TEACHER SUBJECT-MATTER KNOWLEDGE AND YEARS OF EXPERIENCE—NOT GROWTH MINDSET ABOUT STUDENTS—PREDICT STUDENT LEARNING IN FRACTIONS

Background. Teachers' years of teaching experience has been known for decades to be positively associated with student learning. Recent studies have found teachers' effectiveness increases rapidly during their first few years in the profession and more slowly for more experienced teachers (Harris & Sass, 2011; Rockoff, 2004; Papay, & Kraft, 2015). Other potential predictors of teacher competence have been more elusive. Two of the factors that have received the most attention in the research literature over the past two decades are mathematical knowledge for teaching (MKT) and growth mindset (GM). MKT is a theorized, subject-specific type of knowledge grounded in Shulman's (1986) notions of the distinctions among content knowledge, pedagogical content knowledge, and pedagogical knowledge (Ball, Thames, & Phelps, 2008). Many scholars argue fervently and prolifically in support of the importance of teachers fostering a growth mindset in order to increase student learning and human capabilities in general (Dweck, 2006; Hochanadel & Finamore, 2015; Rattan, Savani, Chugh, & Dweck, 2015; Yeager et al., 2019). Despite the widespread proliferation of these ideas, large-scale studies have produced limited empirical evidence of their relationship with student learning (Rockoff, Jacob, Kane, & Staiger, 2008; Sisk, Burgoyne, Sun, Butler, & Macnamara, 2015).

Objective and Research Question. Using a data set available to us, the objective of this study is to examine whether these teacher attributes (i.e., MKT, GM, and experience) predicted student learning in fractions. We asked the following research question. To what extent do intermediate-grades teachers' years of experience, MKT, and GM with respect to students' mathematical abilities predict their students' learning in fractions?

Setting. Third- and fourth-grade teachers (and their students) in 10 states participated in a randomized controlled trial of lesson study and fractions resource kits between 2016–2018. The estimated effects of the intervention on average MKT, GM, and student achievement was in all cases very close to zero. The present study does not look at the impact of the intervention, and the intervention-group membership was ignored in the current analysis.

Participants. Eighty teachers, representing 80 schools, and 1385 of their mathematics students participated in the study. Due to loss of cases with missing data at the student and/or teacher level, the analytic sample for the present study consisted of 65 teachers and 1046 students. Among the students, 556 were girls, and 505 were third graders. Table 1 provides descriptive statistics for the present study.

Research Design. The present study examined the correlational relationship between student outcomes and predictors of interest, conditional on pretest scores. All participants engaged in fractions instruction between the pretest and the posttest. This study occurred within the context of a larger study that involved random assignment of classrooms to one of four conditions. Because analysis of the data indicated virtually zero average treatment effects on all variables of interest (Schoen, Lewis, Rhoads, & Lai, manuscript in progress), treatment group membership is ignored in the current study.

Data Sources. Teachers provided their consent to participate in the study and reported their personal demographic information (e.g., highest degree earned, years of teaching experience) in a Web-based survey. Pretest data and consent for students and teachers were collected before fractions instruction occurred for the year.

MKT. Teachers completed the Knowledge for Teaching Early Fractions (K-TEF) test, which focused on content knowledge for teaching early fractions concepts (Schoen, Yang, Liu, & Paek, 2018). Dimensionality analyses supported essential unidimensionality, and coefficient α and standard error of measurement were calculated to be .76 and 2.32, respectively.

GM. Teachers completed a four-item questionnaire designed to assess their growth mindset with respect to student learning with a specific focus on mathematics. Table 4 contains the items and their standardized factor loadings. Dimensionality analyses supported unidimensionality, and coefficient α and standard error of measurement were calculated to be .69 and 1.38, respectively.

Student mathematics performance. Students completed two different forms of the Early Fractions Test (EFT), one before fractions instruction occurred and one after. Teacher and student responses to the questionnaires and the tests were calibrated using item response theory (Schoen, Liu, Yang, & Paek, 2017; Schoen, Yang, Liu, & Paek, 2017).

Data Analysis. We fitted a series of multilevel models to the data using HLM 7 (Raudenbush, Bryk, Cheong, Congdon, & du Toit, 2011). We first examined descriptive statistics and correlations among level-2 variables. For the multilevel model analyses, we first fit an unconditional model (model 1) to the data. We then used student posttest score as the outcome variable, level-1 variables in Table 1 as level-1 predictors, and level-2 variables in Table 1 as level-2 predictors (model 2). In our final model (model 3), we removed the level-2 predictors with p-values greater than .10 and re-ran the analysis.

Results. Table 2 shows the correlations among level-2 variables. Preliminary analyses suggested nonlinear MKT-student-achievement and teacher-experience—student-achievement relations. Teacher growth mindset had weak and positive correlations with both class mean pretest and posttest scores. Table 3 presents the results of multilevel model analyses. At level 1, students' pretest score was strongly associated with their posttest score, but their gender and ELL status had no significant effects after controlling for their pretest score. At level 2, teachers' MKT and years of experience predicted their students' posttest score when controlling for individual student pretest and class-mean pretest scores.

Conclusions. We found that teachers' subject-matter knowledge and years of experience—but not their growth mindset about their students—were significant predictors of their students' learning in mathematics. Our finding is consistent with previous findings on the effects of teacher MKT and teacher experience on student mathematics achievement (e.g., Harris & Sass, 2011; Hill, Rowan, & Ball, 2005; Kelcey, Hill, & Chin, 2019; Rockoff, Jacob, Kane, & Staiger, 2008).

We used listwise deletion based on the assumption of missing completely at random. This resulted in a loss of data, which may bias the parameter estimates. Several approaches to sensitivity analysis, however, obtained similar findings to those reported here. Future analyses may benefit from exploration of possible transformations of the MKT and experience variables to better support linear modeling.

Table 1
Descriptive Statistics for Level-1 and Level-2 Variables (n = 1046 students in 65 schools)

Variable	Description	Mean	*SD*	Min	Max
	Level 2 (school/class/teacher)				
%FRL	Percentage of students in school eligible for free or reduced-price lunch	0.63	0.25	0.15	1
GM	Teacher growth mindset	0.17	0.78	-1.24	1.11
MKT	Mathematical knowledge for teaching	0.11	0.85	-1.59	1.99
Experience	Years of teaching experience	12.39	7.65	1	32
Departmentalization	Teacher specializes in mathematics	0.31	0.47	0	1
Degree	Teacher has masters or specialist degree	0.51	0.50	0	1
MathCert	Teacher holds certificate in mathematics	0.08	0.27	0	1
Grade 4	Fourth-grade mathematics class	0.49	0.50	0	1
ClassPre	Class mean pretest score	-0.02	0.65	-1.09	1.45
ClassPost	Class mean posttest score	0.97	0.51	-0.12	2.00
	Level 1 (student)				
ELL	Identified as English-language learner	0.18	0.39	0	1
Female	Coded as 1 for female student	0.53	0.50	0	1
Pre	Student pretest score	0.07	0.90	-1.92	2.63
Post	Student posttest score	1.04	0.79	-1.08	2.69

Table 2
Correlations among Level-2 Variables

	ClassPost	GM	MKT	Experience	Dept	Degree	MathCert	%FRL	Grade4
ClassPre	.77**	.31*	.06	.01	.07	-.07	.10	-.36**	.68**
ClassPost		.24	.19	.18	.09	.07	.09	-.41**	.46**
GM			.02	.14	-.11	-.03	.15	-.09	.29*
MKT				.14	-.07	.14	.01	-.33**	-.05
Experience					-.23	.13	.09	-.27*	-.19
Dept						.06	-.07	.05	.01
Degree							.17	-.06	-.02
MathCert								-.11	.06
%FRL									-.10

Note. ClassPre= mean pretest score at class level; ClassPost = mean posttest score at class level; GM = growth mindset; MKT = mathematical knowledge for teaching; Experience = years of teaching experience; Dept = departmentalization; Degree = the highest degree teacher received; MathCert = subject-specific certification in mathematics; %FRL = percentage of students in school eligible for free or reduced-price lunch.
* $p < .05$, ** $p < .01$

Table 3
Parameter Estimates of Fixed and Random Effects of Multilevel Model Analyses for Posttest Scores

Fixed effect	Model 1		Model 2		Model 3	
	Estimate	S.E.	Estimate	S.E.	Estimate	S.E.
Intercept	0.99***	0.06	0.99***	0.04	0.99***	0.04
ClassPre			0.60***	0.07	0.60***	0.05
GM			0.00	0.04		
MKT			0.05†	0.03	0.07*	0.03
Dept			0.06	0.08		
Degree			0.07	0.07		
MathCert			-0.04	0.06		
Grade4			-0.02	0.10		
Experience			0.01*	0.00	0.01**	0.00
PCT_RFL			-0.11	0.16		
Pretest slope			0.63***	0.03	0.63***	0.03
ELL slope			-0.06	0.06	-0.06	0.06
Female slope			-0.06	0.03	-0.04	0.03
Random Effect	**Model 1**		**Model 2**		**Model 3**	
	d.f.	Variance	*d.f.*	Variance	*d.f.*	Variance
Intercept	64	0.22***	55	0.08***	61	0.07***
Level-1 Residual		0.41		0.24	0.24	

Note. ClassPre= mean pretest score at class level; ClassPost = mean posttest score at class level; GM = growth mindset; MKT = mathematical knowledge for teaching; Experience = years of teaching experience; Dept = departmentalization; Degree = the highest degree teacher received; MathCert = subject-specific certification in mathematics; %FRL = percentage of students in school eligible for free or reduced-price lunch.
† $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$.

Table 4
Standardized Factor Loadings for the Confirmatory Factor Analysis of the Four Growth-Mindset Questions

Items	Standardized Factor Loading (*SE*)
Students can always substantially change their math ability.	0.61* (*0.04*)
Students' math ability is something about them that can't be changed very much.	0.74* (*0.03*)
Students have a certain amount of math ability, and they can't really do much to change it.	0.75* (*0.03*)
Students can learn new things, but they can't really change their basic math ability.	0.82* (*0.03*)
	Model
χ^2	18.14*
df	2
CFI	0.99
TLI	0.97
RMSEA	0.16*
SRMSR	0.06

Note. CFI = Comparative Fit Index; TLI = Tucker-Lewis Index; RMSEA = Root Mean Square Error of Approximation; SRMSR = Standardized Root Mean Square Residual; Items are six-point Likert-type scale ranging from Strongly Agree to Strongly Disagree. Out of concern for pressure to provide socially acceptable responses, three items were worded in a way that was antithetical to a growth mindset; their responses were reverse coded.
* $p < .05$

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