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A Comparative Study of High School Students' Math Achievement and Attitudes: Do Math Teacher Qualifications Matter?

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Abstract

Using nationally representative High School Longitudinal Study of 2009 data, this quantitative study examined how math teacher qualifications affect U. S. 9th graders' math achievement and attitudes. The study is guided by the Cognitive Apprenticeship Theory that emphasizes that expert teachers enable students to learn as apprentices and construct knowledge within the activity, context, and culture in which it is learned. The study shows that not only does cognitive apprenticeship enable skill development and knowledge acquisition, but it shapes student math self-efficacy and interest in the subject, and it develops their math identity if students viewed math teachers as role models. The study employs a comparative research design to explore the main effects and interaction between teachers' credential type and field of study degree on student outcomes. One notable finding is that teacher credentials (i.e., level of education & certification) affected student math achievement and math identity but had weaker effects on math self-efficacy, math utility and interest in math courses. Second, holding a math degree affected students' math achievement and math identity, while holding a degree in education had some positive effects on increasing students' interest in math courses. Results have direct implications for the field of Mathematics Education showing that teacher qualifications affect student beliefs and attitudes toward mathematics.

Introduction

Educators, policymakers, parents, and students recognize that mathematical skills lead to a successful life, including employment, income, and career success (Bregant, 2016). Although increasing students' math competency and overall math achievement is vital, the 2015 National Assessment of Educational Progress (NAEP) indicated only 25% of Grade 12 students in the United States performed at or above proficient achievement level in mathematics (The Nation's Report Card, 2015). Moreover, since 2005, the NAEP achievement trends in mathematics have remained unchanged for Grade 12 students. Based on the data, it is evident that exploring factors that ensure students acquire mathematical skills is still a topic that requires attention. Moreover, research shows that students' positive beliefs (e.g., a sense of math utility, math self-efficacy, math identity) and attitudes toward mathematics (e.g., interest in the subject) are good incentives toward learning and would enhance performance

(Barr, 2015; Elliott, & Bachman, 2018; Lau et al., 2018).

Although studies have documented the effect of student characteristics on math performance and attitudes, research regarding teacher qualifications is also notable (Cheema & Kitsantas, 2014; Sansone, 2019). More specifically, teacher qualifications include degree level, certification, and experience, as well as holding math degrees (Bagaka's, 2011; Blazar & Kraft, 2017; Clotfelter et al., 2007; Curran Neild et al., 2009; Goldhaber & Brewer, 2000; Heck, 2007; Hill & Dalton, 2013; Lee, 2018; Sansone, 2019). For instance, Bagaka's (2011) indicated that teacher experience has a positive relationship with student self-efficacy belief and achievement. Additionally, Lee (2018) found teacher qualification, including years of experience, degree level, and subject-matter expertise, also affect math achievement. As noted by Clotfelter et al. (2007), "policy makers are increasingly turning attention to the higher order skills taught in high school" (p.3) that require high-quality teachers capable to deliver a more abstract and complex high school math content (Aaronson et al., 2003). As a result, teacher preparation policies and programs focus on the formal knowledge of the content gained through teachers' study (e.g., math-related degree), as well as the pedagogical understanding on how to deliver the content (Boyd et al., 2012; Ingersoll, 2003). Focus on teacher qualification should particularly respond to a call for access to equitable education for all students. For instance, Hill and Dalton (2013) determined that low achieving Grade 9 students are more likely to be taught by a teacher without a math degree and appropriate math-related certification. High-achieving Grade 9 students, however, are taught by a teacher with both a math degree and certification (Hill & Dalton, 2013).

It is evident from previous research that student mathematics achievement, beliefs and attitudes continue to be particularly concerning. Yet, research regarding the impact of teacher certification and subject-matter expertise on student math outcomes at the high school level is limited mostly to student achievement. By exploring the effects of teacher characteristics on math achievement, educators have collected valuable information, including effective strategies that support increasing student success. However, better understanding of the relationship between teacher characteristics and students' beliefs and attitudes toward mathematics (Blazar & Kraft, 2017), may inform teacher preparation policies and programs. Therefore, the purpose of this study was to compare and contrast math achievement, beliefs and attitudes of a nationally representative sample of Grade 9 students by various teacher qualification factors. Focusing on student gaps in mathematics learning early on as students enter Grade 9 would inform high schools on how to prepare students to graduate with the skills necessary to be successful in college and life. Teacher certification, level of education, and field of study are hypothesized to affect students' math performance and shape beliefs and attitudes that enhance student learning and identification with the subject. The overarching question of the study is: Which aspects of teacher qualification are better associated with student math achievement, beliefs, and attitudes toward mathematics?

Literature Review

Student Outcomes

Student success in high school mathematics classes is determined at the intersection of achievement and attitudes. Research shows that positive attitudes toward mathematics are good incentives toward learning and would

enhance performance (Barr, 2015; Elliott, & Bachman, 2018). In addition, one's belief of competence in the subject is a source of math self-efficacy and math identity which increases math achievement (Allen & Schnell, 2016; Bandura, 1997; Lau et al., 2018; Sansone, 2019). The belief in the importance of mathematics (Eccles & Wigfield, 2002; Wigfield et al., 2016) also increases one's interest in the subject, motivation to persist and perform well. Positive attitudes toward mathematics are built on strong beliefs (about self and mathematics) that make the student become a participant in a community of practice, stimulate interest and motivation for the subject (Hannula et al., 2016). Research shows that motivation to succeed in mathematics has high implications for students' academic success and career choices (McKellar et al., 2019). When students are motivated to achieve, their self-concept increases and they are driven to believe that mathematics is important for academic success (Watt, 2006; Watt et al., 2012).

Considering the amount of time students spend at school, one can expect that school and classroom environment are vital factors in shaping students' mathematics beliefs and academic success (McKellar et al., 2019; Watt, 2006). Specifically, teacher-student interactions and feedback positively impact students' achievement and beliefs (Wigfield et al., 2015). Research shows that the teacher-student relationship takes premise when students attempt to strive and achieve in a learning environment (Watt, 2006; Wigfield et al., 2015) shaping self-efficacy in the subject matter. Teachers are also known to have an impactful influence on students' motivation and beliefs (Mason, 2003). Additionally, students' perceptions of math teachers' classroom practices impact their motivational beliefs about math (Mason, 2003; McKellar et al., 2019; Watt, 2006). Further, perceived support from teachers contributes to students' behaviors in the classroom, motivation, and positive attitudes towards math learning (Mason, 2003; Puklek Levpušček & Zupančič, 2009; Wigfield et al., 2015).

Researchers determined that teacher qualifications such as level of education, math content expertise, teaching experience, and certification play an important role in student outcomes (Clotfelter et al., 2007; Goldhaber & Brewer, 2000; Hill & Dalton, 2013; Lee, 2018; Mohr-Shroeder et al., 2017; Podolsky et al., 2019). First, math achievement is significantly increased with teacher qualifications (Clotfelter et al., 2007; Goldhaber & Brewer, 2000; Lee, 2018). For instance, Goldhaber and Brewer (2000) found evidence of higher achievement in middle and high school for students taught by teachers with an advanced degree in the subject they teach. Second, according to Bandura (1994), the school and classroom are places where children develop cognitive competencies and gradually acquire a sense of intellectual efficacy, so the task of creating such conducive learning environments depends on the talents, knowledge, qualification, and self-efficacy of teachers. Teacher's ability and competence impact student beliefs such as math self-efficacy (Bagaka's, 2011), which in turn have a positive impact on math achievement (Barr, 2015; Elliott, & Bachman, 2018; Lau et al., 2018). Therefore, more teacher training on implementing self-efficacy strategies in whole-classroom environments, such as drawing continually attention to students' academic progress, is highly recommended (Siegle & McCoach, 2007).

Level of Education and Content-Specific Major

Some researchers indicated the level of education for math teachers to be insignificant in relation to students' math achievement and long-term educational success (Clotfelter et al., 2007; Lee, 2018). More specifically,

Clotfelter et al. (2007) stated math achievement of students taught by a teacher holding an advanced degree such as a master's degree within the first five years of teaching was similar as for students taught by a teacher without a master's degree. Based on Clotfelter et al. (2007), teachers with a master's degree within five years of teaching were less effective than teachers without an advanced degree. On the contrary, Mohr-Shroeder et al. (2017) argued a teacher's level of education, specifically with an advanced degree, is significantly correlated to student achievement in geometry. Moreover, student achievement is significantly impacted by teachers who have majored in the school subject that they teach (Hill & Dalton, 2013; Lee, 2018). For example, Hill and Dalton (2013) found only 49% of Grade 9 students who performed in the lowest quintile in Algebra I were taught by teachers with a major in math, compared to 68% of students in the highest math performance quintile. Thus, teachers with an educational background in mathematics including an advanced degree in same field of study could positively impact student outcomes in mathematics.

Content-Specific Knowledge

Teachers with content-specific knowledge can support student learning and impact student math achievement (Hill & Lubienski, 2007; Shuls & Trivitt, 2015). Results from the study conducted by Shuls and Trivitt (2015) indicated content-specific knowledge, as demonstrated in teacher certification exams, significantly correlated with student achievement. Hill and Lubienski (2007) stated that "specialized knowledge of mathematics" includes the teacher's ability to determine the methods that are most beneficial for student learning when for example, representing mathematical procedures or solving computational problems. According to Hill and Lubienski (2007), there is a relationship between student's achievement in math and teacher's specialized knowledge of mathematics, especially for minority and low-income students. Based on their investigations, teachers with more content knowledge were employed in more affluent schools while teachers with low levels of content knowledge taught in schools with a high population of minority and low-income students.

Pedagogical Training and Teaching Experience

Although level of education, field of study and content-specific knowledge support student learning, a teacher's general pedagogy training and years of experience can also contribute to student math achievement. Shulman (1987, as cited in Boyd et al., 2012) argued that effective teachers need to acquire formal knowledge of the content as well as pedagogical understanding of the content, gained through both preparation and experience. Ingersoll (2003) defines the "in-field teacher" as someone who has a mix of both subject and pedagogical knowledge; he acknowledges the apparent debate between "those who argue that content or subject knowledge—knowing what to teach—is of primary importance for a qualified teacher… and those who argue pedagogical or methodological knowledge —knowing how to teach—is of primary importance to be qualified" (p.10). In some cases, teachers are expected to develop their subject-specific pedagogy in mathematics classrooms through professional development (Gonzalez & Maxwell, 2018).

Math education research also shows the importance of teaching experience on student outcomes. Podolsky et al. (2019) analyzed 30 studies regarding the effect of teaching experience on student achievement, and established

teacher experience was related to gains in student achievement. Additionally, years of teaching experience contribute to teacher effectiveness, which also results in an increase in math achievement (Clotfelter et al., 2007; Lee, 2018; Mohr-Schroeder et al., 2017; Papay & Kraft, 2015; Podolsky et al., 2019, Wiswall, 2013). Although research shows that teaching quality grows most rapidly during first five years on the job, teachers continue to improve their ability to increase student math achievement beyond the first five years of teaching (Harris & Sass, 2011; Papay & Kraft, 2015; Wiswall, 2013).

However, Harris and Sass (2011) indicated gains in math achievement were associated only with elementary and middle school teachers' years of experience. Like Papay and Kraft (2015), Harris and Sass (2011) revealed elementary and middle school students' math achievement increased with teacher's years of experience even after the first few years of teaching. On the contrary, the data illustrated that high school teachers with more experience were ineffective in producing higher math scores for their students (Harris & Sass, 2011).

Teacher Certification

Examining other teacher qualifications such as certification will provide more information to determine the impact on high school math achievement. State policy requires certification in the content area secondary teachers will teach (Curran Nield et al., 2009; Gonzalez & Maxwell, 2018; Shuls & Trivitt, 2015). Traditional and alternative certification methods exist for teachers to earn their teaching licensure. Traditional certification practices entail students earning a bachelor's degree in education with student teaching experience (Shuls & Trivitt, 2015). However, alternative certification involves students acquiring an emergency certification as a result of having an out-of-field bachelor's degree (Shuls & Trivitt, 2015). In many states, both routes to certification also require the teacher to pass a licensure exam (Shuls & Trivitt, 2015).

Evidence suggests that teacher certification in the area they are assigned to teach can impact math achievement. For example, Goldhaber and Brewer (2000) found a 1.3 -point increase in math achievement for students who were taught by a teacher with a certification in mathematics. Moreover, teachers with National Board Certification are more effective in raising achievement scores in math than teachers with other certifications (Clotfelter et al., 2007). It is important to note that Shuls and Trivitt (2015) reported differences between traditional and alternative certification pathways and their impact on student achievement. Shuls and Trivitt (2015) found little difference between the two certification methods. However, teachers performing higher on their licensure exam was associated with higher student achievement. Overall, teacher certification, regardless of the pathway, traditional or alternative, impacts student achievement, particularly in mathematics.

In summary, there is evidence that various aspects of teacher qualifications contribute to the educational success of students, especially by increasing achievement and shaping positive beliefs and attitudes toward mathematics. Many of these research accounts focus on selected teacher qualification indicators (e.g., certification) or are based on an examination of small samples. The current study is using a large nationally representative sample of high school math teachers in the United States to examine student outcomes in relation to a typology of qualifications that include credentials (i.e., level of education and certification) and areas of expertise.

Theoretical Framework

We anticipate that teacher characteristics (i.e., degree level, certification, and subject-matter expertise) play an essential role in student outcomes (i.e., achievement, attitudes) because teachers' skills, experience, and passion for the subject are at the root of authentic and effective teaching. Authentic instruction requires students to construct meaning of their learning by using inquiry and reflection and performing tasks for which they see value beyond obtaining school grades (Newmann & Wehlage, 1993). The authenticity of a teacher is recognized in his/her personal identity, effective pedagogy, and ability to model or cultivate similar values in others (Bialystok, 2015). As suggested by Lampert (1992), effective and responsible mathematics teaching "means constructing curriculum and instruction in ways that make it possible for students to participate in activities that are genuinely mathematical and to learn from those activities" (p.295). Rule (2006) contends that "authentic learning in mathematics must occur through discovery, inquiry and induction" (p.3) which requires the authentic teacher to be "a mentor and resource procurer rather than a disseminator of knowledge" (p.2). Moreover, an authentic teacher creates a cognitive apprenticeship environment to share expertise and enable the apprentices "to acquire, develop, and use cognitive tools in authentic domain activity" (Brown et al., 1989, p.39). Not only does the cognitive apprenticeship process enable skill development and knowledge acquisition in students (Collins, 2006), it also increases math self-efficacy and interest in the subject. Further, it helps develop math identity if students view math teachers as role models (Allen & Schnell, 2016). The current study is guided by the Cognitive Apprenticeship Theory (Collins et al., 1989) that assumes well-qualified math teachers possess the characteristics to engage students into "authentic learning practices through activity and social interaction in a way similar to that evident - and evidently successful - in craft apprenticeship" (Brown et al., p.37).

Method

Data and Research Sample

This paper uses data from the High School Longitudinal Study of 2009 (HSLS: 09) -- a national longitudinal representative sample of 23,000 ninth graders in 2009, followed-up in 2012 and 2016. In 2009, the HSLS database included surveys of students, parents, math and science teachers, school administrators, and school counselors. In this study, we used only the 2009 data based on students and math teachers' surveys that include 14,475 ninth-grade students for whom math teachers answered the 2009 survey. We differentiate the sample in two ways based on whether teachers hold or not degrees in either Math/Statistics or Education.

Variables

Student math achievement in Grade 9, and motivational belief scales of math identity (i.e., either the student or others see him/her as a math person), math self-efficacy (i.e., student is confident will understand textbook, master skills, do well in math courses), math utility (i.e., math courses are useful for everyday life, for college or for future careers), and attitudes toward mathematics manifested in interest in Grade 9 math courses (i.e., student is enjoying classes, does not think they are boring or a waste of time) are the dependent variables in the study (see Appendix). HSLS includes quintile measures of math achievement that we treated as an ordinal continuous

variable. Survey items describing student beliefs and attitudes about mathematics are all measured on Likert scales from 1 (Strongly disagree) to 4 (Strongly agree). After recoding reverse scored items, the reliability was tested for each scale, and final scale scores were obtained as item means. All scales were highly reliable, alpha Cronbach coefficients varying between .775 and .898.

Teacher qualification variables are based on several survey questions that describe having a math teaching certificate, the level of education (Bachelor or Advanced/Specialized degrees), and whether the teacher had any degree (either a bachelor's or a graduate degree) in Math/Statistics or in Education. We captured two dimensions of math teacher qualification: credential qualification (i.e., level, certification) critical to obtaining teaching employment (Clotfelter et al., 2007; Gonzalez & Maxwell, 2018; Lee, 2018) and major degree of study qualification that indicates the type of knowledge (i.e., content, pedagogical) that is relevant to high quality teaching of mathematics (Boyd et al., 2012; Ingersoll, 2003; Koehler et al., 2014). Therefore, we first created a 4-category variable (i.e., credential) that combines the level of education and holding a math teaching certificate that is a requirement in many states (Boyd et al., 2012; Ingersoll, 2003). Second, since HSLS identifies the major program for both bachelor and advanced degrees, with both Education and Mathematics/Statistics majors specified, we created two binary variables (No/Yes) to identify whether the teacher obtained postsecondary degrees in these fields of study, with the assumption that Education majors are predominantly building the pedagogical skills while majors in Mathematics/Statistics are critical to building the subject-matter knowledge. If the teacher has only a bachelor's degree, the binary variables identify if the bachelor's degree was obtained (or not) in Math or in Education. If the teacher has Advanced degrees, data does not allow to determine the level of the specific Math or Education degree. Nevertheless, the two binary 'degree' variables are indicators of the math content-specific or general pedagogy-specific focus of the teacher degree qualification (Koehler et al., 2014). We did not include years of experience in the study because the data did not allow to identify if the experience was related to high school mathematics teaching.

Statistical Procedures

This is an exploratory comparative study aiming at describing and contrasting Grade 9 students' math outcomes by various indicators of their math teachers' qualification. We first used descriptive statistics to explore the teacher qualification profiles and then organize the sample based on the field of study degree hold by teachers: Math/Statistics profile and Education profile. We recognize that the Math/Statistics and Education variables may not be mutually exclusive (e.g., some teachers may have both Math and Education degrees, or none). For each of these two degree-identified profiles, we conducted a series of separate 2-way ANOVA statistical analyses to explore the main effects and the interaction between the credential type factor (i.e., 4-category variable) and the degree factor (i.e., 2-category variable) on student math outcomes: math achievement, math identity, math self-efficacy, math utility, and interest in math.

Thus, we conducted five 2-way ANOVA tests on outcomes by credential and Math/Statistics degree (content-specific knowledge), and five 2-way ANOVA tests by credential and Education degree (pedagogical knowledge). Although performing multiple comparisons in a study raises concerns about Type I errors and often Bonferroni

corrections (or other techniques) are expected, we argue that in our study the results of each individual tests are important, so the significance of each test will be reported and discussed appropriately (Armstrong, 2014). Rescaled weights were computed from the Base year math-course enrollee analytic weight (W1MATHTCH) and were used in estimating correct population proportions while reporting sample counts.

Research Questions

1. What are the qualification profiles of high school math teachers?
2. Are there differences in Grade 9 student math achievement and student attitudes (i.e., math identity, math self-efficacy, math utility, and interest in math) by teacher qualifications (e.g., level & certification credential, and field of study degree)?

Results

Math Teacher Qualification Profiles

Table 1 describes the teacher qualification profiles with respect to credential and degree factors.

Table 1. Teacher Qualification Profiles (counts/column %)

Degree	Degree in Math/Statistics Profile		Degree in Education Profile		ALL
Credential	NO	YES	NO	YES	
Bachelor/ No-certification	1289	486	1304	471	1775
	(13.1%)	(10.5%)	(24.4%)	(5.2%)	(12.3%)
Advanced/ No-certification	841	318	363	796	1159
	(8.6%)	(6.8%)	(6.8%)	(8.7%)	(8.0%)
Bachelor/ Certification	3938	1462	2761	2639	5400
	40.1%)	(31.5%)	(51.7%)	(28.9%)	(37.3%)
Advanced/ Certification	3760	2381	917	5224	6141
	(38.3%)	(51.2%)	(17.2%)	(57.2%)	(42.4%)
ALL	9828	4647	5345	9130	14,475

First, as shown in the last column, more than 50% of high school math teachers have Advanced degrees and almost 80% have math teaching certification. In total 9,130 teachers (63%) have Education degrees (either Bachelor or Advanced), while about 4,647 (32%) have degrees in Math/Statistics, with about 14% of teachers holding degrees in both Math and Education fields. However, 19% of math teachers in the sample do not have degrees in either Education or Mathematics. We acknowledge that some of these teachers may have strong math/statistics preparation by holding degrees in math-related or statistics-related fields (e.g., physical sciences, engineering, psychology). We also recognize that the Math/Statistics and Education profiles may not be mutually exclusive, but we limit the discussion to examining only their separate effects on student outcomes (e.g., some teachers may have both Math and Education degrees, or none).

When examining the profiles of teachers holding Math degrees (second column), we notice that more than 17% are not certified compared to only 14% among those with Education degrees (fourth column). In addition, about 58% of those with Math degrees have Advanced education credentials, as compared to 66% among teachers with Education degrees. Therefore, it is more likely that math teachers who obtained Education degrees, have both math teaching certificates and Advanced education. Most likely career path for high school math teachers is to complete a bachelor's in mathematics, and then obtain math teaching certification and graduate credentials in Education. This would create a teaching career path based on strong subject expertise and pedagogical skills for highly qualified teachers (Lee, 2018).

Student Math Achievement

Student performance in math courses has always been an instructional goal and is often associated with teacher effectiveness in the classroom. Table 2 shows the results of 2-way ANOVA analyses, that contrast the mean scores of math achievement (scale 1 to 5) when comparing student groups by teacher credential and field of study degree for the two teacher profiles describing whether teachers hold degrees in Math/Statistics or Education. Overall, a math achievement score of 3.12 indicates 9th graders achieved at the 3rd quintile level. The main effect for credential is statistically significant for both degree profiles, but the effect of subject expertise is significant only in the first analysis (i.e., Math degree). Thus, differences in math achievement are more pronounced when comparing teachers who had (or not) a degree in Mathematics. There is also more variability in the math achievement scores at the intersection between credential type and holding a Mathematics degree, with the highest achievement scores across all groups obtained by students taught by teachers holding Advanced graduate credentials (with or without certification) and having math degrees. Meanwhile, students taught by teachers with a bachelor's degree, no math certification, and no formal degree in Math obtained the lowest average math scores. Overall, there are strong effects of teacher qualification on student math achievement, and results show that teachers with Math degrees appear to be more effective in raising student performance (Clotfelter et al., 2007; Goldhaber & Brewer, 2000; Lee, 2018).

Table 2. Mean Scores of Student Math Achievement by Credential and Degree Types

Degree	Degree in Math/Statistics Profile		Degree in Education Profile		ALL
Credential	NO	YES	NO	YES	
Bachelor/ No-certification	2.83	3.13	2.90	2.93	2.91
Bachelor/ Certification	3.03	3.09	2.98	3.13	3.05
Advanced/ No-certification	2.97	3.61	3.19	3.12	3.14
Advanced/ Certification	3.21	3.28	3.26	3.24	3.24
ALL	3.07	3.23	3.03	3.18	3.12
2-way ANOVA tests	Credential: F=23.98 **		Credential: F=21.78 **		
	MathDeg: F= 64.84 **		EducDeg: F=.52 (ns)		
	Cred x MathDeg: F=13.26 **		Cred x EducDeg: F=3.47 *		

Note: *p<.05; ** p<.001

Student Math Identity Belief

Research shows that students who identify themselves as 'being a math person' gain confidence and achieve better in math courses. Table 3 shows the results of 2-way ANOVA analyses, by contrasting the mean scores of math identity (scale 1 to 4) when comparing student groups by teacher credential and degree for the two teacher profiles describing whether teachers hold degrees in Math/Statistics or Education. Overall, a math identity score of 2.50 indicates 9th graders are quite neutral in their identity assessment. For both analyses, the main effects for credential type and for field of study degree are significant. However, differences in student math identity are more pronounced when teachers had a degree in Education; apparently, teachers with a degree in Education are more able to instill a higher level of math identity in students. The analysis also shows statistically significant interactions between credential and degree type, that are more pronounced when analyzing the sample based on the degree in Education profile. For instance, when teachers have a bachelor's degree only and a math teaching certificate, student math identity is higher if the teacher has a degree in Education. However, when teachers have an Advanced credential without teaching certification, students' math identity is higher if teacher's degree is in Mathematics. Overall, there are strong effects of teacher qualification on student math identity as shown in previous research (Allen & Schnell, 2016).

Table 3. Mean Scores of Student Math Identity by Credential and Degree Types

Degree	Degree in Math/Statistics Profile		Degree in Education Profile		ALL
Credential	NO	YES	NO	YES	
Bachelor/ No-certification	2.40	2.45	2.42	2.40	2.42
Bachelor/ Certification	2.48	2.44	2.39	2.55	2.47
Advanced/ No-certification	2.41	2.60	2.43	2.48	2.46
Advanced/ Certification	2.56	2.56	2.54	2.57	2.56
ALL	2.50	2.51	2.43	2.55	2.50
2-way ANOVA tests	Credential: F=14.78 **		Credential: F=9.99 **		
	MathDeg: F= 5.23 *		EducDeg: F=7.25 *		
	Cred x MathDeg: F=4.31*		Cred x EducDeg: F=6.03 **		

Note: *p<.05; ** p<.001

Student Math Self-Efficacy Belief

Students' self-efficacy is a major factor affecting achievement in a school subject. Math self-efficacy particularly is found to be an important non-cognitive factor paving the way to college. Table 4 shows the results of 2-way ANOVA analyses, by contrasting the mean scores of math self-efficacy (scale 1 to 4) when comparing student self-efficacy by teacher credential and field of study degree for each degree profile.

Overall, a math self-efficacy score of 2.91 indicates 9th graders have positive beliefs about their ability to understand math courses. The main effect for credential type is statistically significant, with students taught by

teachers who have Advanced education and certification scoring the highest for both degree profiles. There is no significant effect of degree type on student math self-efficacy for any of the degree profiles.

There is also a slight statistically significant interaction between credential and degree type when considering holding (or not) a degree in Education. For instance, when teachers have a bachelor's degree only and a math teaching certificate, student math self-efficacy is higher when the teacher degree is in Education. Although there are some differences among groups, we can conclude that the effect of teacher qualification is minimal on student math self-efficacy and holding neither Math nor Education degrees appear to boost student self-efficacy. Although teacher's competence affects student math self-efficacy (Bagaka's, 2011), other student characteristics including prior achievement may be more relevant to boosting self-efficacy (Bandura, 1997).

Table 4. Mean Scores of Student Math Self-Efficacy by Credential and Degree Types

Degree	Degree in Math/Statistics Profile		Degree in Education Profile		ALL
Credential	NO	YES	NO	YES	
Bachelor/ No-certification	2.90	2.88	2.88	2.92	2.89
Bachelor/ Certification	2.90	2.87	2.85	2.94	2.89
Advanced/ No-certification	2.84	2.93	2.88	2.86	2.87
Advanced/ Certification	2.93	2.94	2.94	2.93	2.93
ALL	2.91	2.91	2.88	2.92	2.91
2-way ANOVA tests	Credential: F=4.45 *		Credential: F=3.51 *		
	MathDeg: F= .44 (ns)		EducDeg: F=1.87 (ns)		
	Cred x MathDeg: F=1.96 (ns)		Cred x EducDeg: F=4.05 *		

Note: *p<.05; ** p<.001

Student Math Utility Belief

Utility beliefs about a school subject are expected to be a motivational factor affecting their performance and interest in mathematics, by revealing an understanding of the importance of mathematics learning for college and life. Table 5 shows the results of the 2-way ANOVA analyses, by contrasting the mean scores of math utility (scale 1 to 4) when comparing student groups by teacher credential and field of study degree for the two teacher profiles describing whether teachers hold degrees in Math/Statistics or Education.

Overall, a math utility score of 3.15 indicates 9th graders agree mathematics is important for education, career, and everyday life (last column). The only significant main effect for credential type is obtained when examining the Math/Statistics degree profile. There are no main effects for degree type either and only slight statistically significant interaction effects.

It is interesting to notice that the highest math utility scores are reported when students are taught by teachers who have bachelor's degree in either Math or Education, but no math teaching certification. These teachers may not

deliver high math results for their students (see Table 2) but they may convince students about the importance of mathematics. Understanding the utility value of a task and how it is related to current and future goals increases one's motivation to persist and perform (Eccles & Wigfield, 2002). Although there are some differences among groups, we can conclude that the effect of teacher qualification is minimal on student math utility belief.

Table 5. Mean Scores of Student Math Utility by Credential and Degree Types

Degree	Degree in Math/Statistics Profile		Degree in Education Profile		ALL
Credential	NO	YES	NO	YES	
Bachelor/ No-certification	3.18	3.26	3.19	3.21	3.20
Bachelor/ Certification	3.16	3.13	3.13	3.18	3.15
Advanced/ No-certification	3.20	3.10	3.14	3.19	3.17
Advanced/ Certification	3.14	3.14	3.16	3.13	3.14
ALL	3.16	3.14	3.15	3.15	3.15
2-way ANOVA tests	Credential: F=5.87 *		Credential: F=2.42 (ns)		
	MathDeg: F= .71 (ns)		EducDeg: F=1.83 (ns)		
	Cred x MathDeg: F=4.38*		Cred x EducDeg: F=3.01 *		

Note: *p<.05; ** p<.001

Student Interest in Mathematics Classes

Interest in math as a school subject and enjoyment of math during high school years have been identified in the literature as attitudes fostering academic success in the subject and consideration for future STEM education and careers. Table 6 shows the results of 2-way ANOVA analyses, by contrasting the mean scores of math interest in Grade 9 math courses (scale 1 to 4) when comparing student groups by teacher credential and field of study degree for the two degree profiles describing whether teachers hold degrees in Math/Statistics or Education.

Table 6: Mean Scores of Student Math Interest by Credential and Degree Types

Degree	Degree in Math/Statistics Profile		Degree in Education Profile		ALL
Credential	NO	YES	NO	YES	
Bachelor/ No-certification	2.86	2.83	2.86	2.85	2.86
Bachelor/ Certification	2.87	2.80	2.79	2.91	2.85
Advanced/ No-certification	2.83	2.94	2.77	2.90	2.86
Advanced/ Certification	2.83	2.79	2.81	2.82	2.82
ALL	2.85	2.81	2.81	2.85	2.84
2-way ANOVA tests	Credential: F=3.15 *		Credential: F=1.88 (ns)		
	MathDeg: F= .36 (ns)		EducDeg: F=12.90**		
	Cred x MathDeg: F=3.78*		Cred x EducDeg: F=6.00 **		

Note: *p<.05; ** p<.001

Overall, a math interest score of 2.84 indicates 9th graders are close to agreeing math courses are interesting, but differences in scores vary very little between the four credential groups which suggests that teacher's level of education or math certification are not changing the way students perceive mathematics as a school subject. For the Education degree profile, the main effect of degree is statistically significant; teachers with Education degrees being able to stir more interest in their courses than those who do not have Education degrees, except for those with bachelor's and no certification. On the contrary, for the Math degree profile, the main effect for credential is significant with more variability among students taught by teachers with degrees in mathematics.

The analysis also shows statistically significant interaction effects between credential and degree type that are more pronounced when considering holding a degree in Education. For instance, when teachers have a bachelor's degree only and certificate, or have an Advanced degree even with no certification, student interest in math classes is higher when the teacher has one of these degrees in Education. Having a degree in Education, at any level, with or without math certification matters in making students more interested in the math courses. However, the highest math interest score is shown by students taught by teachers with a Mathematics degree who hold an Advanced degree even without teaching certification. Overall, there are some effects of teacher qualification on student math interest which suggests more qualified teachers are more likely to use classroom practices that stimulate student engagement and interest for mathematics (Skilling, 2014; Skilling et al., 2016).

Discussion

The overarching objective of this study was to describe and explore which math teacher qualifications have the most impact on Grade 9 student math achievement, beliefs, and attitudes toward mathematics. Study findings show that teacher credential type based on the level of university degree and possession of math teaching certificate, combined with subject expertise based on holding either Math or Education degrees have an effect of student math-related outcomes in agreement with prior research (e.g., Hill & Dalton, 2013; Lee, 2018; Mohr-Shroeder et al., 2017; Podolsky et al., 2019). This study contributes to the literature by examining and comparing the combined effect of teacher qualifications in relation to student outcomes.

Thus, a teacher qualification profile based on bachelor's degree and no math teaching certification, regardless of whether the bachelor's is in Math or Education, appears to be the least effective in producing positive student outcomes. Since most state policies require certification in the content area at secondary level, lack of state certification has negative effects on student achievement (Shuls & Trivitt, 2015), particularly if the teacher's degree is not in Mathematics. Since student math achievement is associated with math identity (Allen & Schnell, 2016), it is not surprising that this teacher qualification profile is also less successful in developing student math identity, regardless of the content-specific knowledge of the teacher degree. Not holding a math teaching certificate also suggests teachers are less interested in pursuing a teaching career and may not identify themselves with the subject matter, so they cannot serve as role models for students as anticipated by the Cognitive Apprenticeship Theory (Collins, 2006). As noted previously, these teachers succeed however in shaping math utility beliefs in their students which is the only positive effect on student education.

A teacher qualification profile based on bachelor's degree and math teaching certification, leads also to modest effects on student outcomes. Student math achievement is slightly improved compared to the previous teacher profile, and it appears to be higher if the teacher had a degree in Education rather than Math. This suggests the math certification overcomes the lack of content-specific knowledge that would have been acquired by holding a math degree. This in turn leads to higher levels of student beliefs when comparing the Education and Math degree profiles. Overall, teacher certification on top of a bachelor's degree does not appear to change much the student outcomes because acquired competencies and teaching ability depend more on the actual certification pathway and the performance in the licensure exam (Shuls & Trivitt, 2015).

A teacher qualification profile based on Advanced degrees without math teaching certification, leads to several positive effects. The effect of Advanced degrees on student math achievement is particularly important, since this teacher qualification profile is associated with the highest student achievement for the research sample, if the teacher holds a math degree (at any level). Previous research confirms that teacher's level of education is correlated to student achievement (Mohr-Shroeder et al., 2017) particularly when teachers have majored in the school subject that they teach (Hill & Dalton, 2013; Lee, 2018). Content-specific knowledge is key in supporting student learning and math achievement (Hill & Lubienski, 2007; Shuls & Trivitt, 2015). The current study also found that teachers with Advanced degrees without math certification but math degree background, are fostering a learning environment that leads to highest levels of math identity, math self-efficacy and interest in math courses, However, lack of math certification creates a disadvantage for teachers with Education degrees, leading to lower math identify and math self-efficacy for their students.

An ideal set of teacher qualifications corresponds to the profile based on Advanced degrees and math teaching certification, leading to positive effects on math achievement (Hill & Dalton, 2013), as well as math identity and math self-efficacy (Bagaka's, 2011; Hannula et al., 2016; Mason, 2003). At this qualification level, differences in student outcomes between teacher groups holding (or not) Math and Education degrees are less important because there is a compensatory effect between the educational experience related to an Advanced degree and the content-specific knowledge acquired through math certification.

Limitations

This quantitative study focuses only on a limited number of teacher qualification factors. First, a limitation of the study was to focus only on teacher qualification factors that describe formal education, and not informal qualification based on experience, cultural competencies, etc. The formal teacher qualifications are critical in hiring decisions and in continuing training/education for teachers, so the investigation of their effects is important for policy and practice. Second, we could not include years of experience because the data did not allow to identify the number of years teaching high school math. Moreover, the literature supports the effect of years of experience on students' math achievement is evident at elementary and middle school level, but less at the high school level (Harris & Sass, 2011). Another limitation is related to the use of the degree variables. We acknowledged that the Math/Statistics and Education profiles may not be exclusive (e.g., some teachers may have both Math and Education degrees, or none), but we only described the effect of each degree (i.e., related to either content-specific

or pedagogy-specific knowledge) on student outcomes, and did not test which one impacts more the student outcomes. Even if the selection of teacher qualifications has some limitations, it has allowed to build an argument for this exploratory study. Finally, the data allowed to examine only a limited set of student beliefs (i.e., self-efficacy, math utility, math identity) and one attitudinal measure (interest in math courses) that cover a quite large palette of non-cognitive factors contributing to student success. We also did not include individual teacher characteristics (e.g., gender, race) or teaching classroom practices.

Conclusion

According to Bregant (2016), mathematical competency plays a significant role in determining an individual's success in life. Therefore, a major implication of this research study is the need for educators to understand the factors that increase student math performance. Based on the data from this research, it is evident that teacher qualifications impact student beliefs and attitudes that in turn affect their math achievement. It is also apparent that teacher qualifications cannot be limited only to degree level and certification. Content expertise is crucial in producing authentic math teachers recognized for their effective pedagogy, identity, ability to cultivate similar values in others (Bialystok, 2015), and finally capable to create a community of practice that stimulates students' interest and motivation (Hannula et al., 2016).

Recommendations

The study findings provide useful information for teachers, school administrators and policymakers. Findings show that student math achievement, beliefs and attitudes are related to teacher qualifications. Ideally, in addition to being certified to teach high school math, effective and inspiring teachers obtained degrees in both education and math, reaching advanced levels. The complementary effect of certification, advanced degrees, and subject expertise increases teachers' own beliefs in the importance of high academic standards. Therefore, it is important for schools to encourage math teachers to engage in further education to further develop their math teaching competency, but also learn new strategies to stimulate student self-efficacy and help them identify with the subject. Findings also suggest there is a need for policymakers to focus on certification requirements, support teachers seeking advanced degrees and certification in math, improve hiring practices by attracting specialized teachers, and retain talented and well-educated math teachers.

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Appendix. Variables and Constructs

Variable Name	Type	Codes/Categories
Student Variables		
Student math achievement (X2TXMQUINT)	5-category variable, treated as a continuous ordinal variable, range (1-5)	1=First Quintile (lowest); 2= Second Quintile; 3= Third Quintile; 4= Fourth Quintile; 5= Fifth Quintile
Math Identity (2-item scale: S1MPERSON1, S1MPERSON2)	Likert Scale (1= Strongly Disagree; 2=Disagree; 3=Agree; 4= Strongly Agree). Alpha Cronbach =.841	Composite Score (MEAN) → Continuous Variables (1-4)
Math Self-Efficacy (4 item scale: S1MTESTS, S1MTEXTBOOK, S1MSKILLS, S1MASSEXCL)	Likert Scale (1= Strongly Disagree; 2=Disagree; 3=Agree; 4= Strongly Agree). Alpha Cronbach =.898	Composite Score (MEAN) → Continuous Variables (1-4)
Math utility (3-item scale: S1MUSELIFE, S1MUSECLG, S1MUSEJOB)	Likert Scale (1= Strongly Disagree; 2=Disagree; 3=Agree; 4= Strongly Agree). Alpha Cronbach =.775	Composite Score (MEAN) → Continuous Variables (1-4)
Interest in math courses (3-item scale: S1MENJOYING, S1MWASTE, S1MBORING)	Likert Scale (1= Strongly Disagree; 2=Disagree; 3=Agree; 4= Strongly Agree). Alpha Cronbach =.782	Composite Score (MEAN) → Continuous Variables (1-4)
Math Teacher Qualification Variables		
Credential type (M1HIDEG, X1TMCERT)	4-Category variable combining level of education (Bachelor vs. Advanced/Specialized) with Math certification (Yes/No)	1= Bachelor & No Certification 2= Advanced & No Certification 3= Bachelor & Certification 4= Advanced & Certification
Degree (Bachelor or above) in Math/ Statistics (M1BAMAJ2, M1HIMAJ2	2-Category Variable	0= No 1= Yes
Degree (Bachelor or above) in Education (M1BAMAJ2, M1HIMAJ2)	2-Category Variable	0= No 1= Yes