut off date for the 2014 graduating cohort), we used the national scoring results to convert linearly to the new exam. We used the quartile published points from 2012-13 on the old test and 2013-14 on the new test to determine a linear model for conversion. Ten rubrics were used in the TWS as opposed to the 15 of edTPA. A simple linear conversion with a scale of 1.5 was used for the conversion from TWS to edTPA. We also used TCs from the 2016 and 2017 cohorts who elected to complete edTPA as a pilot group before edTPA was required in lieu of TWS. These scores validated our linear conversion model and verified the conversion had a high correlation (>.90).

We constructed two models for analyses using multiple regression. In the first model, we considered all final grades in mathematics courses in the mathematics major with adjustments to transferred course grades based on known historical grades earned in the next course (e.g. one grade less in calculus transferred from community colleges). We did not adjust for AP scores since we only had Pass records (not whether TCs earned a score of 3, 4, or 5). We included ALEKS assessments (NCTM SPA assessment) used in both capstone mathematics courses (pre-test, post-test, time spent in ALEKS), as well as a technology content knowledge midterm and final exam in the technology math methods course (assessments of math ability standards). We further considered other overall measures such as the teaching field grade-point average (GPA) and overall GPA earned at UA. We did not consider all credits earned as history has shown transferred coursework from community colleges inflates GPAs, hence the adjustments made. All these measures constituted considerations of our independent variables. Praxis II #5161 was our dependent variable (includes converted #5061, #1061 scores) in the first model. In the second model, we considered all final grades in the five mathematics education courses, the hallmark and unit plan assignment rubrics (NCTM SPA assessments), $MCOP^2$ factor scores and total score averages on the three observations, the total number of clinical hours before internship, and overall GPA. The edTPA was our dependent variable (includes converted TWS scores).

Results

Our regression models are reported in Tables 1 and 2 using the stepwise procedure to report the most significant to least significant independent variables. We discuss the results following the respective tables.

Table 1

Summary of Multiple Regression Analysis for Significant Variables on Praxis II (N=52)

	Praxis II Test Score Model				
Variable	*B*	*SE B*	*β*	*t*	Sig.
(Constant)	111.386	15.856		7.025	0.000
Capstone 1 – Adv. Alg. Connections.	7.868	2.185	0.369	3.600	0.001
ALEKS Capstone 2 Time (hours)	-0.621	0.180	-0.335	-3.453	0.001
Capstone 2 - Geometry	4.460	1.799	0.234	2.480	0.017
Tech Content Knowledge Midterm	0.354	0.172	0.180	2.056	0.046

Note: The adjusted R^2=0.683 with a Praxis II mean score of 167.32. Means of the independent variables listed respectively were 3.034, 17.335, 3.067, and 82.356. VIF of all independent variables < 1.63. Durbin-Watson=2.180. Regression assumptions met.

First, we recognize the significant constant in the model. Praxis II is scored on a 100-200 score and the constant indicates an expected score of about 111 prior to the experiences during the junior year in the two capstone mathematics courses and the first mathematics methods course on technology. Prior ability and coursework such as the calculus sequence completed in the freshman and sophomore years explains the significance of the constant. We would expect 100% of our TCs to fail the Praxis #5161 exam without the junior year experience. Second, we see that for every letter grade (e.g., 3.33=B+, 1.67=C-) on a four-point scale with +/-

considered, the first capstone course grade adds nearly 8 points to the Praxis score and about 4.5 points for the second capstone course. Third, we see that if TCs spend an above average time (>17 hours) working on ALEKS in the second capstone course, they generally would lower their Praxis II score. This means, if it takes 30, 40, or more hours to reach proficiency on basic skills and knowledge on high school geometry and trigonometry, they are very likely to have a lower Praxis score (e.g., 40 hours means losing nearly 25 points on Praxis). Lastly, we see that the midterm technology content exam score (0-100) contributes significantly. Scores range from mid-50s to upper-90s generally, with most TCs scoring in the 75-93 range. A difference of 20 points from the mean indicates about 7 points on the Praxis II.

Overall, we interpret these data to imply a heavy and large effect on Praxis II scores based on the junior year capstone courses, ALEKS, and the content heavy first math methods course on technology. The regression model explains nearly 70% of the Praxis variance in scores. Using the population means, we see a positive contribution of nearly 24 points from the first capstone course, nearly 14 points from the second capstone course, and nearly 30 points from the midterm in the math methods tech course. Lastly, the average time to reach geometry/trig proficiency in ALEKS deducts nearly 11 points.

Table 2

Summary of Multiple Regression Analysis for Significant Variables on edTPA (N=50^)

	edTPA Total Score Model				
Variable	*B*	*SE B*	*β*	*t*	Sig.
(Constant)	6.383	4.513		1.414	0.164
Unit Plan SPA Rubric 3C	1.813	0.615	0.313	2.949	0.005
Hallmark Lesson Plan SPA Rubric 2B	1.741	0.515	0.339	3.383	0.001
Clinical Experience Course	2.783	1.008	0.283	2.762	0.008
Hallmark Lesson Plan SPA Rubric 3C	1.027	0.451	0.216	2.279	0.027

Note: The adjusted R^2=0.603 with an edTPA mean score of 42.34. Means of the independent variables listed respectively were 3.59, 7.06, 3.56, and 7.06. VIF of all independent variables < 1.39. Durbin-Watson=2.347. Regression assumptions met. Two unit plan scores were missing from one cohort, we attribute this to a Livetext error in saving rubric scores rather than reassessing at a much later time from the original scoring.

First, we recognize a non-significant constant, indicating we would expect the edTPA score to be no different from zero without any of the junior/senior year coursework in mathematics education. Given the experiences in mathematics education, the constant then plays a role. The edTPA scores can range from 15 to 75 with 37 being the minimum most states are currently using with a high bar of 42 as cut score for consideration (edTPA, 2017). Most notable, is the closeness of the standardized independent variable coefficients, indicating a relatively equal effect size on the edTPA score. Specifically, three indicators from the unit plan and hallmark lesson plan rubrics used for NCTM SPA accreditation (two major final exam-like assignments) carry about 3/4 of the contribution to edTPA scores (http://bit.ly/MTEP-Paper-Rubric). The remainder of the edTPA score comes from the clinical experiences course in which the $MCOP^2$ observation scores are worth 40% of the grade and another 25% for the accompanying lesson plans for the observed lessons (most of the course grade variance). The remaining 35% comes from professional experiences, an evaluation from the cooperating teacher and attending the state mathematics conference.

Overall, we see 60% of the variance explained in edTPA outcomes by semester two and three math methods course final assessments (NCTM SPA assessments), as well as the overall professional experiences discussed within the clinical experience course. We see positive contributions to edTPA scores from semester two's hallmark lesson plan of 19.5 points, an additional 6.5 points from semester three's unit plan, and nearly 10 points from the clinical experiences course. Overall, without considering the constant, these experiences total 36 points just at the minimum for passing. The constant brings this total to the mean 42+ near the high bar recommendation by edTPA.

Summary and Limitations

Strengthening these results, TCs were scored on the hallmark lesson plan rubric by two different faculty. About three-fourths of the clinical grading was done by one faculty member, while that faculty member scored about one-fourth of the unit plans. The second faculty member scored the remainder of each for the entire set of graduates. Two different faculty scored these significant assessments at different times without interrater discussion sessions. This demonstrated the robustness of these assessments across different raters. Largely, we interpret our findings that capstone mathematics courses taught with (1) rigorous assessments that differentiate grades, (2) an ALEKS supplement for improving basic knowledge and skills of the 6–12 curriculum, and (3) advanced perspective of secondary math content strongly contributes to Praxis II scores. Sequentially taught, math methods courses taking TCs from introductory lesson planning, to strong lesson planning, to unit planning results in a strong contribution to edTPA outcomes, as well as a slight impact on Praxis II scores when methods focus on strong uses of technology in teaching and learning mathematics (midterm exam).

We do acknowledge the limitations thus far with plans for advanced analyses upcoming. Converting Praxis II scores in cohort 1, as well as TWS to edTPA scores in cohorts 1, 2, and some of 3 and 4, provides a limitation. Given the strength of the models, we find this limitation less worrisome, but we do recognize the constraints.

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