Mathematical ACTS:

Achievement and Collaboration for Teachers and Students

Project Overview

Mathematical ACTS*: Achievement and Collaboration for Teachers and Students* **(award #0226948) is a targeted partnership between University of California Riverside (UCR) and a Southern California school district. The partnership involved pre-service and in-service education of teachers with an emphasis on student mastery of Algebra I content.**

The district has a diverse student population of 19,000+ students (57% are Hispanic and 5% are African American) and has sizeable English Learner (24%) and Free/Reduced Price Meals (52%) population. Only 52% of the secondary school mathematics teachers have a mathematics major or mathematics teaching credential.

Mathematical -ACTS provided instructional training for grade 4, 5 and 6 teachers and middle school mathematics and science teachers. Three forms of professional development sought to extend teachers' content knowledge and pedagogical repertoire.

MATE (*Mathematics Academy for Teaching Excellence*), is a 40 hour workshop for teachers at all levels. Exemplary teaching is modeled and mathematics is connected to science and other real-world applications.

CHAMP (Climbing Higher with the Academy for Mathematics Performance) is a 25 hour lab-school environment. Teachers observe, model and act as peer coaches as they work on new strategies for presenting grade level math content. Teacher to Student ratios are kept small to allow teachers to test and evaluate their newly learned strategies.

ALIAS (Accelerated Literacy Integrating Algebra and Science) is a 20 hour set of workshops that give teachers inquiry-based and grade level science exercises linked to state mathematics standards. Teachers work on the exercises in small peer groups. During the summer, teachers work with students in a lab-school environment (30 hours) to test and evaluate the classroom exercises.

Evidence Based Research Paradigm

Teachers were randomly placed in to either Treatment of Control groups (stratified random procedure). The 16 elementary schools were paired by demography and mathematics achievement. Schools within pairs where randomly assigned to "Treatment" (i.e. teacher were eligible to participate) or "Control" (i.e. teachers needed to wait until the following year before they would be eligible for "Treatment"). In half the schools, pairs were held as controls for the first two years before being assigned to control or treatment status. This guaranteed control population over the first 3 years but ultimately provided professional development opportunities for all interested teachers during the study.

Idealized Control and Treatment Populations within Elementary Schools
(assumes 2 teacher per grade level, numbers reflect classrooms not students)

		Year 1	Year 2	Year 3	Year 4
	Treatment	24	48	72	96
Control	First Half of Schools	24	0	0	0
Control	Second Half of Schools	48	48	24	0

Participation was voluntary but participants were compensated with class materials and for their time. The district encouraged participation by all eligible faculty

Predictions: Indicators of Success

We hypothesized that participating in Mathematical-ACTS teachers would increase their content knowledge and pedagogical repertoire and that this would lead to increased mathematics achievement as measured by student standardized tests.

A Project Success Story

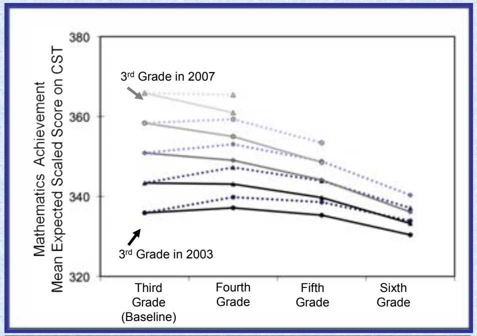

Figure 1: Difference between "Control" (solid lines) and best fit "Treatment" (stippled lines). Control students were assigned a value of 0 for treatment coefficients. For treatment, the mean of all non-zero values of "treatment 6" for each year and grade multiplied by the coefficients shown in Table 1 used for treatment students

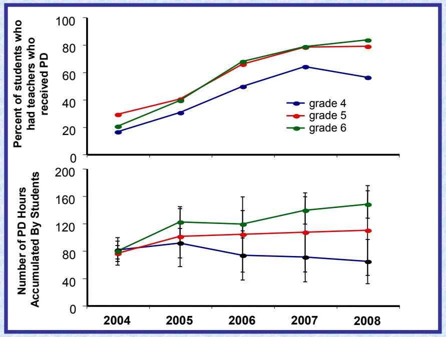

Figure 2: Top: the percent of students from treatment classrooms calculated by considering a student who had been in a 4th grade treatment classroom are still considered "treatment" students as per treatment parameterization 5 and 6 (Table 2). Bottom: the mean ±1 SD of accumulated hours by treatment students

Test scores were slightly higher for students from treatment classrooms. Although the effect size was small, if a student accumulated the benefits of 100 hours of a teacher(s) PD, it is enough to offset the effect of family SES on test scores. Our ability to reach students in grades 4, 5 and 6 fell short of the idealized target of 100%. However, the best fit model suggested that, although students were not always in a "treatment classroom" they carry the PD benefits from their teachers with them. The downward trend seen in grade 4 (Figure 2) is due to teacher attrition from the district, indicating the need for sustained PD over time.

Table 1: Longitudinal changes in students' mathematics achievement controlling for significant individual demographic variables and the effect of Math-ACTS professional development (PD). PD has been parameterized in 6 different ways (see Table 2).

Fixed Effects		Only Control Variables	Math-ACTS: Treatment 1‡	Math-ACTS: Treatment 2	Math-ACTS: Treatment 3‡	Math-ACTS: Treatment 4	Math-ACTS: Treatment 5	Math-ACTS: Treatment 6
Initial Status:	Intercept: Baseline Score for 3rd grade in 2003	335.38**** (1.1826)	335.46**** (1.1892)	335.84**** (1.1862)	335.43**** (1.1878)	335.87**** (1.1857)	335.75**** (1.1917)	335.90**** (1.1863)
	Change in Baseline over years	7.8039**** (0.3138)	7.7557**** (0.3191)	7.5392**** (0.3183)	7.7458**** (0.3176)	7.4414**** (0.3213)	7.6939**** (0.3168)	7.4917**** (0.3222)
Rate of Change:	Slope: Change in score as grade increases	-4.4127**** (0.4320)	-4.4860**** (0.3191)	-4.7310**** (0.4366)	-4.4680**** (0.4437)	-4.7731**** (0.4364)	-4.6797**** (0.4444)	-4.7004**** (0.4357)
	Change in slopes over years	-1.4748**** (0.1430)	-1.4325**** (0.1459)	-1.4851**** (0.1430)	-1.4397**** (0.1458)	-1.3847**** (0.1485)	-1.4565**** (0.1431)	-1.5421**** (0.1539)
Demographic Control Variables	English Language Learner	-19.1940**** (0.8463)	-19.1974**** (0.8463)	-19.2094**** (0.8461)	-19.1926**** (0.8463)	-19.1881**** (0.8461)	-19.1971**** (0.8462)	-19.1131**** (0.8462)
	Free Lunch	-5.4570**** (0.7371)	-5.4527**** (0.7371)	-5.4582*** (0.7368)	-5.4493**** (0.7372)	-5.4434**** (0.7367)	-5.4497**** (0.7370)	-5.4935**** (0.7367)
	Parents Education Level (ranked)	6.3468**** (0.3886)	6.3458**** (0.3886)	6.3374**** (0.3885)	6.3465**** (0.3886)	6.3527**** (0.3884)	6.3226**** (0.3887)	6.3558**** (0.3884)
Mathematical ACTS Treatment	Math-ACTS: Intercept	--	2.114 (1.4673)	2.8356**** (0.5622)	0.0367 (0.0266)	0.0637**** (0.0137)	0.0249* (0.0097)	0.0643**** (0.0123)
	Math-ACTS: Slope	--	-0.7754 (0.6904)	NS	-0.0142 (0.0128)	-0.0156* (0.0062)	NS	-0.0146*** (0.0044)
Random Effects Level 1	Within Student	1107.38**** (13.6852)	1107.30**** (13.6860)	1105.00**** (13.6569)	1107.39**** (13.6902)	1104.85**** (13.6571)	1106.94**** (13.6817)	1105.07**** (13.6592)
Random Effects Level 2	Initial Achievement	3424.49**** (59.2101)	3424.21**** (59.2135)	3430.05**** (59.2701)	3424.25**** (59.2157)	3432.49**** (59.3287)	3425.26**** (59.2146)	3431.57**** (59.3045)
	Rate of Change	12.6386* (6.4050)	12.6515* (6.4065)	13.6226* (6.4070)	12.5937* (6.4091)	13.5276* (6.4073)	12.8945* (6.4098)	13.4574* (6.4094)
	Covariance	-159.21**** (16.4119)	-159.21**** (16.4148)	-161.76**** (16.4273)	-159.17**** (16.4156)	-162.56**** (16.4463)	-159.90**** (16.4158)	-162.75**** (16.4408)
Goodness of Fit	Deviance	383664.7	383662.5	383639.3	383662.7	383630.8	383658.1	383625.0
	AIC	383686.7	383688.5	383663.3	383688.7	383656.8	383682.1	383651.0
	BIC	383771.6	383788.7	383755.9	383788.9	383757.1	383774.7	383751.2

† $p \le 0.1$, * $p \le 0.05$, ** $p \le 0.01$, *** $p \le 0.001$, **** $p \le 0.0001$; *numbers in parentheses represent one standard error*
‡ Math-ACTS intercept remains non-significant when the Math-ACTS slope is not included in the model

Discussion

We anticipated using the SAT-9 Mathematics exam as a measure of student's achievement. In 2003, the State adopted a criterion referenced exam of state math standards that is not norm-referenced. To address the issue of growth in the context of our longitudinal design, we needed to include grade level as covariates in our models. The negative slopes seen in table and figure 1 are an artifact of the manner in which the CST exam is scaled among grades. For example, students generally score lower on the grade six test than they do on the grade five test.

Increased focus on high stakes testing in the State also began in 2003. Many districts (ours included) initiated a range of workshops to increase test scores, in addition to the workshops sponsored by the MSP grant. While this blurs the distinction between control and treatment, a more important unanticipated consequence was a marked "PD fatigue" among the teachers.

The final challenge was how to *model* "treatment". Not all teachers participated in all workshops. The "idealized" treatment roll out (see bottom left) was overly optimistic. An initial solution was to use a continuous variable indexed to number of hours of PD in place of a binary "Control/Treatment" parameterization. That solution ignored the fact that our treatment had three distinct attributes of longitudinal impact on students' achievement, as shown in Table 2.

Table 2: Parameterizations of the Mathematical-ACTS PD provided to teachers in relationship to the three hypothesized mechanisms for influencing student achievement

	Impact of Professional Development Maintained with Teacher Over Time		Impact of Professional Development Tied to Hours Completed	
Student Accrues Benefits over Time	YES	NO	YES	NO
YES	Treatment 6	Treatment 5	Treatment 5 Treatment 6	N/A
NO	Treatment 2 Treatment 4	Treatment 1 Treatment 3	Treatment 3 Treatment 4	Treatment 1 Treatment 2

We empirically assessed alternate hypotheses for how PD given to teachers translates into student achievement by modeling treatment with different parameterizations to reflect the different assumptions. We modeled treatment in six different ways (Table 3) and used model selection criteria to test among these hypotheses.

Table 3: Sample values based on the six different parameterizations of the Mathematical-ACTS PD

Student ID	Student's Grade/ Year	Treat-ment 1	Treat-ment 2	Treat-ment 3	Treat-ment 4	Treat-ment 5	Treat-ment 6
20040004	Grade 4/2004	1	1	20	100	20	100
20040004	Grade 5/2005	0	1	0	40	20	140
20040004	Grade 6/2006	1	1	60	60	80	200

Principle Investigation Team and Acknowledgements

Michael Bryant, Cal Arts University and PI's: Richard Cardullo, UCR Biology, Kathleen Bocian, UCR School of Education, Kimberly Hammond, UCR Biology, Michael Rettig, UCR Chemistry and Pamela Clute, UCR Alpha Center.

We wish to thank James Lewis, Lisa Fast, Cathy Miller, YiFeng Hu, DeWayne Mason and the staff and faculty at the participating school district.