RCML

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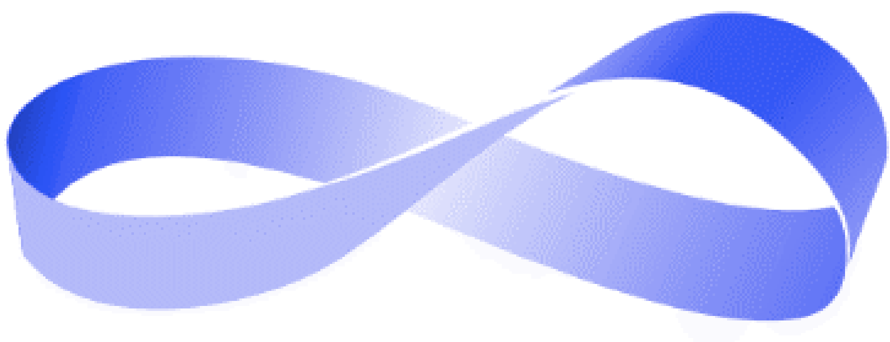
Leading and Learning: Mathematics Made Accessible for All



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Please Note:

RCML History

The Research Council on Mathematics Learning, formerly The Research Council for Diagnostic and Prescriptive Mathematics, grew from a seed planted at a 1974 national conference held at Kent State University. A need for an informational sharing structure in diagnostic, prescriptive, and remedial mathematics was identified by James W. Heddens. A group of invited professional educators convened to explore, discuss, and exchange ideas especially in regard to pupils having difficulty in learning mathematics. It was noted that there was considerable fragmentation and repetition of effort in research on learning deficiencies at all levels of student mathematical development. The discussions centered on how individuals could pool their talents, resources, and research efforts to help develop a body of knowledge. The intent was for teams of researchers to work together in collaborative research focused on solving student difficulties encountered in learning mathematics.

Specific areas identified were:

1. Synthesize innovative approaches.
2. Create insightful diagnostic instruments.
3. Create diagnostic techniques.
4. Develop new and interesting materials.
5. Examine research reporting strategies.

As a professional organization, the **Research Council on Mathematics Learning (RCML)** may be thought of as a vehicle to be used by its membership to accomplish specific goals. There is opportunity for everyone to actively participate in **RCML**. Indeed, such participation is mandatory if **RCML** is to continue to provide a forum for exploration, examination, and professional growth for mathematics educators at all levels.

The Founding Members of the Council are those individuals that presented papers at one of the first three National Remedial Mathematics Conferences held at Kent State University in 1974, 1975, and 1976.

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THE IMPACT OF MATH TEACHERS ON STUDENT LEARNING AND MOTIVATION

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This study examined the degree to which mathematics teacher qualifications, characteristics, and practices influence high school students' motivational beliefs about mathematics and mathematics learning (assessed by 11th grade mathematics achievement). A nationally representative, large-scale data set—the High School Longitudinal Study 2009 (HSLS:09) was used to conduct hierarchical regression analyses. After controlling for student demographics, results indicated that the degree to which teachers emphasized the development of deeper conceptual understanding of mathematics was a predictor of students' mathematics achievement, identity, and self-efficacy whereas the degree to which teachers emphasized the utility of mathematics predicted students' beliefs about the utility of mathematics.

Introduction

Research has uncovered the vital role that K-12 teachers play in students' academic outcomes (e.g., Blanchard & Muller, 2015). However, little research has focused on the degree to which the characteristics, qualifications, and instructional practices of high school mathematics teachers, particularly ninth grade mathematics teachers, have an effect on their students' motivation and learning in mathematics as they near graduation. Therefore, this study will attempt to fill this gap in research by investigating the role that ninth grade mathematics teachers have on high school students' mathematics learning and motivation towards the end of high school by using a national data set.

Theoretical Frameworks

This study is grounded in two distinct but related frameworks: Lent, Brown, and Hackett's (1994) social cognitive career theory (SCCT) and Goe's (2007) teacher quality framework (TQF). The two frameworks are integrated to understand the extent to which both student level and teacher level factors central to each theory shape students' STEM outcomes (Hattie, Masters, & Birch, 2016; see Figure 1). The two frameworks complement each other by highlighting teacher quality as a contextual (environmental) factor in understanding students' STEM outcomes. Guided by these well-established theories and prior research on student academic outcomes at the secondary level and by utilizing a large-scale data set for analysis, this study enhances our understanding of the relation between teacher quality and student outcomes related to STEM, and specifically both mathematics achievement- and motivation-related outcomes.

Social cognitive career theory (SCCT). SCCT posits that one's career choice is influenced by beliefs an individual develops and refines through the complex interaction among the individual, environment, and behavior (Lent et al., 1994; Yu, Corkin, & Martin, 2016). According to SCCT, the most important factors influencing career decisions relate to student motivation (i.e., task value, self-efficacy, interest, outcome expectations). Individuals' behavior and actions are influenced primarily by their sense of personal capability (self-efficacy; Bandura, 1986), their beliefs about the likely consequences of performing particular actions (outcome expectancy; Bandura, 1986; Lent et al., 1994), and the extent they find certain academic domains useful (utility value; Eccles & Wigfield, 2002) and/or interesting (interest/intrinsic value; Eccles & Wigfield, 2002). Empirical research has shown that students with higher math and/or science self-efficacy, outcome expectations, and value for engaging in math and science are more likely to persist and be successful in these areas (e.g., Andersen & Ward, 2014).

In addition to personal motivation, the SCCT framework recognizes several contextual factors including socializing agents such as parents and teachers that influence a person's academic and career aspirations and choices (Yu et al., 2016). Teachers, however, have been found to be the most significant contextual factor accounting for student achievement (Hattie et al., 2016). SCCT mainly focuses on learning experiences (e.g. perceptions of their past performance and vicarious learning experiences) that are sources of self-efficacy (Navarro, Flores, & Worthington, 2007). SCCT does not particularly focus on the role that teacher qualifications, characteristics, and practices have on students' learning experiences. The TQF supplements SCCT by broadening its conception of learning experiences to include a more specific understanding of the teacher characteristics, qualifications, and practices that inherently affect K-12 learning experiences, which in turn, may influence students' academic outcomes.

Teacher quality framework (TQF). The TQF (Goe, 2007) provides the most comprehensive framework to date based on a review and synthesis of research regarding the impact teachers have on student achievement-related outcomes. TQF comprises three strands that are distinct but interrelated: inputs, processes, and outcomes. Inputs focus on two different but related ways of looking at teacher quality: teacher qualifications and teacher characteristics. Teacher qualifications include teachers' degrees, coursework, and grades in higher education as well as teacher preparation routes, certification types, years of experience, and continuing education such as internships, induction, coaching support, and professional development (Goe, 2007; Rice, 2010). TQF also conceptualizes teacher quality as encompassing soft attributes (teacher characteristics) such as subjective judgements, organization skills, critical thinking skills, and attitudes and beliefs (e.g., self-efficacy, beliefs about teaching and learning; Pajares, 1992). The processes strand of the teacher quality framework focuses on factors related to teacher practices—i.e., what teachers actually enact in the classroom including instructional practices and classroom management practices. This study will be guided by the first two strands of the teacher quality framework (teacher qualifications and characteristics and teacher practices) and not the outcomes strand because this strand attributes teacher effectiveness to students' achievement test scores, which has received much criticism (i.e., Darling-Hammond, 2016).

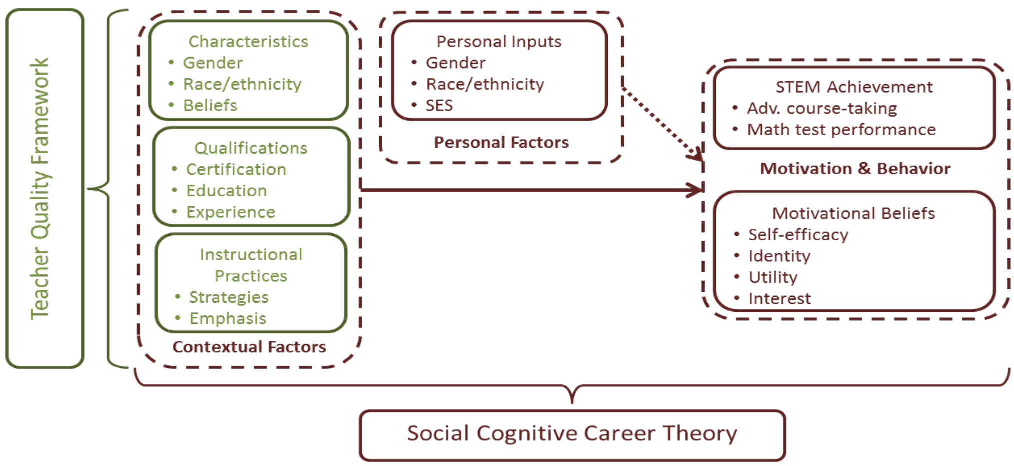

Figure 1. Conceptual framework explaining the connection of TQF and SCCT

Research Questions

1. To what extent do 9th grade math teacher characteristics, qualifications, and instructional practices contribute to high school students' math achievement and motivation?
2. To what extent do 9th grade math teacher characteristics, qualifications, and instructional practices contribute to high school students' math advanced course-taking behavior?

Method

Data Set. HSLS:09 is a study of more than 23,000 ninth grade students as of 2009. Conducted by the Institute of Education Sciences, HSLS:09 includes demographic information and survey responses from nationally representative students and their ninth grade mathematics teachers.

Variables. Student demographic information included gender (binary), underrepresented-minority (URM; African American, Hispanic, American Indian, and Native Alaskan)-status (binary), and socioeconomic status (continuous composite of several indicators; Ingels et al., 2011). Student motivation outcomes (self-efficacy, identity, utility, and interest) were continuous variables measured by several related items that are reliable and validated (Ingels et al., 2011). Mathematics achievement variable was the standardized theta score for a mathematics test taken by all the participants. Student demographic, achievement, and motivation data were retrieved from follow-up data collection cycle (11th grade). The other achievement-related student outcome was advanced course-taking data retrieved from high school transcripts and coded as 1 if students had completed any AP, IB, or dual-credit mathematics courses and 0 if none. Teacher variables were retrieved from base year data (ninth grade) and included students' ninth grade mathematics teachers' demographic characteristics (gender—binary, and URM-status—binary), high school teaching experience (years), mathematics teaching certification (binary—standard vs. alternative), mathematics teaching self-efficacy (continuous composite variable), and mathematics degree (binary—undergraduate/graduate vs. none). The two teaching practice variables included in the study were teachers' emphasis on developing students' deeper conceptual understanding of mathematics (understand) and teachers' emphasis on developing students' interest in mathematics and an understanding of the utility of mathematics (connect). These two variables emerged through the factor analysis of several teacher practice variables asking teachers, for example, how much emphasis they were placing on (in their fall 2009 math course) "*teaching students to reason mathematically*" (understand) and "*teaching students how to apply mathematics in business and industry*" (connect).

Analytic Techniques. First, hierarchical linear regression analyses for continuous outcome variables (e.g., mathematics performance and motivational beliefs) were conducted. Second, binary logistic regression analysis for the advanced mathematics course-taking behavior was completed. The complex sampling design of HSLS:09 required the use of weights and design effects to properly calculate standard error terms for each variable (Ingels et al., 2011). In essence, the use of weights and design effects in a sample allows generalization of the results of statistical models to a wider range of the population (whole high school students in the U.S. in this case) and was a critical step in developing causal hypotheses and inferences. Appropriate BRR weights were incorporated in all analyses using STATA.

Findings

To answer the first research question, a series of hierarchical linear regression analyses were conducted predicting mathematics achievement and four motivational beliefs pertaining to mathematics. The motivational beliefs selected as outcomes are predictors of STEM achievement and persistence according to SCCT theory and research (see Yu et al., 2016). Table 1 presents hierarchical linear regression and logistic regression analyses results.

Table 1

Summary of Hierarchical Linear Regression Analyses (Predicting Mathematics Achievement and Motivational Beliefs about Mathematics) and Binary Logistic Regression Analysis (Predicting Advance Math).

Variable	Achievement β	Self-efficacy β	Identity β	Utility β	Interest β	Advance math[a] $Exp(\beta)$
Step 1						
Male	.01	.11***	.09***	.04***	.02*	0.92*
URM	-.13***	.04***	-.01	.05***	.06***	0.53***
SES	.38***	.12***	.11***	.02**	.06***	1.30***
R-square	.18	.02	.02	.01	.01	.04[b]
Step 2						
Male	.01	.10***	.09***	.04***	.01	0.84**
URM	-.11***	.06***	.00	.05***	.05***	0.56***
SES	.36***	.12***	.11***	.02*	.08***	1.28***
Teacher male	-.02	-.01	-.01	-.01	.01	0.86**
Teacher URM	-.04***	-.01	-.02*	.01	.00	0.95
Teacher self-eff.	.01	.03**	.02	-.00	.03*	1.01
Teacher cert.	.03**	.01	.03**	-.01	.01	1.26**
Teacher degree	.03**	.00	-.02	-.01	-.02	1.18**
Teacher exp.	.05***	.01	.04***	.02	.01	1.02***
Understand	.14***	.03*	.06***	.00	.02	2.32***
Connection	-.02	.02	.00	.04**	.03	1.16*
R-square	.21	.03	.03	.01	.01	.07[b]

Note. *n* = 18,600. β indicates standardized regression coefficient. *Exp(B)* is the odds ratio for the logistic regression. [a]Binary logistic regression. [b]Pseudo R-square for binary logistic regression. *$p < .01$ **$p < .01$. ***$p < .001$.

In the first step of the regression analyses, personal student demographic variables were entered, followed by entry of teacher characteristics, qualifications, and instructional practices. Given the brevity of this report, we only highlighted the teacher factors that had the strongest effects on students' math achievement and motivation. All of the hierarchical linear regression analyses were statistically significant. However, of the five linear regression analyses conducted, the model with the greatest variance explained by student and teacher factors in the ninth grade was math achievement ($R^2 = .21$). The teacher factor that emerged as having the strongest effect on 11^{th} grade math achievement was the degree to which ninth grade mathematics teachers emphasized a deeper conceptual understanding of mathematics ($\beta = .14$, $p < .001$). In other words, students who received instruction from teachers that emphasized connecting mathematics ideas, developing mathematics reasoning and problem solving skills, and understanding mathematical concepts performed better on a math achievement test in the 11^{th} grade compared to students who received instruction from teachers who did not place emphasis in these areas. This finding provided further support for student-centered teaching approaches (informed by constructivist philosophy) that are foundational to reform-based teaching within the mathematics education community (National Council of Teachers of Mathematics [NCTM], 2014). The emphasis on deeper conceptual understanding also had a significant effect on the degree to which students saw themselves identifying with mathematics and being a mathematician (identity; $\beta = .06$, $p < .001$). In terms of whether students perceived mathematics as a useful subject, the strongest teacher factor predictor that emerged was the degree to which teachers emphasized increasing students' interest in math which may have included discussing the applications of mathematics in different academic disciplines as well as emphasizing the history of mathematics ($\beta = .04$, $p < .01$).

To answer the second research question, a binary logistic regression analysis was conducted predicting advanced mathematics course-taking behavior. The percent odds were reported to provide the reader with a clear understanding of the effect size that a variable had on advanced math course-taking behavior. For the odds ratio values presented in the last column of Table 1 that were greater than one, they were calculated by subtracting one from the odds ratio values and multiplying by 100. The odds percentage results reported refer to the effect of every one-unit increase in the given predictor on the odds of advanced math course-taking behavior. Again, the degree to which teachers emphasized a deeper conceptual understanding of mathematics was the strongest predictor of advanced math course-taking behavior. Specifically, when holding all other variables constant, greater levels of emphasis in deeper conceptual understanding of mathematics by ninth grade teachers increased the odds of their students taking advanced math courses in high school by 132 percent.

Discussion

The main aim of the current study was to understand the degree to which the characteristics, qualifications, and instructional practices of ninth grade mathematics teachers predict students' mathematics motivation and learning outcomes as they near graduation. Overall, our findings supported prior SCCT-informed research suggesting that teachers are important socializing agents that promote positive beliefs towards STEM fields (Yu et al., 2016). Specifically, our findings were consistent with prior individual classroom studies indicating that teachers' self-efficacy for teaching mathematics and the extent to which they emphasize understanding of mathematics are positively associated with students' self-efficacy for mathematics and achievement (Stipek, Givvin, Salmon, & MacGyvers, 2001). Furthermore, current findings were consistent with teacher education research that demonstrates the importance of teachers having mathematics degrees and a certification in mathematics in promoting greater student mathematics achievement (Rice, 2010). Our findings contributed to this line of research by showing that teacher qualifications have a positive association with both students' mathematics achievement and motivation over time. The findings were significant given NCTM's (2014) math practice standards, math teacher practice standards, and push towards a conceptual understanding for all students.

Results of this study may inform policies and promote additional research in areas that help broaden participation in mathematics. If we understand which malleable teacher factors most strongly contribute to students' mathematics learning and motivation outcomes over time, we can develop policies to address these important factors, including but not limited to producing and retaining teachers with desired qualifications and supporting professional development. Finally, we encourage readers to consider limitations while interpreting results. First, a limited number of variables in the HSLS:09 relate to teacher practices and are self-reported rather than observational. Second, HSLS:09 includes only ninth grade teacher data and student outcomes from 11th and 12th grades. It may be the case that after the ninth grade, students were taught by teachers who also impacted their STEM outcomes, a common limitation among longitudinal studies attempting to understand the long-term effects of teachers on students (e.g. Bradshaw, Zmuda, Kellam, & Iolango, 2009).

Acknowledgement

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