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Work in Progress: Aligning and Assessing Learning Objectives for a Biomedical Engineering Course Sequence Using Standards-based Grading within a Learning Management System

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Motivation and Long-term Vision

Standards-based grading (SBG) involves the creation of course learning objectives (LO) and linking these learning objectives to particular aspects of course assignments. Assignments are created such that students have the opportunity to show mastery in a particular learning objective multiple times over the course. This approach aligns student assessment with the intended course outcomes, rather than the traditional score-based grading. Advantages of this technique include real-time assessment of progress towards relevant skills, shifting students towards focusing on the learning rather than on earning a grade, and providing a means for program assessment.[1,2] This technique has been implemented extensively in K-12, but we are just now beginning to assess its use in engineering in higher education. Recent work by Carberry, *et al.* investigated the implementation of SBG by ten instructors at six institutions, work that has uncovered best practices associated with SBG which will be applied in our research study as described in the methods section below.[3] More specifically, best practices include tracking a manageable number of standards, using a three to five point score, providing frequent formative feedback, and allowing multiple assessments over the term, among others.[3]

We are motivated to implement SBG to better connect courses in a required, Junior-level course sequence in Biomedical Engineering. Course LO are not well-mapped or optimally assessed throughout this sequence leading to unpreparedness in courses later in the sequence. Currently, the first course in the sequence focuses on electronics and introduces signal acquisition. The second course focuses on advanced digital processing. The last course incorporates content from the previous courses in the sequence as well as from a fundamental statistics course in the context of experimental design and measurement. We anticipate that SBG will allow for frequent, formative feedback throughout a single course as well as inform the instruction of faculty teaching subsequent courses building on these standards, including courses beyond this sequence such as Capstone. Our long-term goal will be to identify, align, and assess LO within and across these courses in the curriculum using SBG. We will also review and assess implementation of SBG in this context.

This preliminary work focuses on implementation of SBG in the culminating course. We hypothesize that Canvas-mediated SBG will 1) allow for frequent formative feedback from instructors resulting in student achievement improvements, 2) be perceived favorably by both students and instructors, and 3) support persistence in the course.

Identification of Learning Objectives

To date, learning objectives have been defined for this course and related standards developed centering on problem solving skills. These skills are heavily influenced by the Accreditation Board for Engineering and Technology (ABET) Student Outcomes[4], the Transferable Integrated Design Engineering Education (TIDEE) framework[5], and competencies identified by employers.[6] These standards extend beyond the borders of a single course. Table 1 below outlines the standards in detail and relates them to the corresponding ABET outcome. ABET outcome 2 and 5 have not been included as they do not relate to learning objectives in this course.

Table 1: Problem Solving Standards[4–6]

PROBLEM SOLVING	DESCRIPTION	ABET
Problem Identification (PI)	Identifies problem and construct a hypothesis. Show a strong connection to the literature.	1
Knowledge Processing (KP)	Locates, evaluates, integrates, and applies knowledge to support hypothesis. Assesses the accuracy of conclusions in literature and generates original critique of third-party methods or assertions.	6
Approach/Experiment Design (ED)	Formulates the approach and appropriate experimental design.	1, 3
Analysis (A)	Analyzes and graphs appropriately data needed to test hypothesis	3
Interpretation (I)	Interprets analysis to draw conclusions about hypothesis and ties to greater significance.	3
Communication (C)	Demonstrates clarity, organization, appropriate format, good use of graphics, and correct scope (appropriate for audience). Presents credible information accurately. Uses citations appropriately.	4
Teamwork (T)	Establishes goals, plans tasks and assigns responsibility to individual team members, meets deadlines, and communicates effectively	7

These standards align well with the traditional sections of a lab report or a journal article and solely comprise the grading rubrics for lab reports related to four modules. Detailed rubrics based on these standards are tailored to each lab module and shared with the students. Communication carries throughout the entire report. Teamwork is assessed through weekly discussions between instructors/teaching assistants and student lab-groups.

Implementation of SBG in Canvas's Outcome Feature and Gradebook

Canvas allows for real-time assessment of students' progress towards mastery of a skill. After inputting the standards and associated descriptions as outcomes we created lab report rubrics using these outcomes. All standards are scored on a scale from one to five where one equates to "novice" and five is "distinguished". We set a level of "3" out of "5" as reflecting sufficient mastery for each skill. Then these scores are given various weightings to produce a final report score which directly comprises a percentage of the final grade. The four reports comprise 7.5%, 10%, 12.5%, and 15% of the final grade respectively. Building the rubric with outcomes allowed for quick visual feedback regarding progression towards mastery as shown in Figure 1 below. This guided instructional effort for subsequent labs and in-class sessions in the course. At the end of the quarter, mastery of these standards within this course will be shared with Capstone instructors to inform their coaching as these are skills fundamental to the Capstone design process.

Assessment of Incoming Related Skills

Until mastery-based grading has been implemented throughout the sequence, quizzes based on the relevant LO of the previous course(s) will be administered to tailor instruction in the absence of SBG data from the previous courses. A statistics concept quiz has been administered with concepts relevant to the experimental design course. Results show overall mastery in selection of appropriate inferential statistics, linear regression, and power analysis with areas of weakness in post-hoc tests and calculation of p-values (n=10). This information has informed teaching in the "analysis" category. Development of other pre-tests are underway.

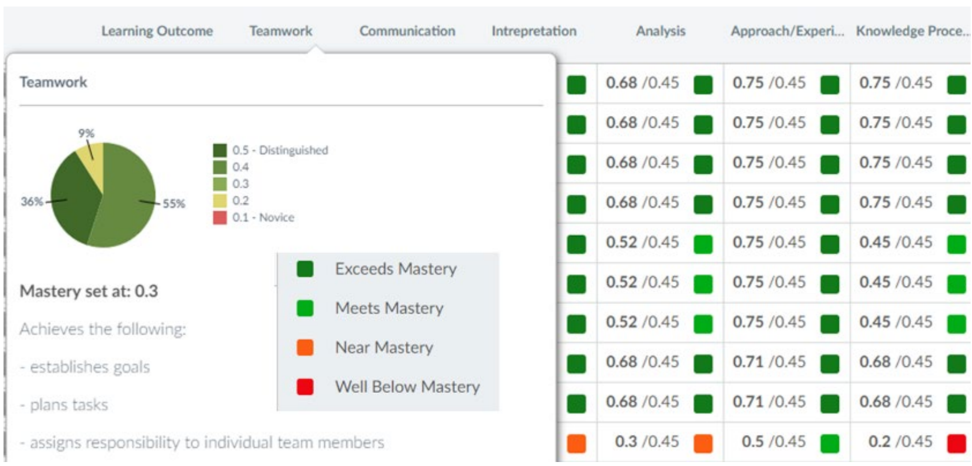

Figure 1: Snapshot of progress towards mastery allows for frequent, formative feedback. *These values correspond to the weighted values. For instance, if "Knowledge Processing" is 15% of the report grade and can span from 1 to 5 for mastery, 0.75 is the maximum score in this category. Each row represents a student and each column represents a standard. A summary of the data for "teamwork" is highlighted. The bottom entry is a test student.*

Assessment of SBG: Achievement, Persistence, and Attitude

Implementation of SBG in this culminating course will be evaluated based on overall achievement and gains (in terms of SBG), persistence (attendance), and attitude (through Canvas surveys) with respect to SGB. To date, we have seen that all students have shown mastery (with mastery being a three out of five) in all the skills listed in Table 1 and have not had any unexcused absences (n=10). Student attitude has been assessed at the beginning of the term using a survey based on confidence in scientific literacy.[7] Students were the least confident in challenging scientific authority and designing experiments, both which are core objectives of the course. This survey will be administered at the end of the quarter. Gains would suggest that the learning environment which is heavily influenced by SBG supports student confidence in scientific literacy. In addition, a student value survey of the standards-based grading technique based on the validated and reliable "Student Value of Muddiest Points" survey will be administered post term to further assess student attitude regarding the intervention.[8]

Conclusion and Future Work

After successful implementation of SBG in a single course, our long-term goal will be to identify, align, and assess LO within and across these courses in the curriculum using SBG. We will review and assess implementation of SBG in this context as a function of student achievement, attitude, and persistence before and after implementation of SBG. We will also evaluate implementation of SBG considering different course and assignment structures. Additionally, we are interested in determining a way to track improvement or sustained mastery in each skill across course boundaries throughout the entire curriculum. SBG not only allows for frequent, formative feedback from the instructor and shifts the focus from grades to learning skills but will also make students more aware of their developing skill set which could be leveraged by students when participating in job interviews.

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