Student Reflections on Standards-Based Graded Assignments

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***Abstract*—Standards-based grading (SBG) provides students with feedback on their achievement of specific course learning objectives. What training students need to make meaning of and plan to act on this feedback is not known. This work in progress took place in a required first-year engineering course in which a SBG system is used. Following two problem, students were asked to respond to reflection prompts concerning their beliefs about their learning, how representative their learning objective based feedback was of their learning, and the actions they planned to take as a result of their feedback. Initial findings suggest that students do not engage in deep thinking on the feedback, though students' ability to reflect or the nature of the reflective prompts and their timing may also have had an impact on the depth of students' reflections. Pairing instruction on reflection and interpretation of SBG feedback is presented as a strategy to overcome the lack of deep thinking on SBG feedback and improve the quality of the reflection data.**

Keywords— standards-based grading, assessment, reflection

I. Introduction

Standards-based grading (SBG) is gaining traction in engineering education as the benefits for student learning and instructor monitoring of student progress become clear. SBG uses clearly articulated course learning objectives as the basis for sound assessment of student learning [1]. Therefore, a prime motivation for using SBG is that it provides feedback to students and instructors about students' progress with regards to the stated course learning objectives. That direct link between student achievement and learning objectives is more difficult to ascertain from a traditional grading system where points or scores are typically not mapped to learning objectives [2]. Beyond course-level benefits, SBG has the potential for monitoring student learning and development across courses and curricula when learning objectives are revisited. Further, SBG can facilitate documentation of student learning for ABET accreditation purposes.

While the potential benefits of SBG are considerable, adopters of SBG do note some challenges; one challenge is students' lack of familiarity with SBG, despite its more wide-scale adoption in K-12 [3]. If students are not reviewing their feedback, not able to interpret it, or do not act on it, instructors' will be frustrated by the effort to adopt this grading system as return on their time investment will not have the intended results of focusing students' energies on the things they are most struggling with. This means that it is necessary to educate students on how to use SBG feedback to monitor their progress and take corrective action as needed. Students training needs in this regard are not known. It is believed that instruction and guidelines for helping students interpret and act on their SBG feedback are needed to lower the barrier to adoption of SBG in engineering education.

In this work-in-progress, first-year engineering students reflected on the SBG assessment of their work on two problem sets at the start of the semester. These were the first of a collection of assignments students reflected on. Themes in their reflections were identified to begin to explore how students make meaning of the feedback communicated through a SBG system. In addition, the appropriateness of the reflection prompts and their administration are considered as a pedagogy for training students to interact with a SBG system.

II. Methods

A. Setting and Participants

This exploratory study was conducted in one section (n=85 initially enrolled) of a large (N~1600) required second-semester first-year engineering (FYE) course offered in Spring 2016 at a Midwest RU/VH institution. This course emphasizes the development of skills associated with programming, data analysis and representation, and mathematical modeling. The computer tool students learn to use is MATLAB®, though some assignments are done for comparative purposes in Excel®. The course also supports students' development of teaming skills and professional habits.

B. Learning Objectives and Assessment of Student Work

Each topic of the course has stated learning objectives with multiple sub-objectives. For instance, the learning objective for the topic of selection structures (e.g. MATLAB's if-end) is: students will be able to create and troubleshoot a selection structure. The sub-objectives state that students will be able to: (1) convert between these selection structure representations: English, a flowchart, and code, (2) code a selection structure, (3) track execution of a selection structure, and (3) create test cases to evaluate a selection structure.

Students' work on problem sets, exams, and project milestones is assessed using rubrics with 5-10 items. All rubric

items are course learning objectives or sub-objectives. Each objective is assessed on a four-level achievement scale: fully achieved (FA), partially achieved (PA), underachieved (UA), and no evidence (NE). For instance, consider a problem in which a student is given a selection structure with three branches. To demonstrate full achievement of the sub-objective concerning the creation of test cases to evaluate a selection structure, the student must create three different and appropriate sets of variable assignments to test each branch of the structure.

While students are working on a problem set or project milestone, they have access to a list of associated learning objectives and sub-objectives. Following grading of an assignment, students can and are encouraged to review their performance on each objective assessed. Similarly, students have access to a list of relevant learning objectives and sub-objectives when preparing for exams. Following grading of an exam, students can review their performance on each objective assessed. As all grading for this course is done through Blackboard® (course management system) rubrics, students can review their performance on the objectives at any time.

C. Student Reflections

At the end of most class periods, students were asked to complete a one-minute reflection and submit it through Blackboard. Reflections were often geared towards what students had or had not learned that day, so that the instructor could start the next class period responding to difficulties. Upon the return of problems sets 1 and 2 (PS01 and PS02), students were to review their achievement of the objectives mapped to the assignment and respond to a series of reflection questions. The first question asked students what they believed they had and had not learned. This question was intended to elicit students' thinking about what they had learned independently of their assessment feedback. The second and third questions asked students whether the learning-objective based assessment reflected their learning, and what actions they planned to take as a result of their feedback. The idea was to have students look at their SBG feedback and identify their strengths and weaknesses and consider a plan of action. Later in the semester, students reflected in a similar fashion on other assignments.

Students' reflections on their PS01 and PS02 SBG assessments were analyzed using an emergent open-coding approach resulting in themes. In the results and discussion sections, student quotes are used as written by the students to exemplify the themes.

III. Results

A. Problem Set 1 Assessment and Student Reflection Themes

The overall section achievement on the PS01 objectives is shown in Table I. Overall, the performance on this problem set was quite high. About 40% of the class demonstrated full achievement on all five objectives; ~20% demonstrated partial achievement on one of the five objectives; and ~20% demonstrated partial achievement on two of the five objectives.

Students received feedback via the Blackboard rubric on PS01 seven days after it was submitted. They were instructed in class the day the feedback was released to "Take a look at the details of our evaluation of your PS01 work via the learning objective based rubric" in preparation for a reflection at the start of the next class. At the start of the next class, 78 students who had submitted PS01 completed a reflection.

TABLE I. Overall Assessment of PS01 Objectives (N= 85)

Objective	Number of Students At Achievement Level[a]			
	FA	*PA*	*UA*	*NE*
Assign and manage variables	77	4	3	1
Perform and evaluate algebraic and trigonometric operations	74	5	5	1
Create and execute a script	48	27	5	5
Manipulate arrays	65	8	2	10
Manage text output	54	20	5	6

[a] FA = Fully Achieved, PA = Partially Achieved, UA = Underachieved, NE = No Evidence

With regards to what was learned, many (29) students provided very general statements about learning it all, learning the basics of MATLAB, or learning about MATLAB. Typical statements were: "I believe I have learned all of the material covered so far in this class.", "I think that I have learned the basics of matlab", and "I believe I have learned how to work with Matlab." A nearly equal number of students (23) made reference to topics they had learned during PS01, particularly how to create vectors, manipulate matrices, and write scripts. For instance, "I think I have a pretty good handle on scripts and matlab." and "Doing PS01 I have learned how to create vectors and matrices in MATLAB. While using MATLAB, I have learned to use good programming practices such as using descriptive variable names and commenting my code." Sixteen students made no reference to their learning.

With regards to what was not learned, half of the students (39) provided no insight. Of those that did, ten provided very generic statements about learning MATLAB: "I believe I am not yet fluent with the concepts of matlab, partly because i haven't done much practise of it.", "What I did not learn is how to use MATLAB properly and really learn what it is." Twelve students pointed to specific things they had not learned on PS01. These students most often referred to not understanding matrices: "I do struggle however with the matrix idea and how exactly to manipulate them the way I want or need to."

Across students' descriptions of what they had and had not learned, students made reference to specific things associated with topics that followed PS01, such as more advanced matrix manipulations and cumulative distribution plots (PS02 topics) and user-defined functions (a PS03 topic).

As to whether the SBG assessment reflected their learning, most students (51) wrote about the fairness or accuracy of the assessment. As in, "Your evaluation of my work is fair.", "I believe the evaluation is fair and reflects what I have learned and what not.", and "I think my evaluation is pretty accurate when it comes to my work." Some students did tie their perception of fairness to the fact that they received full credit or lost no points: "The evaluation of PS01 represents that pretty well because I got a 15 out of 15." Some felt that the

assessment underestimated what they had learned, often pointing to losing credit for issues unrelated to having functioning MATLAB code, like proper commenting. As one student stated, "I dont think the evaluation is a great representation considering points were taken off for forgetting a problem description and my incorrect function was wrong because of a case error." Others students considered how the evaluation did or could help them in the future identify their strengths and weaknesses – "I think your evaluation is accurate and helpful in me seeing what I need to improve on."

Overall, the actions students planned to take as a result of their PS01 SBG feedback were not tied to specific learning objectives but rather to general study and work habits. Fourteen students planned to keep doing what they were doing, "My specific plan to take based on the evaluation of your work was to continue doing what I am doing…" Others planned to check over their assignments more carefully before they submitted them, read the instructions more carefully, attend office hours, and (re)watch the online modules used in the course to introduce MATLAB topics. A few students made reference to specific things related to the learning objectives, typically the need to comment their code better.

B. Problem Set 2 Assessment and Student Reflection Themes

Students received feedback via the Blackboard rubric on PS02 nine days after it was submitted. They answered the reflection questions in class the day the feedback was released. The overall section achievement on the PS02 objectives is shown in Table II. Note that some learning objectives are repeated though the emphasis of the assessment was on different aspects of the objectives (i.e. creating versus interpreting various plots); this was reflected in the feedback.

TABLE II. OVERALL ASSESSMENT OF PS 02 OBJECTIVES (N= 83)

Objective	Number of Students At Achievement Level[a]			
	FA	***PA***	***UA***	***NE***
Manipulate arrays	65	9	2	7
Manage text output	57	8	12	6
Import data from electronic files	73	6		4
Create and evaluate x-y plots suitable for technical presentation [create]	44	26	7	6
Create and evaluate x-y plots suitable for technical presentation [interpret]	66	5	3	9
Create and interpret histograms [create]	69	8		6
Create and interpret histograms [interpret]	55	18	4	6
Create and interpret cumulative distribution plots [create]	50	16	7	10
Create and interpret cumulative distribution plots [interpret]	50	13	1	19

[a] FA = Fully Achieved, PA = Partially Achieved, UA = Underachieved, NE = No Evidence

The overall section achievement on the PS02 objectives is shown in Table II. The performance on this problem set was a little lower than PS01. About 20% of the class demonstrated full achievement on all nine objectives; ~15% demonstrated partial achievement on one of the nine objectives.

Seventy-two (72) students submitted PS02 and completed the reflection. Nearly half (34) of these students pointed to a topic that they had learned on PS02, such as how to manipulate matrices or create a histogram or a cumulative distribution plot. Still, many (21) students made generic statements about their learning - "I believe I have learned the material sufficiently up to this point." Ten students made no reference to their learning.

More than half of the students (47) made no reference to things they did not learn. Eighteen students made specific references to topics they had not learned on PS02 (e.g. cumulative distribution and matrix manipulations). Six students made generic references to either not learning MATLAB or having difficulty with some aspect of problem solving.

Students that reflected on the SBG assessment itself, still continued to find it representative of their learning (21) or fair (13). Some students who found the assessment system representative and fair qualified with "because I got almost all points because I have learned almost all objectives." Others qualified with an acknowledgement that SGB assessment is detecting something they were missing or did not understand. For instance, "The evaluation of my work reflects my deficiency in knowledge of cumulative distribution plots." Seventeen students did not comment on the assessment. A few students felt that the system underestimates their learning, though these students always acknowledged that they had submission troubles or had errors in their solutions.

A few students (5) tied the action they planned to take to a learning objective with which they were having trouble. Many students (18) planned to keep doing what they were doing, while others planned to check their work before submission, read instructions more carefully, watch the online modules, and manage their time better.

IV. DISCUSSION

The FYE students in this work-in-progress were exposed to a university-level SBG system for the first time; the extent to which they had experience with such a system during their K-12 education was not known. By having students' reflect on the the grading of the first two problem sets of the semester, students' initial attempts to make meaning of the feedback being communicated through a SBG system were captured. The results may have revealed students' initial thinking but also raise issues to consider about students' ability to reflect and the design and administration of the reflection prompts.

Students' perception of the SBG system seemed to fall into the category of "it does no harm". It was perceived as fair and representative of their work, though this assessment of the system was periodically qualified as being commensurate with the provision of full credit. One of the benefits of a SBG system should be the deflection of attention away from points and grades and towards learning [4]. When SBG was first introduced into this FYE course, each problem set was graded as all or nothing based on a threshold average achievement of the set of objectives associated with the problem set. This grading strategy resulted in students earning the same overall grade for the collection of problems sets as the previous traditional sum score system but was observed to reduce students' attention to points being taken away and elevate their attention to what was and was not learned. In this semester, due to a course policy change concerning how final grades were computed, points earned were accumulated across all

objectives and all assignments, which can be seen in these results as heightening students' focus once again on points rather than learning. Only a few students acknowledged the benefit of the SBG system in allowing them to see what they do and do not understand. This benefit may have more potential for being realized around the exams or later in the course; this may be detected in the full study.

What was striking in these FYE students' reflections is the complex interplay between students' thinking about their SBG feedback, the problem sets themselves, the SBG system and its administration, and the reflection prompts and their administration. A few of these interrelationships are described below.

Students' reflections were generally shallow. Consider this relatively articulate student reflection on PS01:

> *"Looking at my problem set 01 results, it was clear that I wasn't 100% clear on scripts when I did it. I lost one point on the scripts section of that assignment accordingly, and I thought that it was deserved and reflected my ability at the time very well. Thankfully, now that I have done problem set two, I feel much more confident about scripts, although I will go back and review the materials on scripts from the objectives of ps 01 to make sure."*

This reflection exemplifies that while some students identified topics that they did and did not understand, they did not drill down to anything specific about these topics. (What does this student still need to learn about scripts?) This lack of specificity in students' unpacking of their learning may have led to their listing generic strategies for better meeting the learning objectives (e.g. reviewing materials). The shallowness of the reflections may be the result of both their not knowing how to engage deeply in reflection and their not knowing how to interpret their SBG feedback and what their options are for taking action to better meet a particular learning objective.

What was particularly troubling was the increase in the percentage of students not acknowledging what they had not learned on PS01 (50%) and PS02 (65%), despite the decrease in full achievement of objectives on PS02. This may have been symptomatic of students still trying to find their footing in the course. Some students referred to having to read the assignment more carefully and make sure they submitted all of their work – ideas that seem to indicate they are still in a process of figuring out course logistics and expectations. There may have also been less engagement in the PS02 reflection for which the responses were on average shorter (441 ± 175 characters for PS01, 396 ± 186 characters for PS02).

Students' success on PS01 gave many students little incentive to consider their learning. This problem set was different than PS02. PS01 was a tutorial introduction to MATLAB in which students tried and observed basic syntax and operations. PS02 and later PSs had students apply concepts to solve problems. So while directing students to look at their feedback on PS01 was a matter of practice, the feedback on PS01 provided most students no grounds for action and may have led to less investment in reflection on PS02.

Too much time may have passed between submission of the problems sets and receiving feedback. The delay in feedback is a practical issue for a course of this size with many graders. The result was that a number of students had difficulty focusing their reflection on a past assignment. By the time students were asked to reflect on PS01, they were well into working on PS03. Certainly there was evidence in the details of some students' reflections that their minds were on the current topic rather than the topics of the problem set under reflection.

In addition, many students also seemed to not think about what they believed they had or had not learned independently of the assessment of their work. These students only parroted back their assessment rather than think about whether the assessment really reflected their perceptions of their learning as the reflection questions intended.

It is unclear from these findings whether the reflective prompts are capturing the depth of students' meaning making of their SBG feedback. Is it that students only process that something is amiss with their learning of a topic and do not process what that something might be? Or are students just not conveying the extent of their sense making either due to poor reflection prompts, poor timing of the reflection, unclear expectations for reflection, or their own inexperience with reflection? Likely all of these issues are at play.

A few modifications need to be made to improve the quality of the reflection data in the next iteration of this course. These actions should also benefit student learning if reflection is seen as a means for helping students to learn how to make meaning of and act on their feedback. First, students need to receive instruction on reflection [5], be apprised of the expectations for engagement in reflection, and see examples of how reflection applies to thinking about one's learning with respect to feedback. Second, the reflection prompts need to be rephrased or better timed. One possibility is to ask what they believe they have (not) learned at the time they submit an assignment. Then when work is returned with feedback, students could compare their beliefs with the assessment of their work. Third, students, particularly FYE students, need guidance on effective and efficient strategies for learning. Going to office hours and reviewing online modules, while more specific than "work harder", are not actions that, in and of themselves, will result in greater learning. Fourth, these reflections need to continue across all assignments so students keep practicing reflection and attending to their feedback.

CONCLUSION

This work in progress provided some insight into the training needs of students to make SBG more effective, particularly in prompting students to take action to address learning objectives with weak demonstrated achievement. Students do not naturally engage in deep meaning making of SBG feedback. Reflection, such as that used to attempt to capture students SBG feedback sense-making, might provide a means to help students think about their learning. However, reflection does not come easily to students, it requires instruction and practice. Therefore, instruction on how to reflect on one's learning and how to interpret SBG feedback need to be tightly interwoven.

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