Paper Title Student Perspectives on Standards-Based Grading Used in Engineering Project-Based Courses

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Abstract
Most higher education institutions employ a traditional, summative scoring system to report student grades at the end of each semester. This system is limited in that it offers a final grade based on individual assignments completed throughout the semester without testing whether students have sufficiently understood the learning objectives of the course. We propose standards-based grading as an alternate to the traditional system because it offers students meaningful grades, feedback from instructors, a deeper understanding of the learning objectives, and a recognition of future goals based on the evaluation. This study aims to highlight student perceptions towards the standards-based grading system implemented by three engineering faculty at their respective institutions through an analysis of student responses to open-ended reflection questions.

Introduction
Higher education institutions have used traditional, summative score-based grading systems since the late 1700s (see example in Table 1) (Postman, 1992). Such a standardized grading system offers a final grade for the course that helps determine student GPA, but fails to adequately assess student learning in that particular course (Broad, 2000; Sadler, 2005; Shay, 2005). Additionally, course objectives are highlighted in most course syllabi, but are often not mentioned beyond the first day of class nor are they used as a focal point to assess a student's understanding in the course (Sadler, 2005). Students are assessed on their performance for different assignments and exams rather than their understanding of the course objectives and the skills learned to achieve these objectives (Broad, 2000; Sadler, 2005; Shay, 2005). Students who are not able to master the learning objectives of courses early in their degree's curriculum are likely to fail to perform well in the courses that follow (Stiggins, 2005).

Table 1: Traditional, Summative Score-based Grade Book

Traditional, Summative Score-Based Grade Book						
Student	**Homework Total (%)**	**Quiz Total (%)**	**Midterm Exam (%)**	**Final Exam (%)**	**Total (%)**	**Final Course Grade**
Jane	68	72	88	80	77	C+
Cody	78	70	86	89	81	B-
Ben	70	63	60	68	65	D
Megan	98	100	95	97	98	A+
Kristen	87	95	90	92	91	A-

Standards-based grading (SBG) is an alternate approach to this traditional score-based grading system that measures students' expertise towards the course objectives. SBG was developed during the 1900s when public K-12 education was reformed by U.S. states (Reeves, 2003; Marzano, 2010). The goal was to establish a standard for what all students should learn in educational settings (Reeves, 2003; Marzano, 2010). A report is used to assess the skills developed by students, which pertains to course objectives. This report measures student skills throughout the duration of the course and tracks student performance through class assignments and projects. Instructors use a pre-established grading policy (i.e., minimal grading scale) to determine final course grades for students (see Table 2).

Table 2: Standards-Based Grading Report

Standards Based Grading Report (Jane Smith, 1/1/2017)					
Final Project		**D**	**M**	**CO**	**T**
1. Benchmarking		2	-	3	-
2. CAD Model		-	3	2	-
3. Prototype		3	-	-	3
4. Summary Report		-	-	3	3
	Learning Objective Scores:	**2.5**	**3**	**2.7**	**3**
Project Score: 2.8					
Project Grade: B+					
Progress Level:	3- Fully Achieved 2- Partially Achieved 1-Underachieved 0-No Evidence				
Learning Objectives:	D: Design M: Model CO: Communicate & Organize T: Teamwork				

There are several advantages of using SBG over the traditional, summative score-based system (Figure 1). First, students are assessed on learning outcomes highlighted in the syllabi through various assignments and projects (Sadler, 2005). Second, students are evaluated through meaningful and personalized feedback throughout the course, which highlight their proficiency and progress in each learning outcome (Scriffiny, 2008 and Sadler, 2005). Third, SBG holds students accountable for their own progress through a transparent and fair grading system, which in turn encourages them to seek different ways to develop their skills (Reeves, 2003). Fourth, students are also encouraged to focus on the content and developing skills rather than obtaining a particular grade towards the end of the course (Scriffiny, 2008). Finally, ABET, (formerly the Accreditation Board for Engineering and Technology Inc.) outlines certain expectations to be met through courses taught to students (Felder et al., 2003). SBG has the added benefit of providing useful information for such accreditation boards since it measures student's mastery of learning outcomes that aim to align with the accreditation standards.

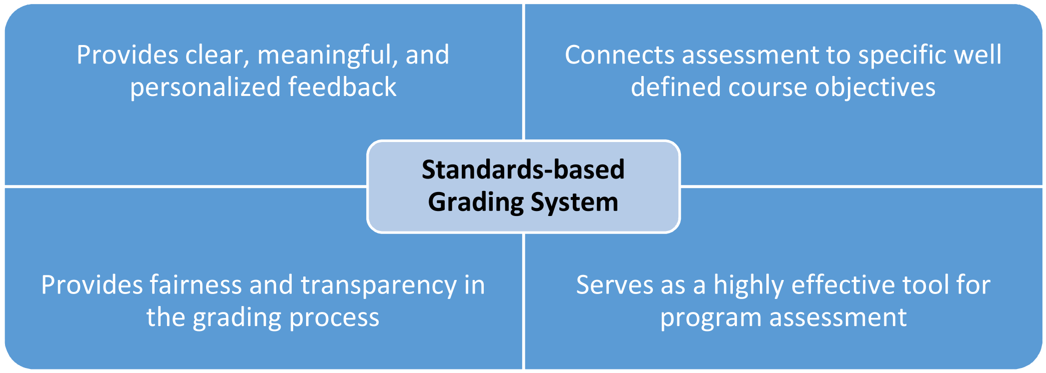

Figure 1: Observed benefits of Standard-Based Grading

Previous research has shown that implementing SBG in engineering courses offers the same benefits that have been documented in K-12 settings (Atwood, Siniawski & Carberry, 2014; Carberry, Siniawski, & Dionosio, 2012). The purpose of this study is to assess the effects of SBG in engineering project-based courses by receiving student insight and feedback of the SBG system through open-ended guided reflections.

Research Design

Sample

The SBG system was incorporated by three instructors at three different institutions. Participants consisted of students (n=128) enrolled in the undergraduate level engineering courses taught by these three instructors.

1. Large Public Southwest RU/VH Institution: The students (n=40) enrolled in a required second-year use-inspired design project course. The course used a project-based approach to provide students with opportunities to design, model, research, test, and evaluate open-ended design tasks. Students practiced these skills in a team-based environment that encouraged communication and organization skills.
2. Large Public Midwest RU/VH Institution: The students (n=81) were enrolled in a required second-semester first-year engineering course. The data collected came from one section (85 initially enrolled). This course emphasized the development of skills associated with programming, data analysis and representation, and mathematical modeling. The course also supported students' development of teaming skills and professional habits. Each topic of the course had stated learning objectives with multiple sub-objectives.
3. Small Private Master's L Institution: The students (n=7) were enrolled in a full year senior capstone design course for mechanical engineers. This is a two-course sequence where students complete various phases of their team-based design project. Various project options were offered, including student design competitions, industry-sponsored projects, and service-learning projects. Student teams participated in major design reviews and completed other project milestones (design reports, etc.) throughout.

Data Collection

Students were asked to reflect on several components of SBG through questions provided either at the end of the course or as periodic reflections throughout the course. Some questions included:

- *What learning outcomes are high priority for you to work on learning based on the assessment of your work in this course?*
- *How well do you think the evaluation (your grades) of your work represents what you have and have not learned in this course?*
- *What specific actions do you plan to take based on the assessment of your work in this course?*

Students submitted their responses to these open-ended questions to capture their insights regarding the SBG system. Student responses were recorded electronically and de-identified.

Data Analysis

Members of the research team used thematic analysis to code the data (Braun and Clarke, 2006). Two raters coded a subset of student responses to identify emergent themes and determine agreement across raters to establish inter-rater reliability. The researchers discussed the codes and ensured full agreement before the remaining data were coded. A single rater coded all remaining data. One rater was an instructor of a course included in this study and therefore, did not score any of his own students to remove any possible bias.

Results

An overall depiction of how students responded to the posed questions is seen in Figure 2. Student reflections generally aligned with the benefits of using the SBG system. About half of the student sample explicitly recognized specific skills acquired through different course learning outcomes (55%), identified specific skills from these learning outcomes that were high priority areas of need (52%), and recognized the evaluation as being meaningful since they could identify their strengths and weaknesses and measure their improvement throughout the duration of the course (53%).

Smaller percentages of students discussed the fairness and transparency of SBG (34%). An even smaller percentage pointed out the benefit of SBG acknowledging their proficiency with the course learning outcomes and identified what actions were needed based on the evaluation they received from the course (22%). Those who did discuss this aspect stated that they would seek out ways to hone

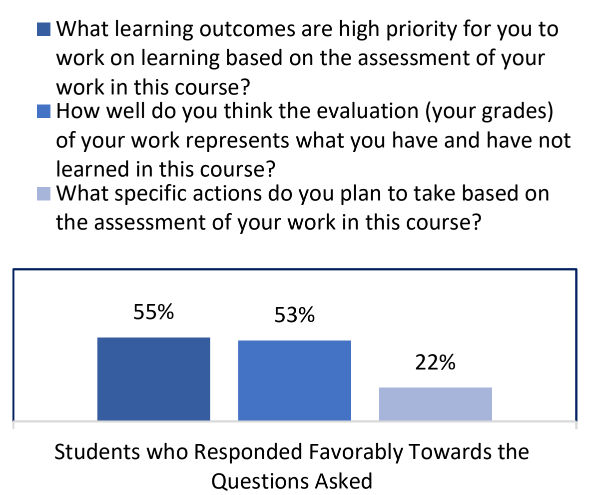

Figure 2: Percentage of Student Responses

their professional skills as budding engineers, learn to effectively manage time, look for jobs/internships, increased motivation, focus on mastering learning outcomes for future exams, and obtain more practice in learning outcomes that were highlighted as areas for growth through the SBG system.

Overall, students were satisfied with the SBG system. They reflected on what they learned and did not learn from the course based on the evaluations they received. Example statements included:

“The grading evaluation was my favorite part of this class, and I wish other professors would evaluate students this way in all group projects” (Southwestern)

“Our evaluations have helped by allowing me to see what I am doing wrong, and then I can learn how to solve this problem.” (Midwest)

"I love the non-competency based grading system. I think it has a better way of showing how a student is doing in the class. The competency system is so black and white while this adds color to the grading system, in a manner of speaking." (Southwest)

"..and the grades did seem to represent what work was being done. " (Private Master’s L Institution)

"Review my work, and make improvements based on the evaluations. " (Midwest)

“I plan on returning to notes about my [Learning Outcomes], watching the modules, reworking the problem sets that are relevant, and taking practice tests to learn these [Learning Outcomes].” (Midwest)

While the majority of the responses were positive, some students expressed frustration regarding the SBG system. Those with negative statements often felt that evaluations did not cover everything that they had learned in the course. For example, students said:

“The evaluation didn't cover about how to solve those unexpected errors so far.” (Midwest)

“I believe I know more than the evaluation gives me credit for.” (Midwest)

"I have been somewhat disappointed sometimes by the interpretation of the rubrics that we were graded on when I understood something differently than the professor but it only became apparent after the grading became available." (Southwest)

Discussion and Implications

The results suggest that SBG is viewed by students as an effective form of grading for project-based engineering courses at the undergraduate level. These findings align with instructor perceptions of student gains from SBG (Carberry, Siniawski, Atwood, & Diefes-Dux, 2016), including the ability to gage their strengths and weaknesses, providing a mechanism to effectively self-assess their learning, and encouraging students to focus on learning rather than what needs to be done to earn a grade. Fewer students keyed in on additional instructor perceptions including connecting to real world assessment and skill building and recognizing that failing early allows one to learn from their mistakes by rewarding improvement.

Few students expressed frustration towards the SBG system, which could be a factor of familiarity for students since the SBG system is a change from the traditional grading system. Another possible reason could be the level of comfort with implementing SBG for instructors. This limitation can be overcome by incorporating student feedback and making the necessary changes to best fit the needs of the students.

This form of grading has the potential to shift student focus from grades to learning necessary skills related to the course learning outcomes. There is a greater need to infuse this notion as demonstrated by low percentages of students reflecting on the fairness, transparency, and next steps required for further mastery. Students will perform better in higher-level courses and beyond their education once they are able to recognize what they have learned, what they have not learned, and what is needed to master a set of skills. The SBG system explicitly shows students how well they have mastered the necessary learning outcomes for a particular course and provides a platform for future improvement. When students shift their focus from achieving a particular grade to working on building the skills needed to master learning outcomes, they learn how to learn and improve their overall knowledge as engineers.

Limitations and Future Directions

The analysis presented focuses primarily on students' reflections of their experiences with the SBG system. A correlation between student reflections and their grade in the course could not be made due to IRB regulations. Future correlations between these two data sources would be valuable in better understanding if a student's actual performance impacts their view of the grading system. Additionally, the three participating educational institutions collected their data from students in design courses and had varying sample sizes. Each of these courses had different content and students were at different educational levels (first-year, second-year and senior students). These differences make it difficult to compare and generalize the results across the three institutions.

Further studies of the implementation of SBG in courses taught at engineering departments across different universities would strengthen results of this study and add to research supporting formative assessment over the traditional, summative assessment. A current study is also being conducted to better understand the impact of similar reflections on SBG throughout a course (Diefes-Dux, 2016; in press).

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