

Best Practices for Using Standards-based Grading in Engineering Courses

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Abstract

Assessment of student achievement using a grading system is a major task required of engineering educators. The traditional approach is to use a summative score-based grading system that reports an end-of-semester letter grade based on student assignment scores throughout the course. Such an approach inherently fails to meet the conditions of sound assessment of student learning because the resulting final course grades only display how well students performed at completing separate assignments rather than how well they learned specific course objectives. Standards-based grading (SBG) is an alternative approach that directly measures the quality of students' proficiency toward course learning objectives. The following paper assessed the use of standards-based grading by ten instructors at six institutions to identify instructor perceived benefits for students, obstacles to implementation, and best practices for integration.

Introduction

Grading systems have been used since the late 1700s to determine how well students meet relevant academic goals¹. Most higher education instructors use a traditional, summative score-based grading system. An example grade book based on this system is shown in Table 1. Scores are assigned and tabulated for various assignments throughout the term. These scores are then weighted by assignment and summed. This total score is then used to determine a final course grade based on a predetermined grading scale. Course objectives (sometimes referred to as course learning outcomes) are usually not directly connected with assignments and are often not even mentioned beyond discussion of the course syllabi on the first day of class². It has been suggested that such a grading system inherently fails to meet the conditions for sound assessment of student learning because final course grades only display how well the students performed at completing the separate course assignments rather than the extent to which they achieved the course objectives²⁻⁴.

Table 1. Example of a traditional, summative score-based grade book.

Traditional, Summative Score-Based Grade Book						
	Homework	Quiz	Midterm	Final		
Student	Total (%)	Total (%)	Exam (%)	Exam (%)	Total (%)	Final Course Grade
John	78	80	77	83	80	B-
Bill	50	60	90	87	72	C-
Susan	70	80	75	83	77	C+
Felicia	70	90	85	95	85	B
Jane	95	100	90	85	93	A

Standards-based grading (SBG) is an alternative grading system that has shown potential to provide a more sound assessment of student learning. Instead of grading student assignments, students are graded throughout the term directly on their demonstrated proficiency in regards to the course objectives. In the SBG system, student progress toward the course learning objectives

is directly and explicitly assessed using student work, which is monitored throughout the duration of the term. An example SBG gradebook for one project within a larger course is shown in Table 2. Changes in proficiency toward the learning objectives can be observed over time. Final course grades are determined based on students' development towards achieving the course objectives according to an established grading policy (i.e., grading scale, assignment weighting, and objective weighting).

Table 2. Example of an individualized SBG gradebook for an engineering project.

Standards Achievement Report (John Smith, 02/15/2014)						
Project 1: Product Dissection Activity	DB	M	TEC	CO	PB	
1: Design description	2	-	-	-	3	
2: CAD model and 2D print	-	2	-	-	2	
3: Mechanism model and calculations	-	3	2	-	3	
4: Project report	-	-	3	3	2	
Learning Objective Scores		2.0	2.5	2.5	3	2.5
Project Score			2.4			
Project Grade			A-			
Progress Level: 3 – Distinguished, demonstrates above average development 2 – Proficient, approaching appropriate development 1 – Novice, needs practice and further development 0 – Not assessed						
Learning Objectives: DB – Design and build products using a user-inspired design process M – Utilize various forms of modeling CO – Communication and organization TEC – Test, evaluate, and compare predicted and acquired measurements PB – Demonstrate professional behaviors (teamwork and punctuality)						
Objective Weighting: DB – 25%; M – 25%; TEC – 20%; CO – 15%; PB – 15%						

Standards-based grading was first developed for K-12 education during the 1990s when academic standards were established for what students should know and be able to do⁵⁻⁶. This grading approach has gained popularity and increased use at the K-12 level along with versions of competency-based grading in higher education. To date, however, there have been no studies outside of the current investigators' work that has analyzed SBG within higher education engineering courses⁷⁻⁹. In an effort to add to this literature, the following paper evaluates the use of standards-based grading in engineering courses by ten different instructors at six different institutions to identify best practices for implementation. The goal of this paper is to provide a framework for instructors seeking to implement SBG in their courses and to disseminate feedback about lessons learned from others using SBG.

Research methods

Sample: Ten engineering instructors at six institutions completed an open-ended electronic survey based on their experiences with SBG. The instructors included tenure/tenure-track faculty ranging from assistant to full professor. The instructors' home institutions ranged from small, private liberal arts colleges to large state research universities at various locations around the United States. The courses referenced by the surveyed instructors were primarily engineering design-based project courses, but did also include other technical courses in engineering and computer science.

Data Collection and Analysis: An open-ended survey was administered through the online surveying tool Qualtrics. Each instructor was asked the following questions:

1. Please describe your implementation of standards-based grading in your course(s), including best practices.
2. Please describe any barriers or obstacles you have faced or currently face in your implementation of standards-based grading.
3. What benefits do you believe students gain from your course(s) using standards-based grading?

Three members of the research team independently analyzed responses using an emergent open-coding approach¹⁰⁻¹¹. Salient utterances in the form of direct quotes or summaries from the raw data were noted for the three categories of perceived gains, obstacles, and best practices. Each rater then created a succinct list of emergent themes in each category by grouping the salient utterances. Finally, a discussion amongst the raters was used to determine agreement and a final list of emergent themes in each category.

Results

Emergent themes from the instructor surveys included five areas of perceived student gains, six obstacles to implementation, and seven best practices for successful implementation.

Perceived Student Gains

1. Provides clear and direct feedback toward expectations that allows students to gage their strengths and weaknesses toward relevant skills.
2. Provides a mechanism for students to effectively self-assess their learning.
3. Allows a student to fail early and learn from their mistakes by rewarding improvement.
4. Better connects to real world assessment and skill building.
5. Encourages students to focus on learning rather than what needs to be done to earn a grade.

Obstacles to Implementation

1. Faculty and student pushback to change based on lack of familiarity with the grading scale.
2. Student confusion and frustration in understanding their current grade/standing in the course.
3. Difficulty integrating the grading system within currently available course management systems.
4. Increased initial faculty workload.
5. Consistency in scores across instructors, teaching assistants, graders, and programs.
6. Fit within the variety of courses taught within an engineering program.

Best Practices

1. Establish a manageable set of learning objectives at the beginning of the course with rubrics that clearly explain expectations for success.
2. Utilize a simple 3 to 5 point grading scale.

3. Assess each objective multiple times over the course of a term.
4. Provide students with clear, detailed, and frequent feedback.
5. Map activities and develop assignments around the course learning objectives.
6. Weight assignments and objectives based on content and timing.
7. Use student scores to address immediate needs and future programmatic changes.

Discussion and Implications

Few studies with the intention to improve engineering education have considered the importance of how a grading system and instructor feedback impact student learning¹²⁻¹⁵. This paper is the first to survey multiple engineering instructors at a variety of higher education institutions to identify perceived gains, obstacles, and best practices of implementing standards-based grading in higher education, specifically within an engineering education environment.

The perceived student gains that instructors identified are well aligned with the literature regarding improved learning. Standards-based grading requires that faculty make course objectives explicit to students in order to monitor their achievement and allowing them the space to fail early and improve¹⁶. As a result, standards-based grading provides clear and direct feedback in order to improve student learning¹⁷. Students can regularly conduct self-assessment in regards to learning real-world skills, which has the potential to provide for increased student motivation. Despite these perceived gains, instructors face obstacles to implementing standards-based grading.

Primary obstacles centered on the fact that instructors, students, and course management systems are most familiar with traditional, summative grading methods. Changing from a traditional, summative score-based grading system is not commonly considered among instructors. Summative grading has a long tradition in higher education and remains most widely used and promoted internationally¹⁸⁻²³. Additional obstacles can also emerge relating to increased initial faculty workload and consistency amongst graders²⁴. Any of these barriers can be mitigated by adopting some of the best practices listed in this paper.

The best practices identified by the instructors are largely practical and reasonable to implement. Limiting the number of learning objectives and developing small-scale rubrics with clear expectations promote simplicity, transparency, and specificity in grading. Mapping activities and assignments to the course learning objectives set at the start of the semester is also a key for success, often called backwards course design. Multiple opportunities for assessment paired with frequent formative feedback allow both students and instructors to assess progress throughout the semester.

Additional insights emerged when considering the response categories holistically. First, new instructors may be in the best position to implement standards-based grading. Much of the work is in initial course preparation, but can be managed from the outset with effective identification of objectives and mapping of assignments and rubrics. One potential consequence may be lower student evaluations, but new faculty have room for improvement and can expect future cohorts of students to be familiar with alternative grading methods from their K-12 experiences in the United States. In addition, standards-based grading lends itself to real-time feedback on

instructors' teaching effectiveness around specific learning objectives, which may help faculty adjust their pedagogy.

Second, the use of standards-based grading may expand as higher education programs are increasingly asked to rigorously assess student learning. The direct mapping of assignments to learning objectives and the ability to track progress and mastery of those objectives during the term or throughout a program lends itself well to assessment and continuous improvement. Investigating alternative grading systems like standards-based grading demonstrates that programs are making an honest effort to avoid complacency and to answer a recent call by the US Department of Education urging improvement and increased accountability to monitor student learning in higher education²⁵. Such assessment is also expected of ABET accredited programs.

Conclusions

Accurately assessing student work through a single end-of-course grade makes it difficult to meaningfully represent student achievement. Most institutions of higher learning default to a traditional score-based grading system because of student and educator familiarity and comparability across institutions. Such reasons, however, do not provide a strong foundation for continued use of such a system. We as educators owe it to our students to provide them with sound assessment that accurately depicts their learning and provides their future employers with valuable insights into what skills and knowledge they possess.

We have demonstrated through this analysis of instructors using SBG that an alternative to score-based grading provides valuable benefits to students, including direct feedback, effective self-assessment, opportunities for improvement, and a focus on learning. There are barriers that must be overcome in order to implement a new grading system, including a lack of familiarity amongst students and faculty. Strategies such as establishing a clear, manageable set of learning objectives, utilizing a small grading scale, assessing objectives multiple times, providing frequent feedback, mapping activities to learning objectives, weighting assignments, and using such assessments for programmatic changes have been cited as keys to successful use of SBG within engineering courses. These best practices have been compiled in this paper to guide faculty interested in using SBG within their classrooms. Instructors reported that by implementing these best practices, many of the obstacles could be overcome, resulting in perceived increases in student learning and motivation.

We believe that all educators and institutions as a whole should aim to provide students with adequate assessment that allows them to gauge their overall knowledge and skills. SBG is one alternative with ties to real world assessment that has the potential to revolutionize how we assess student achievement in higher education.

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