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# Equity Trends in Mathematics Education: A Content Analysis of Meta-analytic Research

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## Abstract

The purpose of this quantitative content analysis (QCA) was to characterize equity-related trends in meta-analyses of mathematics education studies. An a priori keyword search and retrieval process produced an initial pool of 156 studies. After applying the prescribed inclusion criteria, the initial pool of studies was reduced to a final sample of 32 studies. These studies were coded and analyzed as part of the QCA. The coding and analysis were guided by a critical quantitative research lens, which examines how numeric trends can help to unpack systemic and systematic practices that support the agenda of the dominant cultural group. The results indicate that 62.5 percent of the reviewed studies lacked an equity focus, while most equity-focused meta-analyses examined challenges related to student ability. Moreover, 14 out of the 16 or 87.5 percent of the equity-related moderators had a statistically significant influence on effect size variance. The results of this study suggest that across most mathematics education meta-analytic studies effect size magnitude is impacted by equity-related moderators that are often absent. The researchers provide implications for meta-analytic thinking and equitable research praxis in mathematics education.

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## Introduction

The ability of research syntheses and meta-analyses in mathematics education to inform teaching and learning across student populations and contexts is a measure of these studies' impact on equitable classroom practices and educational policy. According to the National Council of Teachers of Mathematics (NCTM), “creating, supporting, and sustaining a culture of access and equity require being responsive to students’ backgrounds, experiences, cultural perspectives, traditions, and knowledge when designing and implementing a mathematics program and assessing its effectiveness” (NCTM, 2014). Since research often guides or informs classroom practice and policy in mathematics, it is imperative that study designs and results also reflect similar sentiments. In this manner, the research design, analysis, and reporting processes can afford or constrain progress towards equity in mathematics teaching and learning.

Meta-analyses are uniquely positioned within mathematics education research to impact classroom practice because they synthesize multiple studies coherently and comprehensively for both researchers and classroom

stakeholders. Meta-analysis is defined as the exhaustive inquiry that combines ostensibly similar studies to generate an average overall measure of effect size across studies and contexts. The obtained effect size summaries from meta-analyses provide a measure of relationships amongst variables. The implications of these relationships support theory building and testing, which has a tremendous scholarly impact (Aguinis et al., 2011). Moreover, the efficiency and accessibility of meta-analyses are often reflected in the substantial differences in citation frequency counts for meta-analyses and other review articles compared to individual empirical studies across multiple fields and subject areas (Aksnes, 2006; Kulkarni et al., 2013; Schumm & Crawford, 2019). Given the impact of meta-analyses on mathematics educational practice, these syntheses must reflect equitable research practices.

The use of meta-analysis in mathematics education has grown drastically over the last several decades. The results of meta-analyses inform every stage of the mathematics teaching and learning process. These projects include studies synthesizing the effects of technology integration on mathematics achievement, gender-differences in mathematics achievement, as well as summaries of the effects of interventions on student mathematics dispositions (Else-Quest, Hyde, & Linn, 2010; Picho, Rodriguez, & Finnie, 2013).

The results of meta-analyses and systematic reviews inform effective teaching and learning for all students in mathematics. However, meta-analysis results must represent all students before they can foster equitable changes in mathematics classrooms. In summary, well-designed meta-analyses in mathematics education should inform teaching and learning for all students. Still, little work has been done to examine the extent to which meta-analytic studies in mathematics exhibit equity in their design and data presentation practices.

## **Conceptual Framework**

This study interrogates the results of prior meta-analyses that focus on mathematics learning outcomes. This study aims to critique the methodological traditions of meta-analytic research in light of the increased attention that has been placed on the numerous equity-related challenges and considerations in mathematics education research and practice. Critical quantitative research (CQR) is used as a framework to appropriately position this work within the equity-centered education literature.

### **Critical Quantitative Research**

Critical Quantitative Research (CQR) is: dedicated to asking critical questions; connected to strategic political actions and agendas; guided by research questions and data grounded in a historical and political context; equipped to examine systems that promote power and privilege, and critical of current methods but seeks viable alternatives (Covarrubias & Velez, 2013, Stage, 2007). Critical research, in general, asserts that: (1) knowledge is mediated by longstanding societal power relations, (2) facts are not absent from values, (3) the relationship between concept and object is evolving and socially mediated, (4) language facilitates subjectivity, (5) certain groups have privilege over others that is maintained when the subordinate group accepts their position, (6) oppression has multidimensions that must be examined simultaneously, and (7) traditional research practices

tend to reproduce class, race, and gender oppression (Kincheloe & McLaren, 1994). Although other emergent forms of critical quantitative inquiry exist (e.g., Quantcrit), CQR remains relatively absent from investigations of equity trends within mathematics education.

Quantitative interrogations of critical issues are not only viable but warranted (Stage, 2007). However, methods to guide these analyses remain in their infancy compared to other research methods and approaches. Figure 1 presents the research methods and motivations for the Critical Quantitative paradigm. Essentially the critical quantitative paradigm operates at the intersections of the Critical and Positivist-Postpositivist paradigms. The Critical Quantitative Paradigm's methodological framing is drawn primarily from the Positivist-Postpositivist paradigms of traditional quantitative research. Thus, the Critical Quantitative paradigm seeks to aggregate data in a broad, generalizable, group-focused, and context-independent manner.

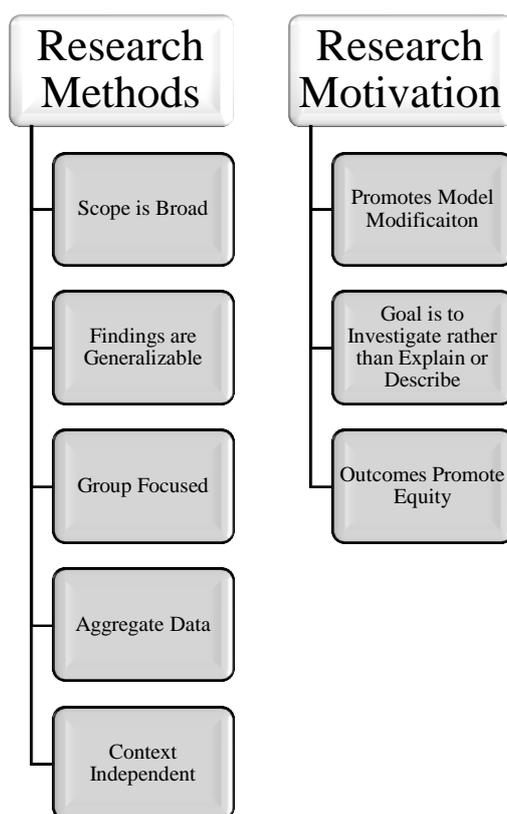


Figure 1. Research Methods and Motivation for Critical Quantitative Research

In contrast, traditional critical research is more in-depth, interpretive, individual focused, idiographic, and context dependent. However, the motivations of the Critical Quantitative paradigm are more closely aligned to the critical paradigm. For instance, the Critical and the Critical Quantitative paradigms are both equity-focused. This is important because equity and social justice remain essential to NCTM's dedication to successful mathematics teaching and learning for all students. Yet, equitable research practices are rarely explicitly addressed in the broader mathematics education research landscape. Unfortunately, mathematics education often relegates discussions of equity to a subset of scholars within the mathematics education field, rather than establishing policies and practices that encourage all mathematics education researchers to champion the cause

for equitable research practice.

There are two fundamental factors related to the research motivations of the Critical Quantitative paradigm that make it uniquely divergent from the Critical and Positivist-Postpositivist paradigms. The Critical paradigm seeks to question models, while the Positivist paradigm seeks to verify and confirm models. However, the Critical Quantitative researcher works to move beyond questioning the model to making modifications to the model that disrupt the power structures that maintain the status quo. Hence, through the present study, we seek to dismantle the tradition of under sampling, under-examining, and underreporting specific demographic groups within mathematics education, limiting the ability to inform their learning through research.

Finally, unlike the critical paradigm that seeks to describe and the positivist paradigm that seeks to explain, the Critical Quantitative paradigm aims to investigate. To investigate means to carry out a systematic or formal inquiry to discover and examine the facts so as to establish truth (Merriam-Webster, n.d.). The Critical Quantitative paradigm goes beyond describing, which only considers all the relevant characteristics, qualities, or events, and explaining, which seeks to make a problem clearer by describing it in more detail or revealing facts or ideas. Through investigation, the Critical Quantitative paradigm leverages quantitative research methods to uncover facts and then scrutinizes these facts adding a critical voice to the data that provide a new truth.

This study leverages the elements of the Critical Quantitative paradigm to investigate the research reporting and foci represented in mathematics-related meta-analytic research. This CQR project focuses on meta-analyses because these studies use quantitative methods to provide statistical summaries of the factors and interventions that influence mathematics learning outcomes. As critical quantitative researchers, we have two tasks: (1) use data to represent educational processes and outcomes on a large scale to reveal inequities and to identify social or institutional perpetuation of systematic inequities in such processes and outcomes and (2) question the models, measures, and analytic practices of quantitative research to offer competing models, measures, and analytic practices that better describe experiences of those who have not been adequately represented (Stage, 2007, p. 10). By leveraging prior meta-analytic results, we have chosen arguably the largest scale for this project because these data represent decades of research in mathematics education.

Mathematics education has made tremendous strides toward more inclusive, equitable, and socially justice teaching practices. Still, until the research practices that guide the field are interrogated, it is more likely that the research informing mathematics teaching and learning practices will reflect the dominant culture's interests. Secondly, meta-analyses are highly cited studies that drive not only classroom practices but educational policy. By utilizing CQR, we will question the methods, reporting, and interpretation of these studies. Based on our investigation, we provide alternative interpretations and methods to lead the field towards analytic and pedagogical practices that better represent the experiences of those who are traditionally marginalized.

### **Why are Equity-focused Meta-analytic Practices Important?**

Meta-analytic thinking is essential to theory development, empirical evaluation, and subsequent classroom

practices. Notable early meta-analyses in mathematics education have altered perceptions on mathematics anxiety (Hembree, 1990), gender differences in mathematic attitudes (Hyde et al., 1990), and legitimized the presence of calculators in the mathematics classroom (Hembree, & Dessart, 1986). These three articles have a combined citation count of nearly 3,500 according to Google Scholar, which is indicative of their importance to the field of mathematics education. These three studies provided quantitative summaries of research and detailed explanations that moved the field of mathematics education forward when individual effects were misleading or inclusive. Equity-focused meta-analytic practices can have a similar impact on the field through the application of meta-analytic thinking.

Meta-analytic thinking is an important practice that can help foster equity through empirical evaluation and benchmarking. Meta-analytic thinking allows scholars to use the mean effect sizes and confidence intervals from meta-analyses to benchmark primary studies' effect sizes. This form of meta-analytic thinking transcends the realm of statistical significance into practical significance by facilitating the comparison of a primary study effect sizes to overall effect size estimates. For example, suppose we have a mean effect size estimate for an intervention on a specific demographic group of learners. In that case, all subsequent effect sizes could be compared to the overall estimate to evaluate the finding's relative impact. Studies with larger effect sizes can then be replicated to help generalize the results. Thus, meta-analyses that reflect all students' demographics are necessary to move the field of mathematics education efficiently toward more equitable learning outcomes. Unfortunately, these meta-analytic affordances are often not feasible due to poor reporting and sampling practices at the individual and meta-analysis study level.

### **Demographic Data Reporting Trends**

Equity-focused meta-analyses in mathematics education have important implications for classroom practice and policy. Yet, equity-focused meta-analyses are constrained by the limitations of all meta-analyses —study availability and data transparency. Learning outcomes are a common dependent variable in educational research. Thus, most meta-analyses are not limited due to a lack of reporting or availability of studies with specific measured learning outcomes. However, the underreporting of participant demographic data is a concern across multiple social science disciplines (Jones et al., 2020) and has profound equity implications. According to the Organisation for Economic Cooperation and Development (OECD), equity on the PISA is measured by whether education outcomes, such as access to schooling, student performance, students' attitudes, and beliefs and students' expectations for their future, are related to a student's background. Yet, participant background information is often limited, despite specific recommendations from the American Psychological Association (APA). According to the APA, researchers should “Report major demographic characteristics (e.g., age, sex, ethnicity, and socioeconomic status) and important topic-specific characteristics (e.g., achievement level in studies of educational interventions) (APA, 2020, p. 78). Yet as noted earlier, these demographic characteristics tend to be under-reported. Subsequently, due to the under-reporting of student demographic characteristics in primary studies, meta-analytic inquiries into specific issues related to equitable learning outcomes are often underpowered and remain under-examined.

## **Equity Related Moderators**

Access to student demographic data such as gender, race, language, and socio-economic status (SES) are essential to examining equity in meta-analysis through moderator analysis. In practice, moderator analyses are conducted using ANOVA meta-analytic analogs (for discrete variables) and regression (for continuous variables). Moderator analyses have major implications for equitable mathematics teaching and learning. Moderators allow the meta-analyst to quantify qualitative variables that influence the strength or direction of relationships in meta-analytic research (Steel & Kammeyer-Mueller, 2001). Quantifying these relationships is the key to understanding how to increase the efficiency of educational interventions.

Moderators are also essential because they identify statistical interactions, which do not imply causation but add context to effect size results (Cooper & Patall, 2009). Notably, in a meta-analysis, moderator effects represent relations between the moderator variable and effect size (Hedges & Pigott, 2004). Given the distinctions among the associations they identify, moderators are consistently placed in three categories: (1) methodological variations, (2) theoretical constructs, or (3) participant characteristics (DeCoster, 2004). All three of these categories of moderators have implications for mathematics education. However, in the present study, we focused our attention on participant characteristics as these moderators often reflect student demographic characteristics and elements related to the learning environment.

## **Purpose Statement**

The impact of participant demographic characteristics is often examined as moderators within meta-analyses of research; however, the reporting of race, gender, ability, culture, and SES demographic data usually varies across studies. Moderator analyses are one mechanism to examine equity trends within meta-analyses. However, what remain elusive are examinations of reporting trends in equity-related student demographic moderators examined in mathematics meta-analyses. Therefore, the purpose of this quantitative content analysis was to characterize equity-related trends in meta-analyses of mathematics education studies. The following research questions guide the present study:

1. How are demographic characteristics represented in meta-analyses of mathematics education research?
2. What is the impact of demographic characteristics on the results of meta-analyses of mathematics education research studies?

## **Method**

We applied a non-experimental approach using quantitative content analysis to examine meta-analyses in mathematics education published between 2000-2015. We chose this timespan because, after the STEM Education Act of 2015, there was a decline in mathematics-specific meta-analyses and an increase in interdisciplinary content area meta-analyses in education (e.g., STEM). Quantitative content analysis was applied in the present study because it provides a systematic, structured, and objective means to quantitatively characterize trends in journal articles and other media sources (Riff et al., 2019). The units of analysis for the

present study were a representative sample of meta-analyses selected from journals with an acute focus on the teaching and learning of mathematics. We conducted an exhaustive search of the published literature to locate meta-analyses that examined mathematics education-related independent and dependent variables identified by applying the guiding principles for school mathematics (e.g., teaching and learning, access and equity, curriculum, or tools and technology). To locate appropriate studies, we searched the following academic databases: Academic Search Elite, ERIC, and PsychInfo using the keywords *mathematics education*, *meta-analysis*, *literature review*, and *systematic review*. Additionally, we searched the following journals given their specified scope: *Journal for Research in Mathematics Education (JRME)* and *Review of Educational Research (RER)*. The search process yielded an initial pool of 156 studies. Then we used three inclusion criteria to narrow the pool of studies. Specifically, we only included studies that: (1) included a statistical synthesis of effect sizes, excluding qualitative meta-syntheses or narrative reviews, (2) were published between 2000 and 2015, and (3) had an acute focus on mathematics education. After applying these criteria, a final pool of 32 studies was identified for coding and analysis. We initially coded 10 of the 32 studies together as a training exercise for interrater agreement and then coded the remaining 22 individually.

A comprehensive coding sheet was developed to collect descriptive statistics and pertinent categorical data from each meta-analysis (see Figure 2). The coding sheet was used to collect descriptive statistical data such as year of publication, number of effect sizes, mean effect sizes, number of moderators, and moderator type. We also cataloged the number of citations each article received from Google Scholar over 48 hours to reduce the odds of additional citations accruing over time. Initially, we hoped to utilize other citation reporting sources such as Scopus but found that more than 50 percent of the included articles were published in journals not indexed in Scopus or Web of Science. Thus, for consistency Google Scholar was used to gather article citation frequency scores. To account for the “vintage effect” or influence of time on the number of citations accrued, a citation index was developed by computing the ratio of the number of article citations by the number of years the article was available. All denominators in this calculation were rounded to the nearest year. Thus, the citation index estimates the number of citations each article received per year and is one indicator of the impact of each study in the field. We exported all coded data into a Microsoft Excel spreadsheet for frequency analysis and categorization. The representative coded variables are presented below:

1. Year of population: between 2000-2015
2. Grade level: 0 for elementary, 1 for middle school, 2 for secondary, 3 for post-secondary, and 4 for mixed levels
3. *N*: number of included studies
4. *k*: number of effect sizes
5. *ES*: reported mean effect size
6. Diversity and Equity Focused (i.e., IV): 0 for No, 1 for Yes
7. Equity focus: 0 for Gender, 1 for Race, 2 for Ability, 3 for Linguistic Diversity, and 4 for SES
8. Moderators: number of moderators analyzed
9. Diversity related moderators analyzed: 0 for Gender, 1 for Race, 2 for Ability, 3 for Linguistic Diversity, and 4 for SES
10. GS: number of google scholar citations

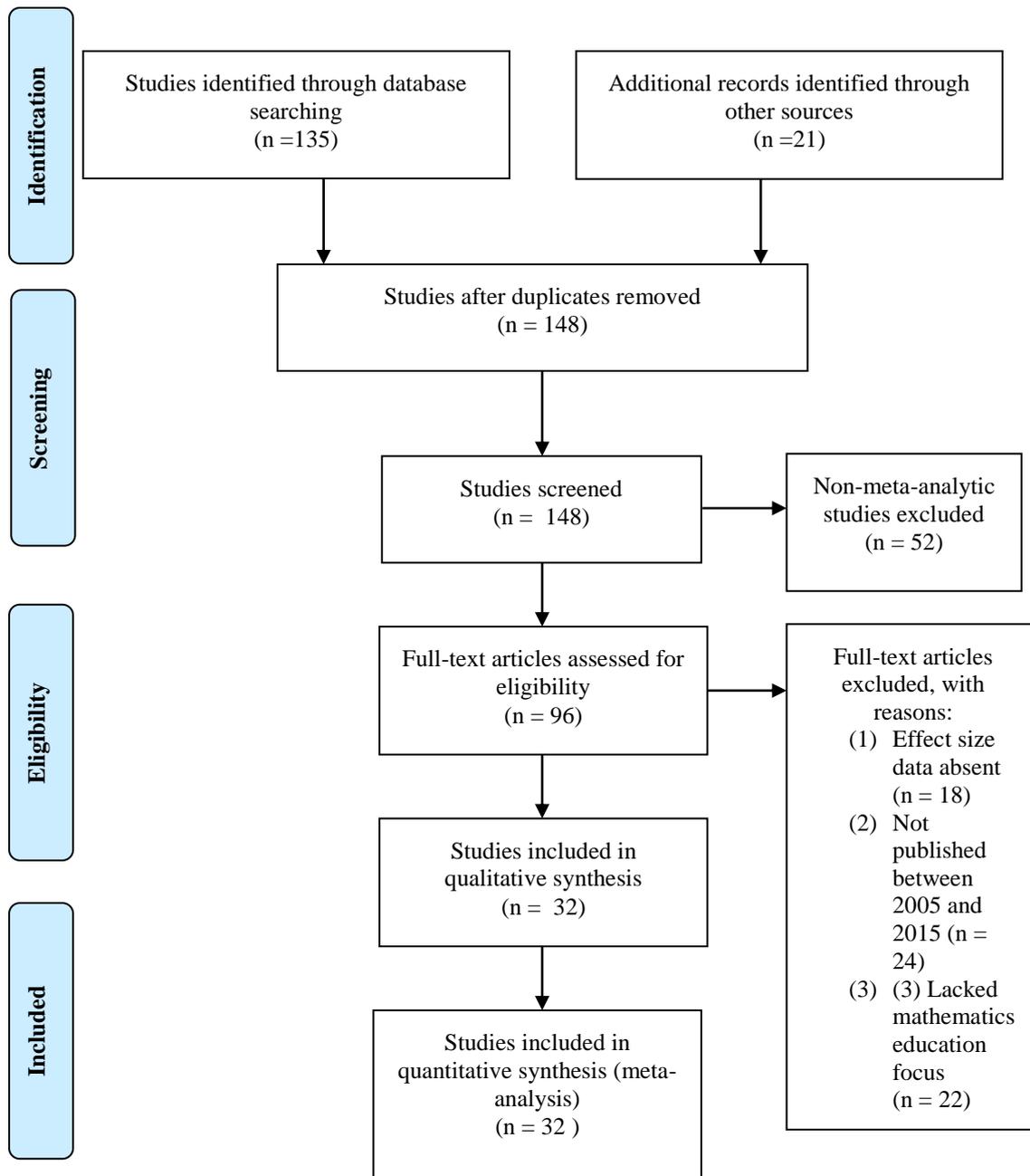


Figure 2. Flowchart of Study Retrieval and Review Process

## Results

From the pool of 32 meta-analyses reviewed in this study, the years of publication ranged from 2000 until 2015, the median and mode of the years of publication were 2011 and 2013, respectively. The majority of the studies included were articles (87.5%), with only four unpublished studies (i.e., research reports and conference proceedings). Moreover, 9(32.14%) of meta-analyses were published in educational psychology journals, followed by 7(21.88%) in general education journals, and 4(12.5%) in each of the remaining categories (i.e., mathematics education, special education, review journals, and unpublished studies). On average, each meta-

analysis included a mean of  $M_n = 44.50$ ,  $CI[42.27, 47.73]$  independent studies, from which an average number of effect sizes of  $M_k = 90.47$ ,  $CI[83.14, 96.87]$  independent effect sizes were analyzed.

The central tendency and distribution of overall effect sizes are important indicators of the included studies' empirical and practical impact. Due to the vast array of independent and dependent variables measured across the included meta-analyses, an overall mean effect size was not appropriate. However, we did determine that the median  $ES$  was  $Mdn_{ES} = .36$ . It is important to note that the data depicted in figure 2 represent only effect size magnitude and not the direction of the effects as some of the dependent variables were negatively scaled (e.g., mathematics anxiety and stereotype threat). Using an adaption of Cohen's benchmarks as an organizational tool, we consider 3 effect sizes to be small (i.e., 0.0-0.1), 7 to be modest (i.e., 0.1-0.3), 13 to be moderate (i.e., 0.3-0.5), and 8 to be large (i.e., >0.5). The smallest mean effect size was observed for gender differences in mathematics achievement (Lindberg et al., 2010), while the largest mean effect size was observed for the effect of problem posing on problem-solving (Rosli et al., 2014).

Table 1. Meta-analysis Studies

Author	Purpose	Equity Focus	Diversity Moderators	$K$	$ES$
Baker et al. (2002)	A meta-analysis of the effects of interventions to improve mathematics achievement of students considered at risk for academic failure.	Ability	Absent	39	.46[.38, .54]
Blank & de las Alas (2009)	A meta-analysis of professional development with a content focus on mathematics outcomes.	Absent	Absent	21	0.21[.06, .36]
Capar & Tarim (2015)	Examined the influence of the cooperative learning method compared with that of traditional methods on mathematics achievement and attitudes towards mathematics.	Absent	Absent	36	0.59 [.38, .80]
Carbonneau et al. (2013)	A meta-analysis to examine the empirical evidence regarding the use of manipulatives during mathematics instruction.	Absent	Absent	55	0.37[.30, .44]
Chan & Leung (2014)	A meta-analysis to evaluate the effects of DGS-based instruction on improving students mathematical achievement.	Absent	Absent	9	1.02[.56, 1.48]
Codding et al. (2011)	A meta-analysis of research on interventions to support basic fact fluency.	Ability	Absent	55	0.5[.36, .64]
Durkin (2011)	A meta-analysis of the positive self-explanation effect across mathematics domains.	Absent	Absent	18	0.37[.12, .63]
Ellington	A meta-analysis of the effects of calculator	Absent	Ability*	61	0.32[.07, .58]

(2003)	use on student achievement and attitude levels.					
Ellington (2006)	A meta-analysis of the effects of non-CAS calculators on attitudes and achievement in mathematics.	Absent	Absent	97	.35[.09, .61]	
Else-Quest et al. (2010)	A meta-analysis of cross-national patterns of gender differences in mathematics achievement.	Gender	Absent	86	.47[.37, .57]	
Fischer et al. (2013)	A meta-analysis of interventions supporting children's mathematics school success.	Ability	Ability*	39	0.36[-.27, .99]	
Gersten et al. (2009)	A meta-analysis of instructional approaches to enhance mathematics proficiency of students with learning disabilities.	Ability	Absent	41	.63[.60, .66]	
Haas (2005)	A meta-analysis of effects of teaching methods on algebra achievement.	Absent	Ability*	66	.39[.17, .60]	
Holmes (2013)	A meta-analysis of the existing evidence for manipulatives interventions.	Absent	Absent	21	.22[.05, .39]	
Hughes et al. (2014)	A meta-analysis of interventions aimed at improving algebra performance of students with disabilities.	Ability	Ability*	12	0.62[.48, .76]	
Jacobse & Harskamp (2011)	A meta-analysis examining the impact of interventions in mathematics education in K-6 classrooms.	Absent	Ability	69	0.58[.45, .72]	
Kroesbergen & Van Luit (2003)	A meta-analysis of mathematics interventions in special education.	Ability	Ability*	61	0.51[.44,.58]	
Kunsch et al. (2007)	A meta-analysis of peer-mediated interventions on the mathematics performance of students with disabilities and those at risk for mathematics disabilities.	Ability	Ability*	55	0.47[.20, .61]	
Li & Ma (2010)	A meta-analysis of the effects of computer technology on mathematics education.	Absent	Gender, Race, Ability*	85	0.28[.13, .43]	
Lindberg et al. (2010)	A meta-analysis of gender differences studies of mathematics performance.	Gender	Race*, Ability*	441	0.05[-.01, .10]	
Mickelson et al. (2013)	A meta-analysis examining the effects of school racial composition on mathematics outcomes.	Race	Race*	98	-0.06[-.08,-.05]	
Nunnery et al. (2013)	A meta-analysis of the mathematics achievement impacts of a cooperative learning model.	Absent	Absent	15	0.16[.10, .21]	

Picho et al. (2013)	A meta-analysis of the effects of stereotype threat (ST) on mathematics outcomes.	Gender	Gender*	103	-0.24[-.35, -.14]
Rakes et al. (2010)	A meta-analysis of the effects of instruction on algebra instruction.	Absent	Absent	109	.34[.24,.44]
Rosli et al. (2014)	A meta-analysis of research findings on the effectiveness of problem posing in the teaching and learning of mathematics.	Absent	Absent	14	1.31[1.04, 1.59]
Sokolowski et al. (2015)	A meta-analysis examining the effects of word problem solving and exploration in grades 1 to 8.	Absent	Absent	24	0.6[.53, .66]
Sosa et al. (2011)	A meta-analysis examining the effects of CAI on statistics achievement.	Absent	Absent	45	0.33[.20, .46]
Steenbergen-Hu & Cooper (2013)	A meta-analysis of the effectiveness of intelligent tutoring systems (ITS) on mathematics learning.	Absent	Ability*	65	0.09[-.03, .20]
Uttal et al. (2013)	A meta-analysis of the malleability of spatial skills	Absent	Gender*	1,038	0.47[.43, .51]
Vaughn (2000)	A meta-analysis of the relationship between music and mathematics achievement.	Absent	Ability*	41	.24[-.38, .86]
Wang et al. (2007)	A meta-analysis of the impact of administration mode on K-12 student mathematics tests.	Absent	Absent	44	-0.11[-.12, -.09]
Young & Young (2015)	A meta-analysis of the effects of anxiety on mathematics achievement in K-12 African American students.	Race	Absent	10	-0.36[-.48, -.23]

To measure the impact of the included meta-analyses on the field, we retrieved the number of citations associated with each study. The mean citation number for the included meta-analyses was  $M_{\text{cite}} = 102.28[97.21, 106.79]$ . Since citations typically increased over time, we also calculated the mean of the ratio between the number of citations and the number of years the study was available ( $M_{\text{citeratio}} = 12.46[6.46, 18.48]$ ). The included meta-analyses represent the overall effect size estimates for important mathematics learning outcomes and are relatively well cited across multiple disciplines and venues. Hence, the selected studies have practical as well as empirical implications for mathematics education.

### Equity-focused Studies and Moderators

Five categories of demographic characteristics (i.e., gender, race, ability, language, and SES) were used to identify studies with an equity-focused population of interest. Of the 32 studies included in the present content analysis, 12 had an equity-focused population of interest. Specifically, 7(58.33%) of the meta-analyses focused on students with disabilities, followed by 3(25%) with a focus on gender, and 2(16.67%) of studies focused on

different ethnic or racial groups. Likewise, 13 meta-analyses or 40.63 percent included at least one demographic characteristic as a categorical moderator variable. In sum, 16 demographic characteristics were analyzed as moderators, 14 were statistically significant moderators of study effects (87.5%). In the next section, we unpack the trends in examined equity moderators.

Ability was examined in 10(62.5%) studies and was always a statistically significant moderator of effect sizes across studies. Gender and race were examined as moderators in 3(18.75%) studies independently and were both statistically significant moderators 2 out of the 3 individual instances examined within each category. It is important to note that language and SES were not examined as moderators in any included studies. Additionally, amongst the four meta-analyses published in mathematics education-related journals, only one focused on equity. Likewise, only one of the studies published in a mathematics education journal included demographic characteristics as moderators of effect sizes (see Figure 3).

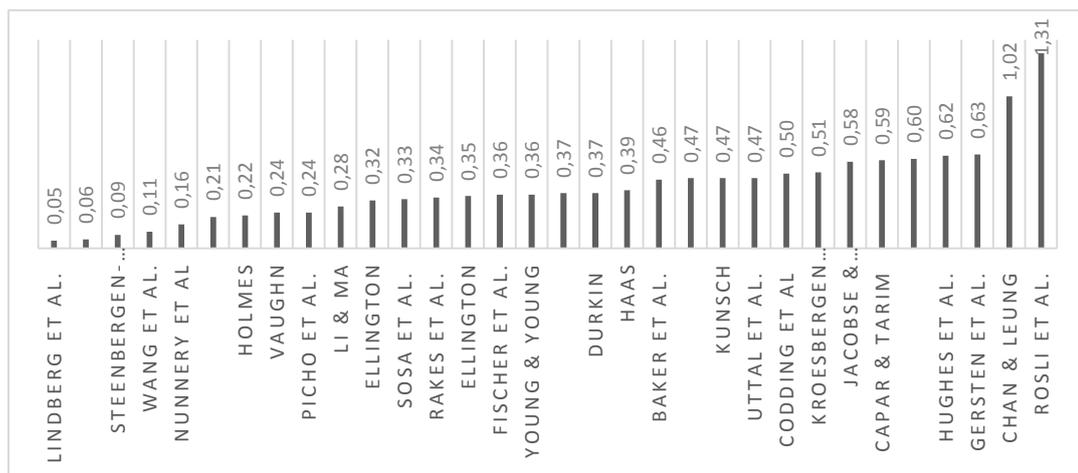


Figure 3. Overall Effect Size Trends across Included Studies

## Discussion

The data from this content analysis have instructional as well as empirical implications for equitable mathematics education. Moderators are recognized for their ability to enhance theory development and increase the general richness of empirical work (Aguinis et al., 2011). Given the empirical merit of meta-analyses in mathematics education and the contextualization offered by moderator analysis, characterizing the equity-focus demographic characteristics across studies is practically and empirically necessary to support all learners' achievement. The following discussion sections review the instructional and empirical implications of the present study.

### Instructional Implications

The effect size data indicate that the reviewed interventions in mathematics education have a noticeable impact on mathematics learning outcomes. The median overall effect size for the reviewed meta-analyses was .36. This

median effect size is comparable to the so-called “zone of desired effects” ( $d=0.4$ ) observed by Hattie in his synthesis of over 800 meta-analyses of educational research. According to Hattie (2008), an effect size of .4 or less is the expected annual student growth each year. Thus, effect sizes less than or equal to .4 do not represent a meaningful impact on learning. In the present study, 13 or 40.6% of the meta-analyses had effect sizes larger than .4, indicating a meaningful instructional impact. These numbers, however, require further interrogation as many of the studies that met the threshold for “desired effects” did not report or examine any student racial, gender, ability, or socioeconomic characteristics, which is a threat to the external validity of the results as the generalizability across groups is unknown.

Beyond posing a potential threat to external validity, the absence of demographic characteristic data impedes progress towards equitable mathematics learning opportunities for all students. When meta-analysts fail to address the impact on student backgrounds as moderators of overall effect sizes, communities serving culturally, linguistically, and economically diverse learners are now dually challenged as they are often under-resourced and now underinformed. Subsequently, this lack of pertinent research data increases opportunity gaps because the data governing these schools' decisions do not adequately or accurately reflect their needs.

For instance, Rosli et al.'s (2014) meta-analysis of the effects of problem posing on mathematics teaching and learning generated an overall effect size of more than a standard deviation, which is a considerable effect size by all accounts. Yet, because the researchers did not examine how student backgrounds such as gender, race, ethnicity, or ability may afford or constrain these effects, the results are less meritorious for educators serving diverse learners. Historically, mathematics education research has been conducted in communities serving mostly White middle-class learners; thus, it is fair to assume that when researchers underreport participant demographics in primary studies or meta-analyses, the included participants are more likely not culturally, linguistically, or economically diverse learners.

However, it is important to note that in the meta-analyses where student backgrounds were examined, there were statistically significant empirical and substantial instructional impacts worth considering. Equity-focused demographic characteristics were consistent moderators of effect sizes, which has pertinent instructional implications. Moderators of effect sizes in meta-analyses of mathematics education varied in their influence on learning outcomes. However, the practical significance of these findings is important. For instance, one of the smallest effect sizes observed was -.06 for the effects of school racial composition on student achievement in mathematics. This has substantial practical merit for social justice because it suggests that although schools that serve larger populations of students of color have lower mathematics performance than other schools, the relationship is essentially negligible. This is important because it helps dispel the common narratives that blame the students rather than the system. The negligible relationship suggests that other factors beyond just the racial composition of schools have a larger influence on school achievement differences. Notably, examining school opportunity structures is essential to understanding achievement differences across schools. This is just one example of the importance of equity-focused meta-analytic research to support social justice in mathematics education.

Furthermore, the results indicate specific demographic characteristics of participants were the focus of only 40% of meta-analyses reviewed. Given that mathematics education research and most educational meta-analyses are intervention focused this result is not surprising, as many scholars tend to operate under a “color-blind” research lens (Wells, 2014). However, because demographic characteristics were statistically significant moderators of effect sizes almost 90% of the time they were included and reported, student backgrounds cannot be ignored in the mathematics research as the data indicate that student demographics matter.

Moreover, this is an important reminder to mathematics educators that we do not teach “mathematics”; rather, we teach students. This critically important distinction is often lost and devalued as one ascends the grade level continuum from Pre-K to 12<sup>th</sup> grade. Because students are unique, they require instruction from teachers dedicated to developing their dispositions (e.g., identity, attitude, and self-efficacy) and mathematics content knowledge. For traditionally marginalized and minoritized populations of mathematics learners such as students of color, girls, and children with special needs, these affective dimensions are essential to their perseverance and long-term success in mathematics.

### **Research Implications**

The research implications from the present study are twofold. First, the studies reviewed in this content analysis are well cited in the field based on the average number of recorded citations per article. These citation trends suggest that these studies currently inform research and mathematics education praxis. Secondly, and of more import to the present study, the results summarize the effect sizes across studies and characterize the influence of equity-focused demographic characteristics on these effect sizes' heterogeneity. In the remaining sections of this discussion, we focus on unpacking these demographic characteristics' influence on effect size magnitudes across studies.

The range of effect sizes in the present study was notable. However, moderators' observed influence on the magnitude of effect sizes across studies has important implications for research. Moderator analysis is the most critical feature of any meta-analytic study. As Rosenthal (1991) argues, “The search for moderators is not only an exciting intellectual enterprise but indeed...it is the very heart of scientific enterprise” (p. 447). Moderators offer conditions for theorized effects, thus informing researchers of the circumstances in which the effects under investigation can be reliable (Schmidt & Hunter, 2014). This information is essential to the development of high-yield interventions and strategies that support diverse mathematics learners. Essentially, differences in strength and direction in effect sizes are identified through moderator analyses, thus examining moderators provides researchers the ability to generalize the optimization of study effects.

In this study, we observed that equity-focused demographic characteristics are powerful moderators of effect sizes that are unfortunately underreported or considered in mathematics education research's meta-analyses. Less than 40 percent of the studies examined in this content analysis had an explicit focus on equity or included diversity-related moderators. The majority of meta-analyses focused on student ability, followed by gender. Subsequently, as a field, mathematics education has made tremendous strides towards inclusion and gender

parity. Arguably, a great deal of this progress was due to the representation of ability and gender-related studies related to mathematics teaching and learning. Contrarily, racial, ethnic, and linguistic diversity remain underreported demographic characteristics in many primary research studies, limiting the investigation of these characteristics as moderators in meta-analyses.

According to global statistics, culturally and linguistically diverse students and students experiencing poverty remain under-served in many mathematics classrooms (International Association for the Evaluation of Educational Achievement, 2019). Global underachievement trends are often attributed to differences in opportunities to learn. However, we contend that culturally unresponsive research designs and poor reporting practices contribute to researchers' lack of opportunities to “discern” when intervention effects are truly generalizable. Our results indicate that future meta-analyses within mathematics education should reflect culturally responsive sampling and participant reporting practices. These practices will help research consumers to discern better the applicability of study results to the populations of learners they serve.

Culturally Responsive Research (CRR) involves moving “beyond foci on a priori, static group identities, and outcomes towards the inclusion of sociohistorical processes that locally reproduce enduring educational disparities (Trainor & Bal, 2014, p. 204). This is the ideal operationalization of CRR. However, as noted earlier, all meta-analysts are limited by the data collected and reported in primary research. Hence, we call on the entire field of mathematics education to improve reporting practices by considering a CRR reporting approach. In the context of the present study, we argue that the future meta-analyses differentiate their search and inclusion processes to maximize the potential to include diverse populations of mathematics learners (Trainor & Bal, 2014). Likewise, to improve meta-analytic reporting practices, researchers should describe participant characteristics identified as potential moderators. However, if these data are noticeably absent from most primary studies in the pool, researchers should report the frequency statistics for these variables to increase awareness. This form of data transparency will improve primary study inclusive practices by explicitly identifying participant gaps present in primary studies. In summary, we urge all education journal editors, specifically mathematics education journal editors, to encourage CRR reporting practices for primary researchers and meta-analysts to increase the examination of diversity-related moderator submissions.

## **Conclusion**

The present content analysis examined meta-analyses as one mathematics education research tradition that could inform classroom practices that support under-served students' unique needs. According to Cooper (2016), a meta-analysis involves (1) summarizing several studies regarding effect sizes and (2) combining the results to make summative inferences. The complete process involves calculating the average effect size, testing for homogeneity, detecting moderators, and explaining any heterogeneity (Hunter & Schmidt, 2004). Clear, consistent, and comprehensible evidence is necessary to promote the actualization of equitable mathematics teaching. Thus, meta-analysis was selected as the unit of analysis in the present study given the highly structured research process.

We argue that researchers can make better decisions concerning equity and diversity in the mathematics classroom by using a meta-analytic lens. Yet, as shown in the data observed in the present study, there is an under examination of race and linguistic diversity within meta-analytic research in general and within moderator analyses. It is important to note that this study, much like meta-analyses in general, was limited by the availability of studies examining certain factors. However, given the longstanding disparities in the predictive learning outcomes between well and poorly-resourced communities, more meta-analytic examinations of the impact of race, linguistic diversity, and SES are warranted. In general, whenever feasible diversity-related moderators should be examined to help promote social justice and equity within mathematics education. In conclusion, we contend that this study is a step forward for equitable practices in mathematics education and culturally responsive research designs and reporting in mathematics education research.

## References

- Aguinis, H., Dalton, D. R., Bosco, F. A., Pierce, C. A., & Dalton, C. M. (2011). Meta-analytic choices and judgment calls: Implications for theory building and testing, obtained effect sizes, and scholarly impact. *Journal of Management*, *37*(1), 5-38. <https://doi.org/10.1177/0149206310377113>
- Aksnes, D. W. (2006). Citation rates and perceptions of scientific contribution. *Journal of the American Society for Information Science and Technology*, *57*(2), 169-185. <https://doi.org/10.1002/asi.20262>
- Baez, B. (2007). Thinking critically about the “critical”: Quantitative research as social critique. In F. K. Stage (Ed.), *Using quantitative data to answer critical questions* (pp. 17-23). San Francisco, CA: Jossey-Bass
- \*Baker, S., Gersten, R., & Lee, D. S. (2002). A synthesis of empirical research on teaching mathematics to low-achieving students. *The Elementary School Journal*, *103*(1), 51-73. <https://doi.org/10.1086/499715>
- \*Blank, R. K., & de las Alas, N. (2009). Effects of teacher professional development on gains in student achievement: How meta-analysis provides scientific evidence useful to education leaders. Washington, DC: The Council of Chief State School Officers. Retrieved from <http://www.ccsso.org/content/pdfs/Final%20Meta%20Analysis%20Paper%20full.pdf>
- \*Capar, G., & Tarim, K. (2015). Efficacy of the cooperative learning method on mathematics achievement and attitude: A meta-analysis research. *Educational Sciences: Theory and Practice*, *15*(2), 553-559.
- \*Carbonneau, K. J., Marley, S. C., & Selig, J. P. (2013). A meta-analysis of the efficacy of teaching mathematics with concrete manipulatives. *Journal of Educational Psychology*, *105*(2), 380-400.
- \*Chan, K. K., & Leung, S. W. (2014). Dynamic geometry software improves mathematical achievement: Systematic review and meta-analysis. *Journal of Educational Computing Research*, *51*(3), 311-325.
- \*Coddling, R. S., Burns, M. K., & Lukito, G. (2011). Meta-analysis of mathematic basic-fact fluency interventions: A component analysis. *Learning Disabilities Research & Practice*, *26*(1), 36-47.
- Covarrubias, A., & Velez, V. (2013). Critical race quantitative intersectionality: An anti-racist research paradigm that refuses to “let the numbers speak for themselves.” In M. Lynn & A. D. Dixson (Eds.), *Handbook of critical race theory in education* (pp. 270-285). London, England: Routledge.
- \*Durkin, K. (2011). *The self-explanation effect when learning mathematics: A meta-analysis*. Paper presented at the Society for Research on Educational Effectiveness, Washington, DC.
- \*Ellington, A. J. (2003). A meta-analysis of the effects of calculators on students' achievement and attitude

- levels in precollege mathematics classes. *Journal for Research in Mathematics Education*, 433-463.
- \*Ellington, A. J. (2006). The effects of non-CAS graphing calculators on student achievement and attitude levels in mathematics: A meta-analysis. *School Science and Mathematics*, 106(1), 16-26. <https://doi.org/10.1111/j.1949-8594.2006.tb18067.x>
- \*Else-Quest, N. M., Hyde, J. S., & Linn, M. C. (2010). Cross-national patterns of gender differences in mathematics: a meta-analysis. *Psychological bulletin*, 136(1), 103. <https://doi.org/10.1037/a0018053>
- \*Fischer, U., Moeller, K., Cress, U., & Nuerk, H.-C. (2013). Interventions supporting children's mathematics school success: A meta-analytic review. *European Psychologist*, 18(2), 89-113. <https://doi.org/10.1027/1016-9040/a000141>
- \*Gersten, R., Chard, D. J., Jayanthi, M., Baker, S. K., Morphy, P., & Flojo, J. (2009). Mathematics instruction for students with learning disabilities: A meta-analysis of instructional components. *Review of Educational Research*, 79(3), 1202-1242. <https://doi.org/10.3102/0034654309334431>
- Gutiérrez, R. (2008). A "gap-gazing" fetish in mathematics education? Problematizing research on the achievement gap. *Journal for Research in Mathematics Education*, 357-364.
- \*Haas, M. (2005). Teaching methods for secondary algebra: A meta-analysis of findings. *Nassp Bulletin*, 89(642), 24-46. <https://doi.org/10.1177/019263650508964204>
- Hembree, R. (1990). The nature, effects, and relief of mathematics anxiety. *Journal for research in mathematics education*, 21(1), 33-46. <https://doi.org/10.2307/749455>
- Hembree, R., & Dessart, D. J. (1986). Effects of hand-held calculators in precollege mathematics education: A meta-analysis. *Journal for Research in Mathematics Education*, 17(2), 83-99.
- \*Holmes, A. B. (2013). *Effects of manipulative use on PK-12 mathematics achievement: A meta-analysis*. Poster presented at the meeting of Society for Research in Educational Effectiveness, Washington, DC.
- \*Hughes, E. M., Witzel, B. S., Riccomini, P. J., Fries, K. M., & Kanyongo, G. Y. (2014). A meta-analysis of algebra interventions for learners with disabilities and struggling learners. *Journal of the International Association of Special Education*, 15(1), 36-47.
- Hyde, J. S., Fennema, E., Ryan, M., Frost, L. A., & Hopp, C. (1990). Gender comparisons of mathematics attitudes and affect: A meta-analysis. *Psychology of women quarterly*, 14(3), 299-324.
- International Association for the Evaluation of Educational Achievement (IEA). (2019). *Trends in international mathematics and science study (TIMSS)*. <https://nces.ed.gov/timss/results19/index.asp#/math/achievement>
- \*Jacobs, A.E., & Harskamp, E. G. (2011). A meta-analysis of the effects of instructional interventions on students' mathematics achievement. Groningen, The Netherlands: GION, Gronings Instituut voor Onderzoek van Onderwijs, Opvoeding en Ontwikkeling, Rijksuniversiteit Groningen.
- Jones, S. H., St. Peter, C. C., & Ruckle, M. M. (2020). Reporting of demographic variables in the Journal of Applied Behavior Analysis. *Journal of applied behavior analysis*, 53(3), 1304-1315.
- Kincheloe, J. L., & McLaren, P. L. (1994). Rethinking critical theory and qualitative research. In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research* (pp. 138-157). Thousand Oaks, CA: Sage.
- \*Kroesbergen, E. H., & Van Luit, J. E. (2003). Mathematics interventions for children with special educational needs: A meta-analysis. *Remedial and special education*, 24(2), 97-114.
- Kulkarni, K., Kulkarni, M., Ramsden, J., & Silva, P. (2013). Are UK otorhinolaryngologists maintaining their

- research output? *The Journal of laryngology and otology*, 127(6), 556.
- \*Kunsch, C. A., Jitendra, A. K., & Sood, S. (2007). The effects of peer-mediated instruction in mathematics for students with learning problems: A research synthesis. *Learning Disabilities Research & Practice*, 22(1), 1-12. <https://doi.org/10.1111/j.1540-5826.2007.00226.x>
- \*Lindberg, S. M., Hyde, J. S., Petersen, J. L., & Linn, M. C. (2010). New trends in gender and mathematics performance: A meta-analysis. *Psychological Bulletin*, 136(6), 1123–1135.
- \*Li, Q., & Ma, X. (2010). A meta-analysis of the effects of computer technology on school students' mathematics learning. *Educational Psychology Review*, 22(3), 215-243.
- Mackenbach, J. P. (2003). Tackling inequalities in health: the need for building a systematic evidence base. *Journal of Epidemiology & Community Health*, 57(3), 162-162. doi: 10.1136/jech.57.3.162
- Martin, D. B. (2009). Does race matter. *Teaching Children Mathematics*, 16(3), 134-139. <https://doi.org/10.5951/TCM.16.3.0134>
- Merriam-Webster. (n.d.). Investigate. In *Merriam-Webster.com dictionary*. Retrieved March 8, 2021, from <https://www.merriam-webster.com/dictionary/investigate>
- \*Mickelson, R. A., Bottia, M. C., & Lambert, R. (2013). Effects of school racial composition on K–12 mathematics outcomes: A meta-regression analysis. *Review of Educational Research*, 83(1), 121-158.
- \*Nunnery, J. A., Chappell, S., & Arnold, P. (2013). A meta-analysis of a cooperative learning model's effects on student achievement in mathematics. *Cypriot Journal of Educational Sciences*, 8(1), 34-48. <https://archives.un-pub.eu>
- Organisation for Economic Cooperation and Development (OECD). (2019). PISA 2018 results (volume II): Where all students can succeed. <https://doi.org/10.1787/b5fd1b8f-en>
- Oliver, S., Bagnall, A. M., Thomas, J., Shepherd, J., Sowden, A., White, I., ... & Garrett, Z. (2010). Randomised controlled trials for policy interventions: a review of reviews and meta-regression. *Health technology assessment* (Winchester, England), 14(16), 1-165.
- \*Picho, K., Rodriguez, A., & Finnie, L. (2013). Exploring the moderating role of context on the mathematics performance of females under stereotype threat: A meta-analysis. *The Journal of Social Psychology*, 153(3), 299-333. <https://doi.org/10.1080/00224545.2012.737380>
- \*Rakes, C. R., Valentine, J. C., McGatha, M. B., & Ronau, R. N. (2010). Methods of instructional improvement in algebra: A systematic review and meta-analysis. *Review of Educational Research*, 80(3), 372-400.
- Riff, D., Lacy, S., Fico, F., & Watson, B. (2019). *Analyzing media messages: Using quantitative content analysis in research*. New York, NY: Routledge.
- \*Rosli, R., Capraro, M. M., & Capraro, R. M. (2014). The effects of problem posing on student mathematical learning: A meta-analysis. *International Education Studies*, 7(13), 227-241.
- Schumm, W. R., & Crawford, D. W. (2019). Evaluating the quality of literature reviews in the social science: developing a measure of quality with an illustration. *Psychology Research and Applications*, 1(2), 47-69. <https://dx.doi.org/10.22606/pr.2019.12003>
- \*Sokolowski, A., Li, Y., & Willson, V. (2015). The effects of using exploratory computerized environments in grades 1 to 8 mathematics: A meta-analysis of research. *International Journal of STEM Education*, 2(1), 8-17. DOI 10.1186/s40594-015-0022-z
- \*Sosa, G. W., Berger, D. E., Saw, A. T., & Mary, J. C. (2011). Effectiveness of computer-assisted instruction in

- statistics: A meta-analysis. *Review of educational research*, 81(1), 97-128.
- Stage, F. K. (2007). Answering critical questions using quantitative data. In F. K. Stage (Ed.), *Using quantitative data to answer critical questions: New directions for institutional research* (Vol. 133, pp. 5-26). San Francisco, CA: Jossey-Bass.
- \*Steenbergen-Hu, S., & Cooper, H. (2013). A meta-analysis of the effectiveness of intelligent tutoring systems on K–12 students’ mathematical learning. *Journal of Educational Psychology*, 105(4), 970–987. <https://doi.org/10.1037/a0032447>
- \*Uttal, D. H., Meadow, N. G., Tipton, E., Hand, L. L., Alden, A. R., Warren, C., & Newcombe, N. S. (2013). The malleability of spatial skills: A meta-analysis of training studies. *Psychological Bulletin*, 139(2), 352–402. <https://doi.org/10.1037/a0028446>
- \*Vaughn, K. (2000). Music and mathematics: Modest support for the oft-claimed relationship. *Journal of Aesthetic Education*, 34(3/4), 149-166.
- \*Wang, S., Jiao, H., Young, M. J., Brooks, T., & Olson, J. (2007). A meta-analysis of testing mode effects in grade K-12 mathematics tests. *Educational and Psychological Measurement*, 67(2), 219-238.
- Wells, A.S. (2014). Seeing Past the “Colorblind” Myth: Why Education Policymakers Should Address Racial and Ethnic Inequality and Support Culturally Diverse Schools. Boulder, CO: National Education Policy Center. Retrieved [date] from <http://nepc.colorado.edu/publication/seeing-past-the-colorblind-myth>.
- \*Young, J. R., & Young, J. L. (2015). Anxious for Answers: A Meta-Analysis of the effects of anxiety on African American K-12 students’ mathematics achievement. *Journal of Mathematics Education at Teachers College*, 6(2), 1-8. <https://doi.org/10.7916/jmetc.v6i2.611>

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