

Shifting Students' Feelings and Mindsets about Learning Mathematics through Standards-Based Grading

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Standards-based grading is an alternative assessment method that is gaining traction in undergraduate mathematics courses. Reported benefits for students include reduced math and test anxiety, increased achievement rates, and deeper understanding of concepts. However, evidence is mixed, and researchers have called for qualitative studies to explore students' feelings and experiences with standards-based grading. In this study, we examined 228 College Algebra students' responses to an end-of-semester reflection assignment. We discovered that some students expressed a shift in their feelings and mindset towards mathematics, and that these shifts were connected to the standards-based grading assessment structure. We present these findings, which describe how students viewed their learning and how shifts in their feelings and mindsets related to specific features of the course. We also discuss the internal and external motivations for these shifts and pose questions for future research related to students' experiences with non-traditional assessment structures.

Keywords: Standards-based grading, feelings, mindset, assessment

Traditional grading and assessment methods are the norm in undergraduate mathematics courses, particularly at the introductory level (Harsy et al., 2021). However, in recent years, there has been a growing interest in alternative approaches to assessment. These alternative approaches share several characteristics, a primary one being that grades should reflect students' final understanding of a learning objective after they have had multiple opportunities to demonstrate their learning. One such alternative assessment method is standards-based grading, where grades are intended to reflect students' proficiency in clearly defined learning objectives (Lewis, 2021). Points and letter grades are de-emphasized in favor of thorough feedback given to students after an assessment, with students having multiple attempts to demonstrate their understanding on learning objectives throughout the course.

The analysis presented in this proposal builds on a larger research study that examined how students perceived their mathematical experiences in a newly redesigned, introductory-level, mathematics course. Three themes emerged from preliminary data analysis: community, assessment, and mindset, with students discussing both positive and negative feelings throughout their reflections (Uhing et al., 2022). Through this analysis, we discovered that some students expressed a shift in their feelings and mindset towards mathematics, which prompted us to further examine this phenomenon. Students who discussed this shift primarily did so in the context of the assessment structure, which involved standards-based grading. Thus, the purpose of our work is to better understand shifts in students' expressed feelings and mindset with respect to an alternative grading structure.

Background Literature

Standards-Based Grading

While changing the undergraduate mathematics norm of summative exams to implement a new assessment method can be challenging (Elrod & Strayer, 2018), mathematics education

researchers argue that it is a worthwhile endeavor for increased student learning (Prasad, 2020) and decreased test anxiety (Harsy et al., 2021). In a study with 132 undergraduate students in the U.K., students rated less traditional assessments, such as presentations and projects, as some of their least preferred methods of assessment (Iannone & Simpson, 2015). Instead, they preferred more traditional assessments, such as closed book exams and weekly homework assignments. In addition, students preferred assessments that were better discriminators of mathematical proficiency and that seemed the fairest. Notably, this study did not include a standards-based model, where closed-book exams are accompanied with feedback and can be taken repeatedly.

Students in Zimmerman's (2020) large-scale standards-based grading College Algebra course expressed that this assessment structure held them accountable for their learning, gave them more feedback, and led to a deeper understanding. Zimmerman concluded that a standards-based grading approach "removes the extrinsic motivation factor that often fosters unproductive learning behaviors" (p. 1052); however, their precise meaning of "extrinsic motivation factor" is unclear. In our study, we sought to explore different types of motivating factors and how they influence students' shifts in feelings and mindsets about learning mathematics.

Emotions and Expressed Feelings toward Assessment

Wass and colleagues (2020) documented 14 distinct negative emotions expressed by students who completed undergraduate course assessments, such as "satisfaction", "fear", and "worry". The two most common positive emotions were "happiness" (7%) and "pride" (5%) and the most common negative ones were "annoyance" (17%) and "frustration" (10%). They found that students' positive or negative emotions toward assessments corresponded to their performance and argued that understanding students' emotions better could help educators design more effective and supportive assessment structures.

In our study, we use the term "expressed feelings" rather than "emotions" as "emotions are thought of as very primitive, extremely fast, unconscious mechanisms" while feelings are the "conscious and cognitive perceptions" of those emotions (Hansen, 2005, pp.1426-1427). Indeed, much of psychology research is in agreement that there are 27 distinct human feelings, which can be divided into two disjoint groups: positive feelings and negative feelings (Cowen & Keltner, 2017). This dichotomy of feelings allows for examination of a change in feelings valence (e.g., Kleine et al., 2005).

Traditional forms of assessment have been linked to increased feelings of stress and anxiety for students (Lewis, 2020; Prasad, 2020; Wass et al., 2020). A reported benefit of standards-based grading formats is that they are lower-stakes, and thus can reduce anxiety for students (Harsy et al., 2021), although the evidence across disciplines is varied (Lewis, 2020). In mathematics, Lewis (2020) received contradicting responses from students on a survey related to their mathematics text anxiety in Linear Algebra and Differential Equations courses taught with a standards-based grading approach. Specifically, analysis of pre/post survey items showed that test anxiety significantly increased over the semester; however, students self-reported a decrease in text anxiety at the end of the semester and an appreciation for the standards-based grading format in their qualitative responses to open-ended questions. Lewis (2020) called for future research to examine this apparent contradiction using qualitative study methods.

Mindsets about Learning Mathematics

The notion of reflecting on, revising, and reattempting work builds on a growth mindset perspective of learning (Dweck, 2010). A student with a growth mindset believes that through their efforts they can nurture and develop a better understanding of a mathematical concept;

whereas, a student with a fixed mindset believes that mathematical ability is innate and unchangeable. As students enter mathematics classrooms with (sometimes deficit) views of their mathematical abilities, it is up to the practices of growth-mindset instructors to foster “academic growth by encouraging and recognizing students for their growth in learning” (Harsy et al., 2021, p. 1073). Standards-based grading emphasizes that learning mathematics is part of a process; deep understanding of concepts may not happen immediately. In this way, a growth mindset is a potential outcome of an experience with standards-based grading (Dweck, 2007).

In a study with 104 students in mastery-based teaching Calculus and Linear Algebra courses, Harsy and colleagues (2021) found that there was no statistically significant change throughout the semester based on their responses to growth mindset items on a Likert-type survey. Additionally, regarding a growth mindset toward mathematics, they found no difference between students who experienced mastery-based testing and those who did not. However, they did not qualitatively explore the 89 students (85.57%) who disagreed or strongly disagreed with the fixed-mindset statement “Your math intelligence is something about you that you can’t change very much.” This exploration is a place for further research.

Research Questions

Using the existing literature to frame our study, the research questions we sought to address were:

1. How did students’ experiences with a standards-based grading structure in a College Algebra class lead to shifts in their expressed feelings and mindsets about learning mathematics?
2. Which aspects of students’ experiences in this course were most prevalent in their expressed feelings and mindset shifts about learning mathematics?

Methods

The data for this study come from a Mathography assignment that was collected at the end of the Fall 2021 semester from students enrolled in College Algebra at a large, metropolitan university. Out of 459 students enrolled at the beginning of the semester in 14 sections of College Algebra, 228 students submitted the assignment. During this semester, instructors were involved in a large-scale course redesign effort that involved developing new curricular materials around active learning and using standards-based grading for the assessment structure. Assessments were called Learning Outcome Assessments (LOAs) and were created based on clearly articulated learning outcomes (i.e., objectives). Students were allowed multiple attempts over the semester to complete each learning outcome. Sections of the course were also coordinated, using the same instructional materials and assessments.

The Mathography data included student responses to prompts that were adapted from Drake’s (2006) mathematics story interview, particularly the “peak experience” and “nadir experience” that students experienced during their time in College Algebra. We coded all 228 Mathography assignments in Dedoose individually and met pairwise to discuss and reconcile disagreements until we achieved 100% interrater agreement. Our predetermined codes in Dedoose (2022) included: emotions (subcodes of positive and negative), community and culture, assessment (subcode learning outcome assessments), and personal growth/mindset, which were determined after preliminary analysis of the data (Uhing et al., 2022).

For the analysis of shifts in expressed feelings, we considered excerpts tagged with “assessment” AND “positive emotion” AND “negative emotion” codes. This produced 61 excerpts. We analyzed these excerpts to determine if a negative to positive shift in feelings

occurred, which reduced our sample to 48 excerpts. In our initial tagging of excerpts for positive and negative emotions, we were careful to only include excerpts where students voiced an explicit emotion or feeling. For example, we did not include excerpts where students used verbs such as “struggling”, as this action could be connected to both positive or negative feelings (e.g., enjoying a challenge or feeling frustrated by a problem). To compare, we also looked at excerpts tagged with “positive emotion” AND “negative emotion” AND not with “assessment”. This yielded a total of 16 excerpts, only 9 of which exhibited a shift. We chose not to include these excerpts in our analysis as we wanted to focus on the context of assessment.

For the analysis of shifts in growth mindset, we considered excerpts tagged with “assessment” AND “personal growth/mindset”. This produced 150 excerpts, 27 of which we had already included from the expressed feelings set. We analyzed the remaining 123 excerpts to determine if a shift toward a growth mindset occurred, which reduced our sample to 56 excerpts. Most excerpts included explicit shifts from a fixed mindset (e.g., “I didn’t think I could learn this.”) to a growth mindset (e.g., “It made me realize that if I work hard enough for something then I can accomplish it.”). However, some showed more implicit growth in mindset by discussing a “turning point” moment where they “kicked it into gear” or “started to turn things around”. Overall, excerpts varied in length but were generally 2-5 sentences in response to a single prompt.

We emphasize that the final excerpts in our analyzed dataset are focused on a *shift* in feelings or mindset, not simply a single state. Several excerpts were tagged with positive feelings as students expressed their enjoyment, satisfaction, and confidence as a result of the assessment structure in this course. However, here we focus on excerpts where students first expressed a negative feeling or mindset, such as concern or nervousness, and subsequently expressed a positive feeling or mindset as a result of some shift during their experience in this course. Then, we used open, data-driven coding (Saldaña, 2016) to analyze the excerpts for the type of shift that occurred.

Findings

In our analysis, we found five primary causes that students attributed to a shift in their feelings or mindset (see Table 1). Three of the causes (the assessment structure, grading scale change, and LOA performance) related directly to the implementation of standards-based grading in the course, while the other two causes (external resources and overall course experience) were more general in nature.

Table 1. Causes of Shifts in Students’ Feelings or Mindset

Cause of the Shift	Description
Assessment Structure	Overall structure of the assessment and grading system
Grading Scale Change	Instructors changed the grading scale nine weeks into the semester from needing to complete all 24 learning outcomes (LOs) twice, to having 5 "core" LOs and 19 "supplemental" LOs
LOA Performance	How students did on a particular learning outcome assessment (LOA) (i.e., a specific grade or outcome)

External Resources	Other people (e.g., instructors, TAs, classmates) or other external resources
Overall Course Experience	Reflecting back on their experience in the course as a whole (e.g., talking about the hard work that paid off or things they learned about themselves)

Table 2 shows the frequency across student excerpts for each cause with respect to shifts in feelings and mindset. Excerpts were only coded under one cause for a particular shift (e.g., a student excerpt that related to a shift in mindset was only attributed to a single primary cause, such as assessment structure). We expand on these findings below and provide illustrative student examples.

Table 2. Number of Student Excerpts Relating to Different Causes of Shifts in Feelings and Mindset

Shift	Assessment Structure	Grading Scale Change	LOA Performance	External Resources	Overall Course Experience	Total Number of Excerpts
Feelings	7 (14.6%)	7 (14.6%)	23 (47.9%)	9 (18.8%)	2 (4.1%)	48
Mindset	9 (16.1%)	0 (0%)	21 (37.5%)	10 (17.8%)	16 (28.6%)	56

As shown in Table 2, LOA Performance was the most common cause of a shift in feelings or mindset for students. Several students discussed how getting feedback on an LOA cause them to experience this shift. For example, one student remarked:

A peak experience that happened to me in [College Algebra], was after the second to last LOA of the semester. I hadn't gotten any LO's the previous assessments and was very concerned about my grade, especially since I had a core LO that I still needed 2 points in. I put in about an hour and a half of studying leading up to the day of the assessment and, and came out of class feeling accomplished. Every question I answered, I ended up getting the points for, giving me confidence that I will end up succeeding in class.

This excerpt shows how performance on an LOA caused the student to feel "concerned" about their grade, which led to them studying more and doing better on the subsequent assessment, causing the student to then feel "accomplished" and confident.

In terms of mindset, several students mentioned how their performance on LOAs caused them to "push themselves" and "work hard" to achieve better results. One student commented:

A peak experience in my math story took place this year. I looked at my LOA scores and realized that I needed to pick it up or I would have problems passing the class. So, when the next LOA came up, I studied more than I had for any other test, and it paid off and now I am on pace to pass the class if I keep up my study habits for the next couple of tests. This experience says that I as a student am someone who learns well from their mistakes and is a hard worker who wants to achieve his goals.

Instead of giving up after earning a low score on an LOA, this student viewed their mistakes as an opportunity to learn, thus providing motivation to study harder for the next assessment and demonstrating a growth mindset.

Several students mentioned a major change to the grading scale that occurred nine weeks into the semester in their reflections. About halfway through the semester, after reviewing assessment data and having multiple discussions about the assessment structure, instructors of the class decided to reduce the number of learning outcomes that students needed to demonstrate skill on twice. Several students discussed this key event and attributed it to feeling less stressed about the course overall. One student remarked,

At the start of the year, we were having to complete quite a few LOs and we had to do them twice, which was stressful. Once the grading got changed to only having to do the supplemental LOs twice, it helped me gain confidence.

Another student expressed a similar sentiment:

A low point in Math 1220 this semester would be right before the grading requirements were changed. I hadn't scored very well on the LOA's at that point and I wasn't sure if I'd be able to meet all the requirements. Overall, I was very discouraged and didn't think I would be able to pass. I have definitely grown since then in my math skills and math confidence.

Both of these students described shifts in their feelings from being stressed and discouraged to feeling more confident in their mathematical abilities. It is also interesting to note that while this grading scale change was expressed as a cause of shifts in feelings (7 out of 48 excerpts), it was not discussed with respect to shifts in students' mindsets (0 out of 56).

On the other hand, shifts in mindset seemed to occur over the duration of the semester, leading to the code Overall Course Experience. For instance, one student discussed their view on "being good at math" and how they had persevered throughout the semester:

While many people would describe being good at math as simply receiving good grades, that is not necessarily the case. For me, being good at math means persevering when you are not completely sure how to complete something. Being able to make a mistake while learning and growing from it is extremely valuable, not just in math but in life as well. Initially, my goal was to receive a C in the course [...]. However, closer to the end of the semester, my goal is to receive an A in the course. [...] I will be much happier knowing I gave this class my full effort and was rewarded for it.

For this student, the overall experience of being in a course that used standards-based grading helped shift their mindset from wanting to earn a passing grade to wanting to give their "full effort" and feeling "rewarded" for doing their best.

Discussion

The most prevalent cause of a shift in both expressed feelings and mindset was students' LOA performance, meaning how well they did on a specific LOA. This finding surprised us as we were expecting that LOA performance might be more closely related to a shift in feelings (as feelings are more fleeting and transitory) as compared to mindset (which is sustained over time). However, our findings suggest that students' mindsets can also be shifted by their performance on assessments. Moreover, it is clear that even in a standards-based grading environment, students still cared about their grades on assessments as LOA performance was the most commonly referenced cause of both shifts in feelings and mindset.

Zimmerman claimed that a standards-based grading approach "removes the extrinsic motivation factor that often fosters unproductive learning behaviors" (p. 1052). In other words, when students demonstrated a shift in expressed feelings regarding assessment or evidence of a growth mindset, did it appear to be motivated by extrinsic factors? Although the assessment LOA structure was a standards-based grading approach that allowed for multiple attempts,

students were still concerned about their immediate results on the individual assessments. This suggests that many students are still motivated by grades and, oftentimes, by their performance on the first attempt of an LOA.

In addition to seeing a shift in mindset, we saw strong evidence for the presence of a growth mindset in several students, although it was sometimes unclear whether or not they previously held more of a fixed mindset toward learning mathematics. This finding supports other research which claims that the structure of standards-based grading courses provides students with multiple chances to succeed and thus helps students foster growth mindsets about learning mathematics (e.g., Harsy et al., 2021). Our findings further suggest that a standards-based grading structure may encourage students to metacognitively consider their internal and external sources of motivation and to persist toward their learning goals, rather than becoming discouraged after a nadir event (e.g., failing the first exam).

Finally, one finding that we are still investigating is the difference between shifting to positive feelings/mindset versus shifting to non-negative feelings/mindset. For instance, we observed a marked difference between those excerpts that expressed a shift from negative to (explicitly) positive emotions (e.g., from worry to confidence) versus those that went from negative feelings to "decreased negative" or neutral feelings (e.g., from stress to a sense of relief/calmness, such as, "I felt relieved" or "I felt better"). In particular, "relief" appeared to be qualitatively different from the other feelings.

This emergent finding may be connected to Lewis's (2020) contradictory research with math test anxiety, which suggests that the feeling of relief plays a role in how students express their feelings towards mathematics assessments. Namely, does the timing of the survey (or Mathography assignment, in our case) matter? If students respond to questions at the end of the semester, are they more likely to express relief and positive feelings, or, is the stress of final grades weighing more heavily on their minds? Kleine and colleagues (2005) stated that future research should examine the direct relationship between achievement-related emotions and academic performance. We are continuing to explore this research finding.

Implications and Limitations

As other researchers and practitioners of standards-based grading have claimed, it is necessary to carefully consider how the course is designed (Collins et al., 2019), what the learning objectives are (Zimmerman, 2020), how the grading system is communicated with students (Kelly, 2020), and what strategies should be used for implementing these alternative grading approaches. In our study, we found that considering these components was not sufficient for *all* students to shift away from a grades/performance mindset to learning mathematics. We were, however, encouraged by the number of students (56 of 228 students, 25%) who demonstrated a shift toward a growth mindset for learning mathematics, especially those who clearly expressed that they initially held a fixed mindset about their math abilities. However, we emphasize that standards-based grading is not a cure-all for mathematics instruction. Implementing this assessment structure should be done thoughtfully and not prescriptively. Moreover, we should continue to explore how students' feelings are entangled with grading and assessment and how we can work (within the confines of our educational system) to encourage a growth-oriented mindset toward learning mathematics.

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