Motivations for Grading Among Math and Physics Faculty

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A student's course grade is typically an overall representation of multiple graded categories chosen by faculty. This study uses interviews with math and physics faculty to determine their rationale for selecting grading and assessment systems. We hope by identifying common faculty motivations, we can provide a baseline for future discussions on the implementation of alternative grading practices. Semi-structured interviews were conducted to present math and physics faculty with questions regarding enrollment size, length of implementation, and feedback processes. Preliminary analysis of faculty interviews demonstrates significant similarities in rationale across departments. All faculty considered enrollment size and course content when selecting systems. Findings indicated two central student learning goals and the emergence of four dominant motivations.

Keywords: Faculty Rationale, Goals for Student Learning, Teaching Practice, Grading Practice

Background

Teaching practices are at the heart of transforming STEM education in U.S. colleges and universities. More specifically, students' experiences in introductory mathematics courses play a crucial role in their overall retention in STEM fields. Both high and low-performing students have frequently cited teaching in their introductory courses as a factor in their choice to switch majors (PCAST, 2012). Members of groups underrepresented in STEM fields have also experienced significantly lower retention rates (Brainard & Carlin, 1998; Bressoud, 2011; NASEM, 2016). Recent calls for improving mathematics education have focused on the implementation of instructional activities that engage students in active learning and promote higher order thinking (CBMS, 2016; Freeman, 2014; Saxe and Braddy, 2015). This study seeks to expand upon prior research by focusing on teaching practices, specifically grading practices, rather than instructional activities.

To distinguish between instructional activities and teaching/grading practices, we employ the definitions provided by Speer, Smith, & Horvath (2010). Instructional activities refer to "the organized and regularly practiced routines for bringing together students and instructional materials" (p. 101). In contrast, teaching practices encompass the thinking, judgments, and decision-making teachers use to prepare for and teach their courses (Speer et al., 2010, p. 101). Research in this underexamined area of mathematics education will be a valuable catalysis for the widespread adoption of empirically validated teaching practices—a key recommendation advised by PCAST (2012). Furthermore, this research will benefit the expansion of professional development opportunities for faculty as prior research has been limited in scope (Crooks-Monastra, 2021; Deshler, Hauk, & Speer, 2015; Speer, Guttmann, & Murphy, 2009). This study focuses on tenured and tenure-track faculty, as opposed to graduate teaching assistants, because these faculty are more independent and less transient. Concerns expressed by faculty may also be useful for designing professional development materials appropriate to this demographic.

Within the scope of faculty's teaching practices, this study examines the role of beliefs, orientations, and resources in the selection of grading and assessment systems. Assessing student learning is a core component of collegiate teaching and varies greatly by instructor, discipline, and institution type (Lipnevich et al., 2020). Variations of grading scales have been proven to amplify racial or ethnic inequities in introductory STEM courses (Paul & Webb, 2022). Moreover, arbitrary depression of grading scales has contributed to poor student perceptions of STEM courses and decreased persistence in STEM majors (PCAST, 2012). While a large and growing body of research has indicated a need to move toward alternative learning environments, traditional teaching practices have been resistant to change (PCAST, 2012). We believe that understanding the current landscape of collegiate teaching will improve strategies for implementing alternative grading practices. To address these concerns, we sought to answer the question: *What considerations do faculty make when selecting grading and assessment systems for their classes?*

Theoretical Framework

This study utilizes a post-facto implementation of Schoenfeld's goal-oriented decision-making theory. At the core of this theory is the idea that "one's decisions about what goals to pursue and how to pursue them, are made on the basis of one's current resources, goals, and orientations" (Schoenfeld, 2011, p. 8). This theory is especially prevalent in "well practiced" domains, like teaching, where individuals are engaged in established patterns of behavior. Instructors enter the classroom with an array of knowledge and resources that may be conceptual, social, or material. These knowledge bases and resources are then called upon to achieve goals at the macro and micro level of classroom instruction. In this study, we rely upon Schoenfeld's (2011) definition of goals as "something that an individual wants to achieve, even if simply in the service of other goals" (p. 20). In applying this theory to the study of college faculty, we seek to connect motivations for selecting grading and assessment systems to overarching goals for student learning. We rely solely on interviews for this study because assessment practices are generally not accessible to classroom observation (Speer et al., 2010). A comparative study of these interviews will provide insight on the rationale of faculty across the disciplines of math and physics.

Methods

Participants

An invitation to participate in the study was sent to all tenured and tenure-track faculty in the math and physics departments at a public mid-sized research university in the Midwestern United States. Two math and two physics faculty volunteered for the study. Including graduate school experience, the faculty averaged 22 years of teaching. Expanding the study's participant pool to include physics faculty provides greater context for drawing comparisons across and within disciplines.

Data Collection

The first author conducted in-person, 30–60-minute, semi-structured interviews (Browner, 1988) with each faculty member in the summer of 2023. Zoom was used to audio record and auto-generate transcripts. Each interview was followed by a short-written survey to collect demographic information about the participants. All transcriptions were cleaned for accuracy and anonymity by the first author, before being shared with the second author for data analysis. Transcripts were labeled "M#" and "P#" to represent participants' respective disciplines. The numbers indicate the order in which the interviews were collected.

The interview protocol focused on the implementation of grading systems in small and large enrollment courses. For the purposes of the study, small enrollment courses were defined as having 15 or less students and large enrollment courses were defined as having 150 or more students. To distinguish between the discussion of these courses in interviews, participants were asked to answer separate sets of questions about courses of each enrollment size. This section of the interview protocol included the following questions:

1. How do you determine grades for a course with an enrollment of 15/150 students?
    a. Could you describe the percentile breakdown of those different graded tasks?
    b. Why have you chosen these percentile breakdowns?
    c. What course are you using as a point of reference?
2. How long have you been using this grading system?
    a. What do you value about this system?
    b. Some past participants have said they value "ease" in their grading system. Is this something you consider?

Other interview questions included follow-ups about enrollment size that were asked if participants did not distinguish between these courses in their initial response. The interview protocol concluded with questions concerning faculty's consideration of alternative ways of determining a grade. When asked for the definition of "alternative" participants were told that "alternative" referred to systems different from their own.

Data Analysis

We employed generative coding (Otero & Harlow, 2009) to identify themes in participant's responses. Together, both authors read the transcripts and highlighted text segments that characterized participants' motivations for implementing grading and assessment systems within their classes. The highlighted segments were used to find emergent themes across participants. The first author then went through and compiled these motivations, generating a list of 17 items.

Preliminary Results

Our analysis found that faculty across the disciplines of math and physics were influenced by four dominant motivations: (a) grades reflect learning, (b) assumed maturity, (c) clear feedback, and (d) ease of grading. While these motivations were similar across faculty, their manifestations within individual faculty's courses differed greatly by course content and enrollment size. Table 1 summarizes these findings with examples from faculty interviews. We note that the motivations are not ordered hierarchically and were prevalent in all faculty's discussion of grading and assessment systems.

Table 1. Dominant motivations expressed by faculty when discussing grading and assessment systems.

Motivation	Definition	Example
Grades Reflect Learning	Faculty believe grades should be an accurate reflection of student learning.	Participant M2: So, if A is excellent, B is very good, C is average and D is just passing, then how can it be that a whole class gets just A's? **I don't know what the purpose of grades are if everybody's excellent.** How can everybody be above average? That makes no sense to me.
Assumed Maturity	Faculty assume students in upper	Participant M1: Whereas for the **higher-level class**, it was like there are things that I'm not measuring exactly

	division courses have developed more "mature" learning processes.	like are you reading the textbook and, uh, like are you actively trying problems outside of the ones that I specifically asked you? And so yeah, I hope that **there's some level of maturity** that is reflected in the, uh, grading breakdown.
Clear Feedback	Faculty desire systems that allow for clear and timely feedback.	Participant P2: Usually for [a] 20-minute exam, **I use at least the same time**, probably more, to just **discuss the solutions**. To discuss what are possible approaches to solve it and what were the difficulties and challenges and all these things.
Ease of Grading	Faculty rely on systems that simplify grading processes and optimize time spent grading.	Participant P1: We have so few, uh, graduate teaching assistants that we've been forced, and some of us at least. I know that others, I commend them for the effort they put in to, you know, give direct feedback to students. But, um, some of us have resorted, you know, **out of necessity**, to an online homework system.

Grades Reflect Learning reflects faculty's desire for grading systems that accurately measure student learning. In our interviews, this perspective was captured with the question: "What does an 'A' grade represent in your class?" All participants expressed that an "A" student is someone who has a strong understanding of the course content and performs well in multiple graded categories. While the graded categories varied between courses, all participants emphasized the importance of grading systems that accounted for student performance on assessments and engagement in the learning process, e.g., completing and submitting homework on time.

Assumed Maturity reflects instances in which faculty's perception of student maturity influenced their grading system. The "maturity" referred to by faculty is regarding students' approach to the learning process. Across all participants, we found that the inclusion of graded categories for procedural tasks—pre- and post-lecture assignments, clicker questions, and reading quizzes—was primarily done in lower-division courses. Whereas in upper-division courses, grading systems consisted almost exclusively of homework and exams. We found that this was because faculty believed that lower-division students were in the early stages of developing strong study habits and needed incentives to engage in these learning processes.

Clear Feedback reflects faculty's concerns regarding clear and timely feedback processes. We found that participants used a variety of feedback systems in their courses from personalized written notes on assignments to whole-class discussions of exam solutions. Some participants emphasized the importance of "grade transparency," e.g., always having overall course grades available to students through an online gradebook. All participants discussed difficulty with offering detailed feedback to students in large enrollment courses.

Ease of Grading reflects faculty's consideration of time spent grading when selecting systems for their courses. When asked to discuss their grading procedures, all participants commented on having a reliance on grading assistance for large enrollment courses. When graders and teaching assistants were not available, participants utilized online homework systems to provide students with quick and direct feedback. For small enrollment courses, we found that faculty preferred to do all the grading because it gave them a better snapshot of student understanding.

Discussion / Conclusion

We initially approached this study with inductive analysis to determine whether broad themes would emerge in faculty's discussion of grading and assessment systems. Our study found that faculty consider four dominant motivations when making these choices for their courses. We believe the discussion around these motivations could additionally provide insight into the goals faculty aim to accomplish in the classroom. Employing Schoenfeld's goal-oriented decision-making theory, the motivations we found in our initial analysis can be mapped to overarching goals for student learning.

An example goal could be, "Create Timely Feedback Systems." This goal directly connects two of our previously identified motivations: *Clear Feedback* and *Ease of Grading*, (see Table 1). By considering faculty's beliefs, orientations, and resources, we can explain the stark differences between the implementation of grading and assessment systems in large and small enrollment courses. Faculty's lack of material resources—graders and teaching assistants—has led to the use of online, auto-graded homework systems in large enrollment courses. Whereas in small enrollment courses, material resources played less of a role in faculty's decision-making processes.

A second example goal could be, "Balance Process and Product Grading Criteria." This goal refers to faculty's decision making in determining graded categories for their courses and makes use of one previously identified motivation, *Assumed Maturity*. Process criteria reflect student behavior and/or the procedural tasks students complete throughout the learning process (Lipnevich et al., 2020). Product criteria reflect student performance at a point in time, assessed by written and oral exams (Lipnevich et al., 2020). Past research suggests that the most important faculty beliefs are those that concern faculty's perception of the causes of student behavior (Clark & Peterson, 1984). Our research found that faculty's perception of student maturity resulted in variations between grading systems in lower and upper division courses. For example, all participants believed that active student engagement in the learning process could only be accomplished by incentivizing lower division students with points for completing procedural tasks. While in their upper division courses, there were few or no points awarded for these tasks because faculty believed students had developed more mature learning processes.

As we continue to apply Schoenfeld's theory to our preliminary findings, we will build a deeper understanding of how faculty's beliefs, orientations, and resources shape their goals for student learning. These findings will shape the approach to wider implementations of alternative grading practices among tenured and tenure-track faculty.

Questions for the Audience

Is Schoenfeld's goal-oriented decision-making theory an appropriate tool for understanding faculty motivations, or are there other theoretical frameworks that would provide greater explanatory power?

We foresee multiple avenues for this research going forward. What next-step questions do you most want answered?

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