Using Standards-Based Grading to Reduce Mathematics Anxiety: A Review of Literature

Patricia Dempsey

Tonya Huber[1]

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Correspondence concerning this article manuscript should be addressed to
Professor Tonya Huber, PhD, Texas A&M International University, College of Education, 5201 University Boulevard, Laredo, TX 87041-1900. Email: tonya.huber@tamiu.edu
http://orcid.org/0000-0002-5078-8399

Abstract

Mathematics anxiety is a prevalent problem in many K-12 classrooms, and if not appropriately addressed can cause lasting educational harm to students as they enter adulthood. Researchers suggest that the finality of traditional grades has increased mathematics anxiety in today's classrooms. The extreme weight of grades, such as determining participation in school events, scholarship awards, and further education opportunities is a significant contributing factor to the increased heightened stress. The purpose of this literature review is to address one factor that can decrease mathematics anxiety, the use of standards-based grading, which shows mastery or progress towards mastery on individual standards. The beginning of this review will provide an overview of factors that lead to mathematics anxiety, then move into a discussion about the differences between traditional grading and standards-based grading, then a review of the relevant research studies, and finally an analysis of those studies which drives a call for additional research on this topic. The hope for this review of literature is to encourage math teachers to incorporate standards-based grading into their classrooms to help reduce the negative impacts of mathematics anxiety in students.

Introduction

Mathematics anxiety (MA) is significantly apparent in K-12 classrooms across the United States today. "Children have been found to report and demonstrate math anxiety as early as the first grade" (Sorvo et al., 2017, p. 324) which can leave lasting educational hurdles. "Mathematics is the academic area most associated with anxiety and students begin to report mathematics anxiety as early as fourth or fifth grade" (Grays et al., 2017, p. 189) which leaves many more years of schooling for students to suffer from this stress. Because of the prevalence of MA in students and the serious educational ramifications, this literature review will discuss the recent research studies conducted using *standards-based grading* (SBG), or "a practice that bases students' grades on their performance on a set of clearly defined learning objectives rather than the completion of assignments and tests or the accumulation of points" (Scarlett, 2018, p. 59), as a potential solution to reduce MA in K-12 classrooms. This literature review will first begin with an overview of the factors that cause MA; then a brief discussion of the differences between traditional grading and SBG; then an in-depth analysis of the literature that was used to write this review; and finally, a discussion of the findings and a call for additional research studies into the impact of SBG to reduce MA. Definitions of key terms related to this literature review are provided in Table 1. Four main terms that are necessary to define are *formative assessment*, *grades*, *math anxiety*, and *standards-based grading*. The latter two terms are the topic of this review, which warrants them to be defined. The second term in the table, *grades*, is a major factor in producing anxiety in the math classroom. And the first term in Table 1, *formative assessment*, is an influential type of assessment to properly implement SBG in the K-12 classroom.

Table 1

Key Terms

Key Term	Definition
formative assessment	"Data used to *inform* instruction rather than *evaluate* instruction" (Curry et al., 2016, p. 1). "Assignments designed to collect evidence of a student's progress towards meeting standards for feedback to assist the student in monitoring their own learning" (Scarlett, 2018, p. 64).
grades	"Grades are used to provide feedback, promote or retain students, identify students for special classes, grant admission into colleges or universities, and provide college scholarships. Additionally, for almost a century, academic grades have been used as a mechanism for managing adolescent behavior" (Knight & Cooper, 2019, pp. 65-66). "Grades in this approach [standards-based grading] are used to help identify students' strengths and weaknesses to foster growth rather than simply to identify talent" (Scarlett, 2018, p. 61).
math anxiety	"The state of fear, tension, and apprehension when individuals engage with math" (Ashcraft, as cited in Zhao et al., 2019, p. 1). "Mathematics anxiety is characterized by tense and anxious feelings that hinder manipulation of numbers and negatively impacts students' ability to complete basic mathematics courses or take advanced mathematics/science courses" (Grays et al., 2017, p. 180).
standards-based grading	"Core components include basing grades on proficiency of specific standards, removing behavior factors from academic grades, and allowing multiple opportunities to reach proficiency" (Knight & Cooper, 2019, p. 66). "Standards-based grading alters how grades are determined by focusing on standards, isolating academic evidence, and allowing multiple opportunities to demonstrate proficiency" (Knight & Cooper, 2019, p. 68). "Standards-based grading is a practice that bases students' grades on their performance on a set of clearly defined learning objectives rather than the completion of assignments and tests or the accumulation of points" (Scarlett, 2018, p. 59).

Factors That Cause Mathematics Anxiety

For the majority of students, the first encounter with MA happens around the first or second grade when more complex number sequencing or addition and subtraction equations are introduced (Sorvo et al., 2017, p. 324). MA is most commonly developed when students are in the fourth or fifth grade and can be caused from one or a combination of three major factors: age and gender, teaching environment, and family involvement. Many students, unfortunately, have heard the common saying that math is for boys, and it can take a serious toll on young girls who are interested in math. According to Zhang et al. (2019), "several studies showed significantly stronger MA in females than in males" (p. 2). Even though MA can develop at a young age, many students start to feel the intense pressure of performing well in class when they are in high school. Pollio and Hochbein (2015) state that "students' grades in secondary school can have immediate and weighty consequences" (p. 2) such as non-participation in extracurricular activities, loss of scholarship opportunities, or non-acceptance into higher education institutions. These high stress pressures can cause even more anxiety in math classrooms where many students already feel anxiety about complex computations and equation work.

In addition to age and gender as factors that contribute to a student developing MA, the teaching environment is also a factor. The educational philosophy of a teacher and their classroom environment can have a significant impact on student confidence in the math classroom. "Mathematics anxiety can be extreme; this anxiety is often caused by having a negative attitude due to previous bad experiences" (Preston & Radin, 2007, p. 16) which can increase the likelihood of students to avoid challenges in the math classroom. Primary school and elementary school teachers are tasked with the important role in creating a positive atmosphere for learning mathematics. They create the foundations of basic number sequencing and

computations which, if not done confidently or correctly, can increase the development of MA. "Educational professionals must be cognizant of academic and mental health (e.g. anxiety) variables impacting student learning in order to provide a comprehensive treatment package capable of ameliorating academic difficulties" (Grays et al., 2017, p. 198) by creating comfortable and welcoming learning environments. If this is not achieved, students could develop MA. Students "suffer from an irrational fear of mathematics that they are paralyzed in their thinking, inhibited in performance, and of course, prevented from learning" (Morris, 1981, p. 413, as cited in Bekdemir, 2010, p. 312). Students have reported, using the Math Anxiety Rating Scale, that their highest anxiety levels occur when "walking into a mathematics class, taking an examination (quiz) in a math course, taking an examination (final) in a mathematics class, and being given an unannounced quiz in a mathematics class" (Taylor & Fraser, 2013, p. 310). Not only do scheduled or unannounced examinations cause anxiety, the way a teacher collects and determines the grades of those assignments can increase MA. Pollio and Hochbein (2015) stated, "According to a wide array of research, secondary teachers relied on a variety of factors to determine students' grades" (p. 2) such as "effort, behavior, class participation, homework completion, ability level, and growth" (p. 2). This wide variety can cause confusion and concern for students who suffer from MA. With these different factors being considered, MA can increase in students and cause heightened levels of stress and anxiety.

The final factor that contributes to the development of MA is family involvement. Building a positive perception of mathematics within the student's family can encourage students to tackle challenges in the math classroom. "There is even some evidence that this comfort level can lead to decreases in math anxiety" (Furner & Berman, 2003, as cited in Davis & Kelly, 2017,

p. 6) because if students feel supported at home during educational challenges, then they are more likely to reach out for help.

Traditional Grading vs. Standards-Based Grading

Traditional grading is a form of record keeping that many students have endured in school. It is a final numerical grade that summarized the overall success or failure of the course. "For schools and teachers, grades have been operated as the primary form of communicating the performance of students to educational stakeholders … but [did] not necessarily communicate students' academic achievement" (Pollio & Hochbein, 2015, p. 4) especially if behaviors, such as punctuality, participation, and preparedness were averaged in with content mastery. Because of the unknown of a summarized grade, many educational stakeholders, district officials, state officials, and even parents, were genuinely confused between above average or average grades on report cards and then below average or severely below average state assessment grades. This confusion was then amplified when students were withheld grade advancement or even graduation because of failure of state assessments (p. 4). For many teachers, grades were considered "a main tool to encourage and monitor student engagement" (p. 5) with a focus on student understanding of material. But traditional grading has fallen out of favor with many teaching philosophies because of the murky message the grade was sending—what does the student actually know?

SBG "is a practice that bases students' grades on their performance on a set of clearly defined learning objectives rather than the completion of assignments and tests or the accumulation of points" (Scarlett, 2018, p. 59). Instead of one overall grade for the course, multiple grades are displayed that have a direct tie to state standards or a learning target, therefore detailing specific content levels of mastery within a course. A major differentiating

factor between traditional grading and SBG is that SBG bases "academic grades solely on academic factors" (Knight & Cooper, 2019, p. 66), meaning behavior grades are not included in the grade. The most significant factor that separates traditional grading from SBG is that it "practices – and sometimes requires – students to make multiple attempts at proficiency on a given skill" (p. 67). The highlight of using SBG is because "allowing opportunities for reassessment provides teachers with opportunities to use grades to facilitate meaningful communication with students about their specific strengths and weaknesses" (Scarlett, 2018, p. 61). This conversation with students can help reduce MA because it invites those students to be an active participant in the learning discussions and reduces the finality of a grade. "Having the knowledge, or understanding, that it is not the end can greatly help students who suffer from mathematics anxiety" (Sorvo et al., 2017, p. 325) because they know they have a chance to retry or redo their efforts to show a better understanding later on or seek additional help before moving on to more challenging material.

Methodology

In order to find relevant peer-reviewed articles and research studies, a database search through WorldCat was conducted. Refined search criteria included peer-reviewed, full text articles between January 2014 and October 2019 that were available through the databases in Texas A&M International University Killam Library. The research for this literature review began with a simple term search for *standards-based grading*. The results for this search were overwhelming and could not possibly be sorted through, which is why it is not included in Table 2. From this initial point, narrowed searches were conducted, as can been seen in Table 2. The first narrowed search included *reluctant learners* AND *at-risk students* which resulted in 41 sources, 2 of those inspired a more narrowed focus; *standards-based grading* and *math anxiety*.

The determination to focus on this more specific topic is why this search was completed last and is therefore listed last in Table 2. Additional searches focused on the topic of this academic literature review and yielded manageable search numbers, which according to Galvan and Galvan (2017) are search results between 50 and 150 results (p. 42). The final search included *standards-based grading* AND *math anxiety* which resulted in 96 sources and 3 of them were determined to be relevant and provide the foundation for this review. There were many articles and studies that were excluded from this literature review because they (a) limited the participants to just students who receive special education services, (b) did not include sufficient data and/or data analysis to be confidently included in this literature review, and (c) only compared standards-based grading and traditional grading practices without declaring a preferred method.

Table 2

Audit Trail of Database Searches

Database	**Dates Reviewed**	**Search Terms**	**Sources Located**	**Relevant Sources**
WorldCat	Jan. 2014-Oct. 2019	"standards-based grading" AND "reluctant learners" AND "at-risk students"	41	2
WorldCat	Jan. 2014-Oct. 2019	"standards-based grading" AND "effective assessment" AND "math education"	97	2
WorldCat	Jan. 2014-Oct. 2019	"standards-based grading" AND "classroom education" AND "implementation"	21	2
WorldCat	Jan. 2014-Oct. 2019	"standards-based grading" AND "math anxiety"	96	3

Analysis

In Table 3, the researcher gives an in-depth look at the prominent research considered for this literature review. The research studies that were examined thoroughly to create the discussion and conclusions of this literature review are both qualitative and quantitative and were examined based on the guidelines provided in Galvan and Galvan (2017), specifically chapters six and seven, *Analyzing Quantitative Research Literature* and *Analyzing Qualitative Research Literature* respectively (pp. 65-87). Table 3 is formatted into four columns: the author, publication year, and participants; detailed methodology; strengths and weaknesses; and findings. The methodologies of the five research studies ranged from quantitative studies, such as Pollio and Hochbein (2015), to qualitative phenomenological studies, such as Knight and Cooper (2019). The third column discusses strengths and weaknesses identified by the author of this literature review. Strengths were determined based on the relation to the topic of this literature review, using SBG to help reduce MA, specifically focusing on how SBG was used to reduce academic anxieties that were directly tied to math classrooms or how SBG was used to engage and motivate students to continue facing challenges and hurdles in the classroom. Weaknesses of the following research studies were determined based on the classroom environment, sample group, and depth of data analysis conducted by the researchers. The final column details specific findings from the research studies that the author of this literature review determined to be essential learning points of the research studies. These essential learning points formed the basis of the following section, D*iscussion and Findings*, where direct quotes from the research studies are stated and how they work together to support the use of SBG to reduce MA.

Table 3

Overview and Findings of Relevant Research Studies

Author(s), Publication Year, and Participants	**Detailed Methodology**	**Strengths and Weaknesses**	**Findings**
Chamberlin (2013) 108 prospective teachers enrolled in a three-credit mathematics course at two mid-sized universities.	Prospective teachers assessed using a standards-based grading approach: homework, quizzes, tests, and projects At the end of the course, the prospective teachers completed a survey in class, and 106 of them completed the written reflection afterwards.	Strengths • "We aligned the course with recommendations for a standards-based pedagogy. We emphasized conceptual understanding and reasoning, facilitated through the implementation of worthwhile tasks and problem-solving activities" (p. 372). • "Informal and formal assessments were used to guide instruction, to provide information about the prospective teachers' mathematical understandings, and to foster learning" (p. 372). Weaknesses • Participants were prospective teachers in a college level mathematics course. • The prospective teachers "plan failed to take into account their future elementary students' conceptions of mathematics" (p. 376).	"15 prospective teachers said that the emphasis [on standards-based grading] was to understand mathematics, rather than an emphasis on memorization or determining right answers" (p. 374). "Promisingly, the prospective teachers plan to implement in their future teaching many of the standards-based strategies…" (p. 376).
Curry et al. (2016) "A purposeful sampling of mid-sized suburban public-school district in the Midwest" (p. 92).	Qualitative case study that used: interviews, field notes, observations, and document analysis	Strengths: • "Purposeful sampling was used because this district was identified as emphasizing a formative, teacher-centered approach to data generation and utilization at the classroom level to enhance instructional practices and student performance outcomes" (p. 4).	"Teachers stated that a benefit of this 'non-threatening, transparent approach' to data use was that is encouraged teachers to continually evaluate their own instructional practices and adjust those practices to more closely meet student needs" (p. 97). "Given the fact that effective teachers are the single most important determinant of how students achieve, maximizing

		Weaknesses • Focused solely on reading data, which is not the subject of this review. • "We also do not suggest that findings from this study can be generalized beyond this current district" (p. 16).	teacher expertise and teacher motivation to use data to inform instruction is essential" (p. 101).
Gagnon & Maccin (2007) 167 educators who taught math to a random sample of special and general education students.	An open-ended survey that asked teachers to: define math, understanding of course topics, instructional strategies effectiveness, preparation time, factors that increase/decrease effectiveness, such as types of instructional methods, types of feedback, and level of teacher direct instruction.	Strengths: • "The sample was obtained from the Quality Education Data (QED) database. QED is a comprehensive database of U.S. schools and school personnel and has been used in national research" (p. 46). • "Separate surveys for general educators and special educators" (p. 46). Weaknesses • No codes were used to identify those who specifically taught math "increasing the possibility that some participants were ineligible for participation" (p. 46). • "A larger number of special educators than general education educators was sampled" (p. 46).	"The implications noted relate to the importance of teacher training programs and professional development opportunities for training educators to use instructional practices that are effective for helping students with special needs in math" (p. 54). "… there is a need for more intensive, ongoing professional development opportunities for teachers that address both content knowledge and pedagogy" (p. 55).
Knight & Cooper (2019) Purposeful sampling of 7 teachers who currently used standards-based grading (SBG) in their math and science classrooms for at least one school year prior to the study.	Teachers were interviewed, observed, and documentation was reviewed throughout the study. At the conclusion of the study, a more in-depth interview that focused on implications of SBG occurred. Interview data was then compared to the data collected during the observations and documentation.	Strengths • Use of "audit trails and member checks help researchers 'report this data in such a way that it can be confirmed from other sources if necessary'" (Guba & Lincoln, 1981, p. 126, as cited in Knight & Cooper, 2019, p. 70). • Phenomenological methodology Weaknesses • "First, student behaviors were explored through the perceptions of their teachers, rather than directly from students. Second, participants relied on memory to compare	"Participants repeatedly referenced a connection between SBG and more purposeful planning, instruction, and assessment" (p. 74). "Participants noted specific effects of more purposeful planning, instruction, and assessments, namely that their instruction was driven by assessment data and differentiated for student needs, and assessments became more rigorous" (p. 74). "…teachers point out effects of SBG on their education of students' needs, students' understanding of the purposes

		their experiences with SBG and traditional grading, which may have diluted their perceptions of change. A third limitation is that the practice of reflexivity may not have completely removed the influence of our personal experiences with SBG" (p. 70).	and expectations for their learning, the provision of clear feedback for students and parents, and more learning-centered student conversations" (p. 76). "Several teachers mentioned how SBG gave students 'the language to know what they need help with'" (p. 77). "According to some participants, students are not the only beneficiaries of clearer communication; parents also gain a better understanding of where students are and how they can improve" (p. 77). "SBG was perceived to meet students' needs for intellectual safety because both students and teachers become more comfortable making mistakes" (p. 80). "As a result of shifting from fixed to more growth mind-set habits, participants perceived an increase in student confidence" (p. 83).
Pollio & Hochbein (2015) 11 high schools under reform after the Race to the Top legislation was passed in the State of Kentucky. 11th graders in math and science classes.	"… quantitative analyses to compare the association between classroom grades and standardized test scores" (p. 1). "Quasi-experimental" design to study the relationship between standards-based grading and higher achievement on state mandated high stakes test (p. 14). Three groups were created. First group, the control group, was graded using traditional methods of grading. The second	Strengths: • Direct use of standards-based grading in math classrooms. • "strong correlation between the use of standards-based grading and higher scores" on state mandated tests (p. 17). • "students who achieved higher grades in their mathematics class also achieved higher scores on the {state assessment] when they experienced standards-based grading as compared to traditional grading" (p. 21). Weaknesses • "Although standards-based grading enabled teachers to	"Results indicated that the rate of students earning an A or B in a course and passing the state test approximately doubled when utilizing standards-based grading practices. In addition, results indicated that standards-based grading practices identified more predictive and valid assessment of at-risk students' attainment of subject knowledge" (p. 1). "When evaluated by standards-based grading, nearly twice as many students scored proficient when successful in their core content class. These findings provided strong evidence to suggest that standards-based grading approaches should be central to

	group used standards-based grading in both their math and science classes. The third group was spilt into two mini groups, one group used standards-based grading in their math class and traditional grading in their science class, and the second mini group was vice versa.	focus instruction and conversations on subject matter attainment, this emphasis on attainment also challenged them when assessing diligent, but underperforming students" (p. 20). • "In answering our research questions, we did not consider anecdotal evidence" (p. 20). • "The level of implementation of standards-based grading within each school and classroom was not explored in this study" (p. 22).	an educational reform movement" (p. 23). "The results support the reasoning that the grades students receive in a core content class using standards-based grading actually reflect what the students know and can demonstrate on state proficiency assessments. This suggests that grades in a standards-based assessment system more validly reflect student learning" (p. 23).

Discussion/Findings

Using SBG to reduce MA has a strong correlation because of the focus on mastering individual concepts. From the research studies discussed in the previous section, an overwhelming response to the positives of SBG and how it can foster engagement, motivation, and ownership of learning, has tied its use to helping reduce MA. A major component of MA is the finality of grades, which creates the fear of incorrectly using an equation or completing a computation. SBG allows students to demonstrate, at their own pace, their ability to master content and advocate for themselves.

A major component of successful implement of SBG, that is mentioned throughout the literature studied for this review, is the use of formative assessments as the main method to communicate progress on mastery content. As stated in Table 1, formative assessments are used to "*inform* instruction rather than *evaluate*" (Curry et al., 2016, p. 1) mastery or understanding of content. Formative assessments are used as a check for understanding, a place to provide feedback, and useful data points to help teachers craft differentiated lessons or instruction to meet all students at their current level of understanding. Speaking on a personal note on the use

of formative assessments to help combat classroom related anxieties, I have found that the use of formative assessments, graded or not graded, have been beneficial in properly implementing SBG units of instructions. Students are able to see exactly where the confusion or mastery is for that particular piece content. That identification of understanding or not allows students to take ownership of their future learning and build their confidence in the classroom. By using a numerical grade, written feedback, or student self-reflection, the importance of administering, examining, and returning formative assessments to students has been an essential part of implementing SBG in my classroom. Table 4 adds additional points of interest from the five research studies analyzed in this literature review. These quotes add further emphasis of how SBG can be used to reduce MA in K-12 classrooms.

Table 4

Direct Quotes from Research Studies

Author(s) and Publication Year	Direct Quotes
Chamberlin (2013)	The prospective teachers "instructional preferences included providing direct opportunities for students. Promisingly, the prospective teachers plan to implement in their future teaching many of the standards-based strategies utilized in the mathematics course. They felt such strategies respond to students' mathematical 'understandings' and provide learners with firsthand and active experiences" (p. 376). "We should note however that helping prospective (and in-service) teachers move toward a conception-based perspective is challenging, and not much is known about how to do so. One course is likely not enough to significantly change the perspectives of prospective teachers" (p. 377).
Curry et al. (2016)	"… the extent to which data effectively advance instructional practice in the classroom has been linked to teachers' assessment practices, pedagogical views, and the relevancy, usefulness, and accessibility of data" (p. 13).
Gagnon & Maccin (2007)	"Many states have math standards and assessments that reflect the NCTM standards and require students to be proficient in higher level math and problem-solving skills. This may be a daunting challenge for students with a history of math failure – particularly for students with EBD and LD. To help these learners achieve, educators must be prepared to teach math via empirically validated techniques and the use of instructional strategies consistent with the NCTM standards" (p. 55).
Knight & Cooper (2019)	"Although this study was not intended to prove whether SBG is effective, it provided insight for administrators and teachers on the ways in which SBG practices affect planning, instruction, assessment, classroom environment, and students' behavior, thus helping practitioners decide if and how changes may be applicable to their own contexts" (p. 85).
Pollio & Hochbein (2015)	"To make systemic change within secondary education, measurement researchers stated that grades need to be based solely on levels of achievement within a class" (p. 5). "For grades to be a valid measure of student achievement, teachers must assess students on their achievement based on required curriculum standards" (p. 6). "Within two traditional grading cohorts, success in the classroom as defined by grades did not translate into success on the [state assessment]" (p. 15).

Conclusion/Implications

Using standards-based grading to reduce mathematics anxiety is supported by the review of the literature presented in this paper. The key component of SBG is the ability to determine individual standards mastery and the opportunity to continuously improve. By removing the pressure to show mastery at the first assessment and encouraging students to stay motivated by multiple attempts, MA should be reduced. The promise of SBG to reduce MA has potential to be considered in research across other disciplines and areas of study correlated with creating anxiety. A call for future research to definitively determine that SBG can reduce MA is needed to create a stronger case and determine if it is beneficial in other disciplines.

The research studies analyzed in this literature review represented the perspectives of teachers, schools, or district administrators, not students. A suggestion for future research studies is to focus on the use of SBG in math classrooms and the impact on student perceptions of math content through the use of surveys or interviews. Our goal as educators to make learning a student-centered process, therefore including the opinion of students, would greatly add to the validity of using SBG in the classroom. Researchers also need to consider SBG beyond application in teaching math, but also in application to disciplines and courses that create stress and anxiety around learning. As educators, our goal is to inspire students to fully engage in the learning process by helping with challenges and hurdles in the classroom, not placing barriers and restrictions.

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