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Impacts of Standards-Based Grading on Students' Mindset and Test Anxiety

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Abstract: Standards-based grading is an alternative grading method with many claimed benefits. This paper reports on quantitative studies investigating several of these oft-made anecdotal claims, such as reducing students' test anxiety and fostering a growth mindset. We found that standards-based grading did reduce students' test anxiety; moreover, the typically found difference in test anxiety between male and female students was eliminated in standards-based grading courses. We found no change in students' growth mindset, but that students' mastery avoidance goals were reduced.

Keywords: test anxiety, standards-based grading, achievement goal orientation, growth mindset

Introduction

Standards-based grading (SBG) is a method of grading in which course grades are primarily determined by the number of content standards a student masters. Like other forms of mastery grading, SBG has been growing in popularity since the standards-based reform movements of the 1990's (Guskey, 2008). In the secondary setting, adoption has gone beyond the individual classrooms to entire schools and even districts. Implementation at post-secondary institutions has lagged behind but is also growing, particularly in mathematics; these implementations are done almost exclusively by individual instructors.

SBG practitioners cite many benefits over "traditional", i.e., weighted-average, grading. For example, SBG is reported to lower students' stress and anxiety, and promote a more positive mindset; these and other claims are detailed below. Most of these assertions are based on theoretical arguments supported by instructor observations and anecdotal student responses to open-ended questions. While the author agrees with many of these arguments, few have been empirically tested, either with a validated quantitative instrument or a thorough qualitative approach. The purpose of this paper is to conduct a quantitative investigation of two of these proposed benefits, namely whether SBG affects mathematics students' test anxiety and their mindset.

Standards-Based Grading

Standards-based grading is a particular form of mastery grading (sometimes called competency-based or proficiency-based grading). The predominant form of grading at post-secondary institutions is assignment-based: course grades are computed based on a weighted average of scores attached to various assignments. SBG, on the other hand, involves marking grades by content standard, rather than by assignment, and basing the course grade on how many of these standards have been met. Campbell et al. (2020) recently characterized SBG by three defining features:

(1) Student are provided a clear list of objectives ("standards") and the course letter grade is based primarily (or entirely) on how many of these standards a student has mastered by the end of the course.
(2) Student work is assessed for mastery of these standards, often with a binary rubric. Feedback is provided to the student by standard, rather than by assignment; that is, no overall score is given for any assignment.

(3) Eventual mastery matters; students are provided multiple opportunities to demonstrate mastery of each standard and are not penalized for failing to master a standard on a given attempt.

Most of the literature on SBG, particularly in the post-secondary setting, makes theoretical claims about its benefits, and supports them with instructor reflections and/or anecdotal student perceptions. For example, Weir (2020) noted that the structure of SBG promotes the interleaving of material, due to students revisiting standards they did not master on the first attempt; and that this interleaving is known to promote learning (Dunlosky et al., 2013). Owens (2015) reflected that SBG causes a shift in the types of instructor-student conversations that take place: students are less focused on "points", and instead ask richer questions about improving their understanding of the content. Several authors assert that grades under SBG more accurately reflect student progress than under weighted average grading, based on the authors' experience (Lewis, 2020; Weir, 2020).

Combining anecdotal student perceptions with their observations as instructors, both Nochese (2011) and Stange (2018) report that SBG helps increase students' confidence. Carberry et al. (2012) conducted a more robust study showing that SBG improved engineering students' self-efficacy, as measured by a validated tool.

Along the same lines, many papers claim that SBG results in lower stress and anxiety for students (Harsy 2020; Lewis, 2020; Kelly, 2020; Linhart, 2020; Selbach-Allen et al., 2020; Stange, 2018). Though not always doing so explicitly, most authors seem to be referring to test anxiety, which is discussed in detail below. In each case, the authors substantiate their claim with anecdotal student comments: the author is unaware of any thorough qualitative studies supporting this claim, and only a single study that uses a validated quantitative instrument to study the impact of SBG on test anxiety (Author, 2020). In contrast to the previously mentioned literature, this study reported that test anxiety actually increased; the present paper aims to resolve this apparent contradiction.

Finally, there are several papers that argue that SBG promotes a growth mindset, rather than a fixed mindset (e.g. Collins et al., 2019; Harsy, 2020; Kelly, 2020). Similarly, Elsinger and Lewis (2019) provide a theoretical rationale that SBG promotes a more productive achievement goal orientation, which is addressed in further detail below. The literature does not appear to contain any reports of studies empirically testing these claims.

This paper aims to address the claims about test anxiety, growth mindset, and achievement goal orientation; each of these is discussed in further detail in the subsequent two sections.

Test Anxiety

Test anxiety is a well-studied concept, dating back over 50 years, and is generally defined as anxiety arising from evaluative situations (e.g., tests or examinations; Putwain, 2008). While it is well established that test anxiety is negatively correlated with performance (Hembree, 1988), researchers disagree on the direction of causality. Proponents of the cognitive interference model argue that test anxiety interferes with students' ability to accurately demonstrate their competence during an exam. On the other hand, some researchers argue for the (unfortunately named) "deficit" model, in which test anxiety arises as a symptom of a students' awareness of their lack of mastery. The reader is referred to Zeidner & Matthews (2005) and Putwain (2008) for more thorough reviews of the test anxiety construct.

Test anxiety is estimated to adversely affect up to 40% of college students (Gerwing et al., 2015), a number that seems to be increasing over time (Szafranski et al., 2012;). Meta-analyses have consistently shown that test anxiety occurs at higher levels in women than in men (Hembree, 1988;

von der Embse et al., 2018). There are fewer studies reporting a difference based on ethnicity, but the recent meta-analysis of von der Embse et al. (2018) reports that black students have higher test anxiety than white students (though this difference is not as large as differences among genders). Test anxiety also is reported to be exacerbated by higher stakes exams and positively correlated with the perceived difficulty of an exam (von der Embse et al., 2018).

This last point seems to be the mechanism through which SBG can reduce test anxiety. Indeed, Owens (2015), Author (2020), and Harsy (2020) all argue that since students are provided many opportunities to master each standard, any particular assessment becomes lower stakes. As noted above, while many authors report a number of student perspectives supporting this hypothesis, the only study that attempted to quantify test anxiety with a pre-post design found that test anxiety increased over the semester (Author, 2020). One possible explanation, which the present study seeks to confirm, arises from the simple observation that an SBG course does not exist in a vacuum. That is, students in an SBG course are simultaneously taking several other non-SBG courses. Thus, when administered an instrument asking about test anxiety, the phrasing of the questions might result in students providing responses based on their experience in all of their courses. We hypothesize that the earlier finding in (Author, 2020) of increased test anxiety could, in fact, be reflecting an increase in test anxiety in students' non-SBG courses, while their test anxiety did actually decline in the SBG course.

Growth Mindset and Achievement Goals

Growth mindset is an increasingly popular idea in education at all levels and refers to the idea that abilities such as intelligence are malleable, rather than fixed. Studies have shown that a growth mindset is associated with improved achievement; moreover, even short interventions can foster an increased growth mindset (Blackwell et al., 2007; Yeager et al., 2019). While the largest studies on growth mindset seem to be focused on secondary students, there are also some smaller studies reporting similar results in post-secondary settings (Aditomo, 2015; Cutts et al., 2010; Fink et al., 2018).

The construct of growth mindset emerged from early work on achievement goal theory (Dweck and Yeager, 2019). Achievement goal theory divides individuals' motivations into two categories: mastery goals, which reflect an individual's desire to do well at a task or learn a skill; and performance goals, which encompass an individual's desire to demonstrate competency relative to others. Subsequently, performance goals were subdivided along a second dimension of approach vs. avoidance: a performance approach goal orientation is one in which individuals strive to demonstrate their competence relative to others, while a performance avoidance is one in which they strive to avoid appearing less competent than their peers. The division of mastery goals into mastery approach and mastery avoidance goals is more recent (Elliot, 2005).

Payne et al. (2007) conducted a meta-analysis of achievement goal literature and found that both mastery approach goals and performance approach goals were associated with engaging in effective learning strategies. Mastery approach goals have a positive correlation with learning and performance, while performance avoidance goals have a negative relationship with learning. Notably, they found performance approach goals to have no relationship to learning or academic performance. More recently, Baranik et al. (2010) conducted a meta-analysis examining the newer construct of mastery avoidance goals, and found that they were negatively correlated with performance and help-seeking behaviour. It is also interesting to note that test anxiety is correlated with avoidance goals (von der Embse et al., 2018).

Dweck and Leggett (1988) observed that growth mindset is associated with mastery goals, while a fixed mindset is associated with performance goals; subsequently, Elliot and McGregor (2001)

noted that mastery avoidance goals were associated with a fixed mindset. Together, this suggests that fostering a growth mindset and promoting mastery approach goals go hand in hand.

As noted above, several authors argue that SBG promotes a growth mindset (Collins et al., 2019; Harsy, 2020; Linhart, 2020; Tesch, 2016). The general argument is that allowing students many opportunities to demonstrate mastery will better encourage them to learn from their mistakes and thus promote a growth mindset. Elsinger and Lewis (2019) provide some more details when they argue that SBG promotes a mastery approach goal orientation. In an SBG course, course grades are more closely aligned with content mastery, which should promote a mastery goal orientation. Features sometimes used in weighted average grading courses that promote performance goal orientations, such as normative scoring of exams, are necessarily absent from an SBG course. Elsinger and Lewis also note that in an SBG course, students receive feedback on assignments but not a grade; and that Pulfrey et al. (2011) found that the presence of a grade (even alongside feedback) increased performance avoidance goals.

Research Questions

The goal of this paper is to empirically test, using validated quantitative instruments, some of the claims in the literature on the benefits of SBG. In particular, the aim is to answer the following research questions:

(1) Does students' test anxiety change over time in an SBG class and their other classes?
(2) Do students' growth mindset and achievement goal orientation change over time in an SBG class and their other classes?
(3) Is the magnitude of any differences constant across demographic groups, particularly those underrepresented in mathematics?

Methods

To address our research questions, we conducted an observational study in addition to re-analysing the data set from (Author, 2020). Both of these studies were conducted at the author's institution, a regional public university with about 14,000 students, and were approved by the Institutional Review Board there.

Study 1: An Observational Study

An observational study was conducted of all mathematics courses taught using SBG during two subsequent semesters: this totalled five sections of three different courses (Calculus II, Linear Algebra, and Differential Equations) taught by two instructors, one of which is the author.

Students were surveyed at the beginning and end of the semester; the surveys were non-anonymous in order to associate the responses, after which names were deleted. 115 students consented to participate, with 74 completing both surveys. In addition to demographic questions, two validated tools were used: the TAI-5 short test anxiety inventory (Taylor & Deane, 2002), a five-question instrument producing scores ranging from 5-20; and the AGQ-R revised achievement goal questionnaire (Elliot & Murayama, 2008), a 12-question scale that produces scores for each of four goal orientations ranging from 3-15. These were both administered on the pre-semester survey. In order to attempt to distinguish students' views on their SBG course and their other courses, on the post-semester survey, each tool was administered twice: the first time, it was preceded by the prompt

"Rate your agreement with each of the following statements, as they apply **to this class**." Then, the tool was repeated following the prompt "Rate your agreement with each of the following statements, as they apply **to your other classes**."

Study 2: Re-analysis of (Author, 2020)

After the first study was completed, we also re-analysed the data set from (Author, 2020). This data set arose from a similar observational study conducted in SBG mathematics courses across two (preceding) semesters at the same institution: this included 10 sections of Linear Algebra and 3 sections of Differential Equations taught by five instructors (including the author). This data set included 221 participants, with 94 completing both surveys. Of interest here, the TAI-5 short test anxiety inventory was administered at the beginning and end of the semester (but without the distinguishing prompts on the post-semester survey). Additionally, Dweck's (2013) three question growth mindset instrument was administered at the beginning and end of the semester.

Results

Study 1

Of the 115 students who completed the survey, 73% described their gender as male, with the remainder female (no students preferred not to respond, and none preferred to self-describe their gender). 65% of students described themselves as white, 19% as Black or African-American, 5% as Latinx, 5% as Asian, 1% as native Hawaiian or other Pacific Islander, and 4% as other. Of the 96 students who reported their major, the majority were engineering (80%), with the remainder mathematics (9%), science (8%), and education (2%). Note that there was a significant interaction between gender and major (Fisher's exact test, $p=0.003$), with the engineering students being overwhelmingly male.

Table 1. Contingency table of student majors and gender.

	Engineering	Science	Mathematics	Education
Female	14	3	5	2
Male	63	5	4	0

The means from each of the instruments are reported in Table 2. In each case, a Shapiro-Wilk test indicated that the distribution was not normal. Thus, we first conducted a Friedman test for each instrument to determine if the distributions of responses on the three administrations were identical. Only test anxiety ($p=0.024$) revealed a significant difference in the three distributions, while there was not a significance for mastery approach, mastery avoidance, performance approach, or performance avoidance goals ($p=0.329$, $p=0.139$, $p=0.839$, $p=0.472$, respectively).

Table 2. Test anxiety and achievement goals means.

	Pre-semester	Post-semester (Other classes)	Post-semester (SBG class)
Test Anxiety	11.93	12.52	11.46
Mastery Approach	13.60	13.34	13.38
Mastery Avoidance	11.84	12.66	12.00
Performance Approach	12.42	12.73	12.78
Performance Avoidance	12.03	12.78	12.84

We then examined whether changes in each of the instrument interacted with students' gender, race, and declared major. As noted above, the distribution of scores for each construct was not normal; moreover, in most cases, the variance was not homogeneous across groups, precluding the use of an ANOVA. Thus, we instead used Kruskal-Wallis tests pairwise to determine if an interaction was present. Only three cases were statistically significant: there was a significant difference in the change in test anxiety from before the semester and after the semester in the SBG course between men and women (p=.025), and also between students of different majors (p=0.016). Notably, the pre-semester difference between men and women was virtually erased in the SBG course at the end of the semester (Figure 1). Test anxiety decreased most for education majors and mathematics majors, and only a small amount for science and engineering majors (Table 3). The third significant interaction was between gender and the difference in post-semester mastery approach goals between the SBG course and the other courses (p=0.009). Mastery approach goals were higher for women in their other courses than for the SBG course, while for men they were slightly higher in the SBG course (see Figure 2).

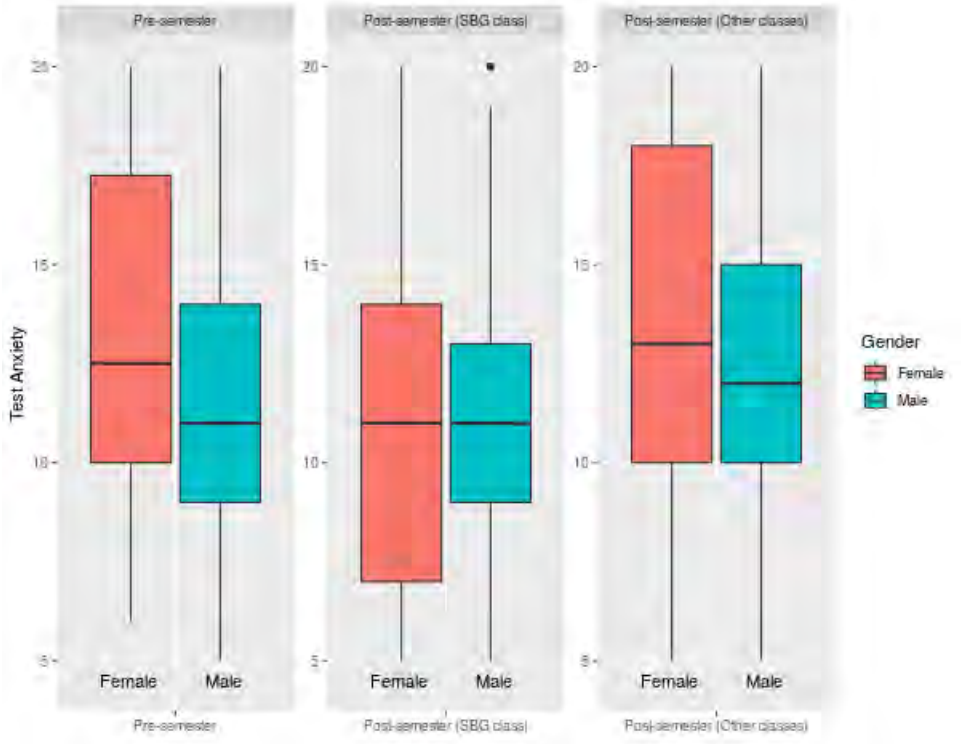

Figure 1. Test anxiety by gender. The medians, interquartile ranges, whiskers (1.5 times the interquartile range), and outliers are shown.

Table 3. Mean test anxiety by major.

	Pre-semester	Post-semester (Other classes)	Post-semester (SBG class)
Engineering	11.87	12.43	11.64
Science	13.75	15.17	13.17
Mathematics	11.11	10.57	7.43
Education	10.50	13.00	6.00

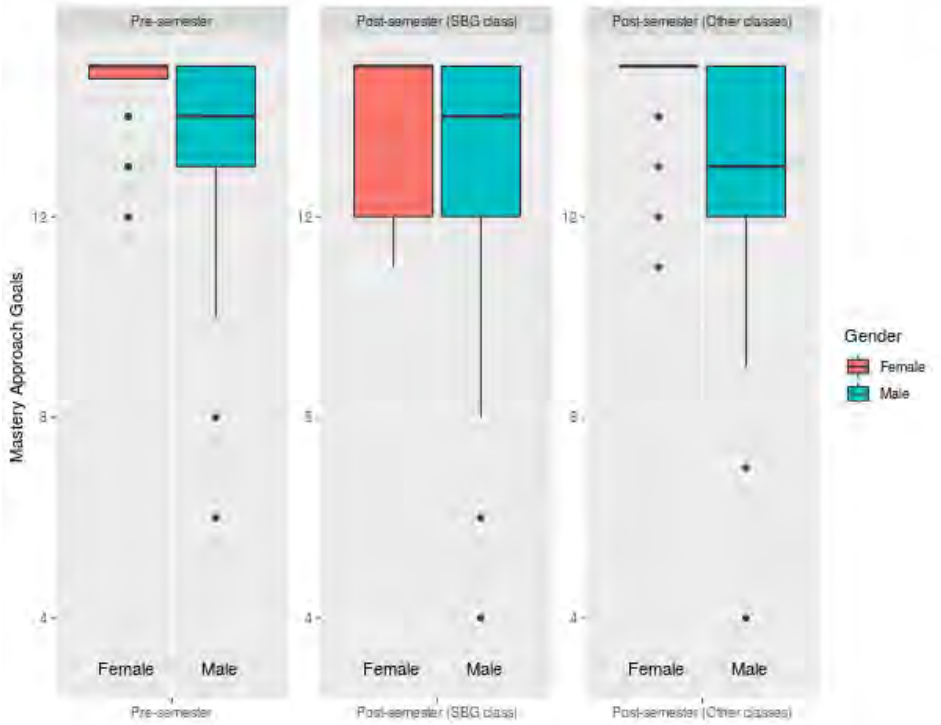

Figure 2. Mastery approach goal orientations by genders. The medians, interquartile ranges, whiskers (1.5 times the interquartile range), and outliers are shown.

Study 2

We then considered the data set from (Author, 2020), in which the post-semester survey included a single application of the Test Anxiety Inventory and Dweck's growth mindset instrument. 80% of these students reported their gender as male, 16% as female, and 4% preferred not to respond (none preferred to self-describe their gender). The author reported in (Author, 2020) that test anxiety increased over the semester, but did not examine differences by gender. In this case, Levene's test did not indicate a difference in the variances in either the pre or the post ($p=0.260$, $p=0.822$) test anxiety score, so we conducted a repeated measures ANOVA and did not find a significant interaction ($p=0.189$), though the expected pre-semester observation of women having higher test anxiety was largely erased at the end of the semester. Similarly, a repeated measures ANOVA did not find a significant change in growth mindset over the semester ($p=0.159$), nor was there a significant interaction with gender ($p=0.341$). Since this data set had four instructors, we also conducted ANOVAs to see if there was an interaction between the instructor and changes in test anxiety and growth mindset; in both cases, we found no interaction ($p=0.406$ and $p=0.364$, respectively).

Discussion

The key finding of this study is that students did in fact have lower test anxiety in their SBG course than in their other courses, with an effect size of r=0.27. This supports the many anecdotal claims in the literature noted above. This also provides a convincing explanation of the finding of (Author, 2020); that study's measurement of post-semester test anxiety was almost certainly measuring test anxiety in other courses (the mean post-semester test anxiety reported in that study was 12.60, compared to the average found here of 12.52 in students' other courses). Moreover, as seen in Figure 1, the difference between male and female students was eliminated in the SBG course but persisted in students' other courses. This is significant as test anxiety is well established to adversely impact women at higher rates than men (von der Embse et al., 2018); our finding indicates that using SBG is an effective method of mitigating this difference, and thus provides a more equitable learning environment.

There also was a significant interaction between changes in test anxiety and student's choice of major. On the one hand, this suggests that SBG can be particularly beneficial for mathematics and education students, who will take several more math classes. However, we caution against reading too much into this finding: not only were number of students in those majors small, but students' majors are not independent of gender. In particular the majors with larger reductions in test anxiety (education and mathematics) were both majority female in this sample. Still, this suggests an area of future work, where perhaps a larger sample size can disentangle this effect.

This study did not find any change in students' growth mindset. However, like the test anxiety data in (Author, 2020), this may be confounded by students' experiences in other courses. Thus, rather than rejecting the anecdotal claims in the literature, the hypothesis probably needs to be refined somewhat: the use of SBG in a course is unlikely to shift students' overall growth mindset, but perhaps a more domain-specific instrument would detect an improvement.

While we did not observe any significant differences in students' performance goal orientation, Table 2 suggests that there may have been some movement in students' mastery avoidance goal orientation, increasing more in their non-SBG course than in their SBG courses. This offers some evidence that SBG could help students have a more productive achievement goal orientation, since (as noted above) mastery avoidance goals have been found to be negatively correlated with performance and help seeking behaviour (Baranik et al., 2010). A significant interaction was detected between gender and the difference in mastery approach goal orientation between the students' SBG course and their other courses. However, these distributions are especially skewed (see Figure 2); in particular, 45% of the women who completed both post-semester applications of the instrument scored the maximum on each. Thus, we are hesitant to put too much weight on this particular finding, absent further research.

Limitations and Future Work

This study was limited to mathematics courses typically taken in the first two years by STEM majors at a single institution. Further, only two instructors' classes were involved in the study. There is variation in how many instructors implement SBG (and, more broadly, mastery grading); a study of a larger number of instructors might be able to detail which features of SBG are key to reducing test anxiety. A thorough qualitative study might also be more illuminating as well. Additionally, further work is needed to determine if SBG has an impact on other forms of anxiety.

While this study quantitatively confirmed the literature's claims that SBG reduces test anxiety, the claims about growth mindset and goal orientation remain unsettled. As mentioned above, it is perhaps natural to expect there to be no change in students' generic growth mindset; rather, one might

instead expect SBG in mathematics courses to improve students' mathematics-specific mindset. One natural follow-up to this work would be thus be to use a mathematics-specific mindset instrument, as in Rattan et al. (2012).

Conclusion

Standards-based grading is a promising alternative assessment technique with positive impacts on student attitudes, such as reducing test anxiety; further research is needed to empirically verify additional benefits to students. Instructors interested in providing opportunities for students to demonstrate their learning while mitigating test anxiety may want to consider using SBG. We refer the interested reader to Owens (2015) or Elsinger and Lewis (2019) for concrete details on how to implement SBG in their courses.

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