

TNE Year End Report

Objective O2B.1: MKT in Math Courses Report

What was proposed? The mathematical preparation of K-5 teachers

We proposed to establish a program for teaching math content courses to teachers which incorporates PCK, or more specifically, Mathematical Knowledge for Teaching (MKT). Our program included

- Continuing study of teaching practices that embody MKT.
- Presenting our classes in ways that support and cohere with MKT. In particular we emphasize conceptual understanding, developing a large repertoire of representations and continually clarifying connections, student explanation and demanding problems. These features are repeated in our work and also the work of or colleagues in education.
- Developing persuasive evidence that we are helping our students to be more successful teachers. We have administered pre and post tests of students in selected sections of the math content courses for K-5 teacher candidates. High performance on this instrument has been statistically linked to success in guiding pupils to higher gains on a national achievement test.
- Coordinating our efforts and data with the work of the field experience committee to track the long term success of our students in the Mathematical methods course, then their student teaching experience and ultimately, and finally in their careers as teachers when we can measure their success in promoting pupil learning.

What was accomplished?

A.

Deborah Ball, Hyman Bass and her colleagues Mark Hoover Thames and Laurie Sleep visited CSUN for 2 days in February. They gave a public lecture to 200 students faculty and teachers from LAUSD, ran a workshop for about 35 participants (CSUN and LAUSD teachers) and met with “TNE” individuals who are working on the field experience in mathematics, the TNE science group, and a group of administrators including the chair of the math department in order to promote future projects (the chair of the Math department has since signed a letter of intent to work to seek funding for a project to develop CSUN as an center for the assessment of approaches to preparing mathematics K-5 mathematics teaching.) All of the discussions led to refined focus and clarified sense of method and purpose for the various groups. In June 2007 several of our colleagues attended the Math Science Research Institute workshop at UC Berkeley on Critical Issues in Mathematical Education

B.

The mathematics study group met 10 times during the semester to study teaching practices. We structured our analyses using an established protocol to view videotapes of several of our members teaching and to judge whether we are providing a specific and well defined treatment in our teaching.

We used the Video Observation Protocol developed by Deborah Ball and her colleagues. The two parts of the protocol we concentrated on address teacher knowledge of mathematics as evidenced in the classroom and teacher interactions with students. We were particularly involved in examination of procedures, justifications & explanations and also advancement of the mathematical work of the lecture.

In order to confidently assert that we are consistently using MKT in our classes we measured the portion of time that each instructor spends on student explanation. We assume that this one particular trait is an acceptable marker for several ways in which we might "use MKT". Also, this involves judgment of what constitutes acceptable explanation and when "to start the clock". With these caveats, we have been able to achieve preliminary consistent, positive results from different observers in our work. We expect to continue this work over the next month.

C.

In order to produce persuasive evidence that our preparation results produces candidates who are successful teachers, we administered pre and post tests of Ball & Hill's survey of MKT to several sections of Math 210 and 310. This instrument has been very carefully developed so that it is reliable and valid. It has been scaled against a large group of in-service teachers and high scores on this test have been *positively correlated with teachers' ability to lead their pupils to positive gains on a standardized achievement test*. This correlation gives us a basis for believing we are preparing our candidates to be successful. Ultimately we aim to directly measure scores of pupils of our candidates when they have become classroom teachers, but the students we have tested are not yet in the classroom and so we rely on this indirect measure.

We have scores for selected sections from Fall 05 to spring of 07 and are presently completing our analysis of fall 06 and spring 07 and revisiting earlier semesters to conduct more thorough analyses. Initially we reported the average pre, post and gains scores for each year. Now we will produce a scatter plot of pre and post test scores and box whisker plot of the gains. We also will be examining performance on particular questions to see if there are significant patterns that may relate to our courses. The results are reported in terms of standard deviations from the mean of the in service teachers that was used for comparison.

In Math 310 on the test of content knowledge in geometry, there were gains of 0.66 in Spring 05, 0.60 in fall 05 and 0.77 in spring 06. and in each case the post test means were positive, which indicates that our students did better than experienced teachers. We suspect that recent learning is rewarded since geometry is not as directly addressed as arithmetic.

In Math 210 on the test of content knowledge in numbers and operations, there were gains of 0.49 in Spring 05, 0.44 in fall 05 and 0.37 in spring 06. The post test means were still below those of experienced teachers which is what we expected. As an example of the strength of these results, for fall 05 scores, $n = 42$, and about 75% of the students had positive gains (post test minus pre test) and for a one-sample t-test that the gain is different from 0 is statistically significant, $p = 0.0044$. There are two other domains measured: KSC (Knowledge of Students and Content) and PFA (Patterns, Functions and Algebra) which address areas that are not covered in our courses and, not surprisingly, our students had no consistent gains nor strong post test results in these areas.

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The interventions in content courses that we are doing are evidently valuable but we also recognize that this is just one part of a long and complex pathway to becoming a teacher and is one of many possible influences in a complex experience. While we remain cautious about the extent to which the effect of a change in a course that a student takes several years before entering the classroom, this is still a point of intervention that deserves careful attention. In particular, it is universally agreed that understanding of content is a significant piece of what our teacher candidates need. The question of “which content” is widely debated and explored. Consequently we are working to connect what is learned in our courses to later stages of the candidates’ experiences. In particular, we believe quite strongly that our candidates need to have a solid understanding of the mathematical content which will be needed in teaching and that our courses need to be connected to what they will be doing in the classroom.

Accordingly we are coordinating with our colleagues in Elementary education to continue and coordinate our work on MKT in their courses. They are using the MKT surveys in the Mathematical Methods course and student teaching and coordinating the results with our earlier results for students. They will be able to survey all of their students and so we can compare the students we surveyed with other students who will form a comparison group. We can also see if our students are being adequately prepared to teach the lessons they will be required to teach and if they can embody and carry out the principles of MKT which we have emphasized in both content courses and the math methods course taught in the college of education. We will be matching candidate performance in the classroom with their scores on the MKT survey and the topics that have been covered in our content courses. Thanks to our working together, the assessment instruments closely match our interpretation of MKT and our education colleagues are helping student teachers, university supervisors and supervising teachers to use evaluation forms and planning forms that embody and promote the notions of MKT which we support. This will be a significant change from a previously less coherent program.

Who was involved and what was the nature of their involvement?

Math Study Group (video analysis, hosting Ball & Bass visit, discussions of practice and administration and analysis of MKT surveys & coordinating with colleagues in the college of education):

Rita Basta , Michelle Erickson , Jerrold Gold, Pam Mason (Teacher in Residence), Grace Mendez and Joel Zeitlin (all in mathematics)

&

Collaboration between Mathematics & Education (hosting Ball & Bass visit + coordinating longitudinal investigations & creation of instruments):

Hillary Hertzog, Nancy O'Rode, Maria Czech, David Kretschmer, (all in the department of Elementary Education).

What challenges did you face?

1. Understanding what constitutes evidence and finding means to provide evidence in a persuasive way. While several of us have experience with statistics in the classroom we are novices in the realm of designing "experiments" that will provide useable evidence in the complicated realm of the classroom. We were extremely fortunate in developing a relationship with Deborah Ball, Hyman Bass, Mark Hoover Thames, Heather Hill and Laurie Sleep who helped us to discover and use instruments that serve this purpose. We should also thank PMET (a project of the Math Association of America) which gave us a grant and held a conference that introduced us to the world of mathematics education.
2. Reaching out to all of the math department has proved difficult. Several of the members of the department have been vigorous participants in the "math wars" and have been resistant if not hostile to our efforts. Nevertheless we believe we have influenced most if not all of the math department. Even the most critical of our colleagues support many of the things we have supported (such as the need for conceptual understanding in our classes) and while there are still many points where we differ we see encouraging signs of common ground (such as agreeing on a common final and the sample questions that should be offered).
3. Bringing change to old dogs. Many of us endorse change and think that we are making significant changes. I am cautious about this in the light of several carefully administered studies--see the recent JRME article by Hiebert & his colleagues which concludes that the recommendations of NCTM of 10 years ago have led to essentially no change in the classroom. How do we insure that we are changing what we are doing in significant ways?
4. It has been difficult to lead individuals in other disciplines (outside of the work of mathematics and education) to develop meaningful programs. Often there is little agreement in a discipline over what constitutes the discipline and hence what should be taught in K-12 or in particular courses in the university. Discussions sometimes were mired in epistemology ("we should be teaching our future teachers to embody whatever it is that constitutes the essential aspects of this kind of knowledge") and not addressing existing realities (such as the standards). This is further complicated by the absence of useful instruments for measuring any particular version of successful teaching characteristics. As I indicate above mathematics has been fortunate to be more susceptible to quantification and to have some instruments in place for measuring MKT. I am still hopeful that the efforts of all the TNE workers have changed the expectations and understandings of those involved and that we are seeing evolution towards PCK and evidence in our community.
5. Change takes time. We thought that 5 years was a long time and we would really get a lot done. Who knew?

What did you learn?

- Evidence is hard to produce but can be produced.
- Change is hard but can come with persistent, detailed, cooperative effort. Effecting change and finding evidence will take more than 5 years and that is realistic.

What changes will be made as a result of this work?

- The pathway to the classroom thru mathematical content and math methods and the field experience for multi subject teachers is becoming more coherent and focused on PCK. This includes a joint focus on conceptual understanding and procedural fluency, practice in mathematical explanation, use of many representations with an awareness of fit for different students, making connections with different representations and also using demanding problems and not robbing them of their cognitive demand. This change will be increasingly guided and supported by evidence.
- The model for evidence will prosper at CSUN, including, we hope, establishment of a program in the math department (and supported by a national panel of experts in education and mathematics) to assess what works in teacher preparation.

The preparation of K-5 teachers will be more connected to mathematical content. Continued coordination between the math department, the department of education and the coordinators of student teaching will be more purposeful, tracking student progress (or lack of it), assessing this through reliable instruments and matching results to possible changes in the program

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Objective O2B.1: Math MKT Longitudinal Study of Multiple Subject Candidates

What was proposed?

Continue a longitudinal study of teacher candidates who have been measured on their growing knowledge of subject specific pedagogy across subject matter and methods courses. The question to be answered is: Does increased focus on subject-specific pedagogy in courses improve teacher candidates' success in teaching?

What was accomplished?

The research populations studied during the 06-07 academic year were ITEP teacher candidates for whom we had scores on the CKTM from Math 310, EED 472 and the end of student teaching.

The study involved 72 pre-service teachers. The four-year undergraduate "experimental" cohort (N = 25) began the program as incoming freshmen, completed two math subject matter courses specifically designed to emphasize "mathematical knowledge for teaching" for future elementary teachers, a math methods course, and then two student teaching experiences of eight and nine weeks, respectively. One student teaching experience took place in a K-2 urban public school and the other took place in a grade 3-5 urban public school. Approximately 50% of courses in the program are taken as a "cohort". The two-year undergraduate "experimental" group and the two year undergraduate "control" group began the program as juniors. Some of the pre-service teachers were native students at the university; others were community college transfer students. The two year pre-service teachers also took two math courses designed for future teachers and the same math methods and student teaching sequences.

The "experimental" groups received differentiated experiences during the program. They worked with mathematics instructors who changed their curriculum and instruction to emphasize aspects of mathematical knowledge for teaching. That population was then tracked into student teaching where they were introduced to support materials designed to focus on four essential components of mathematics teaching, as described in the effective mathematics instruction research base during a student teaching seminar. Those pre-service teachers then worked with university supervisors who used the support materials during the lesson observation/feedback cycle.

The control group experienced the "traditional" sequence of math methods and student teaching in the program. They participated in student teaching seminars that did not include the new support materials and their university supervisors implemented a lesson observation/feedback cycle that used "traditional" methods for evaluating and reflecting on lessons.

Geometry Knowledge of Content was measured at the end of Math 310 and again at the end of second semester student teaching. The results are described in Table 1.

Table 1: *Means (z-scores) of CKT-M Geometry Measures for Three Groups of Pre-Service Teachers*

CKT-M Geometry Measures	4-Year Undergraduate Cohort <i>n</i> = 25	2-Year Undergraduate Cohort <i>n</i> = 17	2-Year Undergraduate Control Group <i>n</i> = 33
Geometry Class Pretest	- 0.17	- 0.45	---
Geometry Class Posttest	0.85	0.10	---
Student Teaching Posttest	0.58	- 0.20	- 0.41

Table 1 presents the mean scores of three groups of pre-service teachers on the Content Knowledge for Teaching Mathematics (CKT-M) Geometry Measures (Ball, Bass, & Hill, 2003) as the students progressed through a geometry content class taught by the mathematics department and then through the second student teaching assignment.

Geometry courses that did not emphasize pedagogical content knowledge also did not administer the pre/post tests, which accounts for the lack of pre/post test information for the control group. For both the 4-Year cohort and the 2-Year cohort, the data reflect a gain in geometry content knowledge at the end of the semester geometry course followed by a slight decline in Geometry content knowledge two or more semesters after finishing the course. The overall gain score for the 4-Year Undergraduate cohort was three-quarters of one standard deviation ($z = .75$) as determined by the range of the pretest (-0.17) to the student teaching posttest (0.58). The overall gain score from the pre-test to the test after student teaching for the 2-Year cohort was one quarter of a standard deviation ($z = .25$).

When reviewing the results it is important to remember that the Content Knowledge for Teaching Mathematics measures have been normed using a population of teachers who have had experiences teaching mathematics in elementary and middle school classrooms. The measures were initially created to track how experienced teachers' knowledge develops in professional development programs. These measures are being used to track mathematical knowledge for teaching in pre-service candidates at CSUN. An expected result for preservice teacher candidates taking this measure would be scores less than zero, scores below the mean for the population of experienced teachers, who have a z or scaled score of zero. A z score of 1 indicates a test score one standard deviation above the mean based upon the population of experienced teachers.

Numbers and Operations Knowledge of Students and Content was measured at the end of Math Methods and again at the end of the second semester of student teaching. Table 2 presents the mean scores of three groups of pre-service teachers on the Content

Knowledge for Teaching Mathematics (CKTM) Number and Operations Measures (Ball, Bass, & Hill, 2003) as the students progress through a mathematics methods class and then through the second student teaching assignment.

Table 2 examines the scores, reported as z -scores with the mean of 0, for three groups of preservice teachers enrolled in the undergraduate teacher preparation program. The table shows that on the first administration of the CKTM measure the group means on the measure of Knowledge of Students and Content was lower than the mean for in-service teachers. On the second administration of the test, after two student teaching experiences, the mean score for each group increased, with the 2-Year Undergraduate Cohort making the most gains.

Table 2: Means (z -scores) of CKT-M Number and Operations Measures for Three Groups of Pre-Service Teachers

Administration CKT-M Number & Operations- Knowledge of Students and Content Measures	4-Year Undergraduate Cohort $n = 25$	2-Year Undergraduate Cohort $n = 17$	2-Year Undergraduate Control Group $n = 30$
Mathematics Methods Class Post-test	- 0.004	- 0.481	-0.236
Student Teaching Post-test	0.270	- 0.067	- 0.089
Gains	0.274	0.414	0.147

A paired samples t -test was conducted to investigate whether the gains in the post-test for each cohort group were significant. The t -test shows significant improvement for the experimental 4-Year Undergraduate cohort ($p = 0.005$). Further statistical analyses are being conducted.

Who was involved and what was the nature of their involvement?

This research was conducted by the math professors involved in the TNE math project (Zeitlin, Gold and Basta) and the education professors involved in the project (O'Rode and Hertzog). In addition, seminar instructors and university supervisors in the Department of Elementary Education assisted in working with the "experimental" populations during student teaching.

What challenges did you face?

Tracking an identified research population across years of undergraduate classes and through identified "experimental" sections of math courses, math methods courses, student teaching seminars and assignments to specific student teaching supervisors is logistically challenging work.

We still face the challenge of further analysis of the data, which can be differentiated to study several variables. For example, we have some subjects in the experimental groups who scored 2 standard deviations above the average z scores reported in the study conducted with inservice teachers. What can we learn by analyzing data from that subpopulation of the research sample?

What did you learn?

The student teaching experiences make a difference; they can cause preservice teachers to build their knowledge base. That difference is more pronounced with regards to Numbers and Operations, which is more highly emphasized in the content standards and instructional time in K-5 classrooms.

We need to expand the number of teacher candidates in the studies so that we can establish statistical significance with more confidence.

What changes will be made as a result of this work?

We are analyzing the curriculum activities in the math methods and student teaching seminars to determine how they can continue to emphasize Knowledge of Students and Content in the areas of both Numbers and Operations and Geometry.

We need to conduct an analysis of how much geometry content our student teachers teach during student teaching experiences and examine how to support them during their development of geometry lessons.

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Objective O2B.2: Field Experience and PCK Report

What was proposed?

Create, implement and evaluate use of PCK-based support materials for multiple subject teacher candidates' student teaching in math, science and social studies. Pilot use of the guides in spring 2007 with in-service university supervisors and teacher candidates.

What was accomplished?

Mathematics Field Support Materials.

In math, support materials for the multiple subject programs were created, faculty were trained, implementation took place during the Fall 2006 and Spring 2007 semesters. Science and social studies materials were developed, but were not field tested or used with student teachers. Results of using the math materials are reported here.

Use of the Mathematics Field Experience Support Materials focused student teachers and university supervisors on aspects of teaching mathematical knowledge for teaching. Changes in lesson plans, written observation notes, feedback conferences and written reflections were noted.

University Supervisors. There was a noted change in the way that university supervisors interacted with the student teachers regarding the planning and teaching of math lessons. Interviews with the university supervisors indicated that all were impacted by having the field guide materials to focus their observation of lessons. All indicated that use of the guide changed their assessment of lesson plans, impacted what they were watching for during math lesson observations, changed the way they recorded written observation notes, and significantly changed the focus and tone of the post-observation feedback conference.

Analysis of written observation notes demonstrated the level of change in the interaction between student teachers and university supervisors. Notes from previous semesters were compared to the notes from the current semester using the field guide. Table 1 shows the categories used for analysis of observation notes and the differences between semesters:

Table 1: *Analysis of University Supervisor Written Observation Notes By Category*

Relative Frequency of Supervisor Comments Specific to Mathematics		
Category	Before	After
Problem Solving	3.6%	8.9%

Explanations/ Justifying Reasoning	5.1%	31%
Representations	9.5%	13.1%
Connections	5.8%	8.3%
Other	2.9%	2.1%

Table 2. *Description of Supervisor Comments in Written Observation Notes Before and After Use of Field Guide*

	Use of Field Guide	
	Before	After
Percent of supervisor comments specific to mathematics	27%	63%
Mean Number of Supervisor Comments		
Specific to mathematics	4.1	16.4
On general classroom practice	11.1	9.4
Per observation	15.2	25.8

Table 3.
Examples of University Supervisor Observation Notes Before and After Use of Field Guides (each comment excerpted by comparing notes of that supervisor before and after the introduction of support materials)

Before	After
<ul style="list-style-type: none"> ▪ Good explanation from Group 1. ▪ Your questions really made them think. ▪ Consider using the overhead projector. ▪ How will you assess their work? 	<ul style="list-style-type: none"> ▪ “Let’s make it taller.” Missed an opportunity to explain to students why the face would not be a square if we made the cube taller. ▪ I liked the way that you let them solve the problem themselves prior to giving them the answers. ▪ You might have modeled the making of the rectangle on the overhead. ▪ Assessed prior knowledge- you handled this well. Covered many understandings (bar graph, coordinate pairs, axes, circle graph, etc).

- Thorough closure to lesson.
 - The closure is the most difficult to bring together because you don't know what children are going to say. Bringing out the mathematical thinking of students rather than 'telling' is something to work on.
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Overall, the math field support materials resulted in an increased focus on elements of mathematical knowledge for teaching. Supervisors in the study used specific mathematical language to communicate their concerns about the lessons and focus their observations more precisely on the mathematics in the lesson.

Student Teachers. Level of implementation was identified as a result of use of the Observation Protocol instrument. Supervisors engaged in the lesson observation/feedback cycle with the student teacher and then rated level of implementation using the Observation Protocol. The protocol assigned a summative indicator to each lesson that ranged from Level 1: Ineffective, Level 2: Elements of Effective Instruction, Level 3 Beginning teacher Level 4: Accomplished, Level 5: Exceptional. Table 6 shows the distribution of scores

Table 6. *Distribution of Observation Protocol Scores*

Category	Observed Lessons Scored at this Level:
Level 1: Ineffective Instruction	4
Level 2: Elements of Effective Instruction	8
Level 3: Beginning Stages of Effective Instruction - Low	7
Level 3: Beginning Stages of Effective Instruction - Solid	10
Level 3: Beginning Stages of Effective Instruction - High	5
Level 4: Accomplished, Effective Instruction	8

We are still in the process of analyzing data gathered as part of the longitudinal study to examine factors related to the distribution of the protocol scores.

Science Field Support Materials.

Science field support materials were developed that use the same format as the math support materials. They have yet to be field tested with student teachers.

Social Studies Field Support Materials.

Social studies field support materials were developed that use the same format as the math support materials. They have yet to be field tested with student teachers.

Who was involved and what was the nature of their involvement?

Nancy O'Rode, math education professor in the Department of Elementary Education (EED) was the leader for this activity, coordinating the work of the three subject areas.

In addition, 10 university supervisors participated in the project, which included two who also serve as Field Placement Coordinators for the multiple subject program options. University supervisors worked on the three subject matter projects based on their areas of expertise in the various fields. Student teaching seminar instructors were included in the math project because they needed to reinforce use of the materials with the student teachers during the student teaching experiences.

David Kretschmer (EED) led development of the science materials. Greg Knotts (EED) represented social studies education in the development of those support materials. Math, science and social studies subject matter professors were regularly consulted during the development of the support materials. In addition, the science subject matter professors are in the process of developing science content support materials that will be used with the field support materials by university supervisors

What challenges did you face?

Training the university supervisors in the use of the math support materials and application of the materials during student teaching seminars required a significant amount of planning and organization on the part of the activity leader. Not all supervisors implemented appropriately, which reduced the number of teacher candidates that could be used as part of the data gathering process.

Placement of the research population into identified sections of student teaching seminars, and assignment to university supervisors involved in the project was a complicated process.

What did you learn?

The use of field support materials focuses the lesson planning/observation/feedback cycle to emphasize aspects of PCK and subject matter content in student teaching lessons.

University supervisors need to be well-trained in use of the materials. We need to train supervising teachers in the use of the materials before we can fully study impact on the student teachers' teaching.

Use of the math materials caused us to identify that there are subject-specific classroom management skills that we need to identify, label, and prepare the preservice teachers to implement.

We need to further study how aspects of PCK based skills need to be adapted to meet the needs of English learners.

What changes will be made as a result of this work?

We have applied for a grant through the Institute of Education Sciences, US Department of Education, to fund the training of university supervisors and supervising teachers in the development of math field support materials.

We will continue to study the use of the math field support materials in math methods courses in the next year, as well as application of the materials in the undergraduate student teaching seminars and student teaching.

We want to begin a study of the use of science and social studies field support materials during the 07-08 academic year.