Grading by Competency and Specifications: Giving better feedback and saving time

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motivation and introduction

Arguably one of the most tedious and time-consuming responsibilities of faculty members, especially in large enrollment courses, is grading. Additionally, creating a personalized learning experience for each student can quickly become overwhelming in such courses. By grading through the utilization of competency-based learning or specifications grading, faculty members can simultaneously provide more agency to students over what they learn and how, while also decreasing time spent on higher quality evaluation.

Specifications grading, an evolution of contract grading [1], is a novel grading approach introduced by Nilson [2] designed to help motivate students to focus on learning rather than feeling the need to obsessively count points. In a specifications grading approach, faculty provide clear specifications of what is required to earn a given grade in the class. Rather than basing grades on point totals or a weighting system, students are given the option to complete specific assignments or bundles of assignments that link to a specified grade. Each assignment is graded on a pass/fail basis where passing is typically defined as B or B+ level work. Each specification should also be clearly linked to the stated course learning objectives and students are sometimes given the opportunity to submit at least a certain number of revisions to assignments that did not match the specification on the first submission. Since its introduction, several faculty have implemented this approach in their courses in fields ranging from counseling [3] to political science [4] to the sciences [5]. More recently, this approach has also been applied to engineering courses with mixed success [6]. One of the benefits within engineering is the potential for a specifications style approach to better represent the expectations students will experience in the professional world where they will address client needs.

Educational outcomes in the broad sense come in a variety of flavors. Nilson [7] defines a learning outcome is a statement of what students are able to do after completing a course or portion of a course. ABET states that student outcomes are “statements that describe what students are expected to know and be able to do by the time of graduation” [8]. It is important to note that these views suppose that the behaviors, knowledge, and skills a student demonstrates are developed in response to a course or program. While still an outcome-based pedagogical tool, competencies, in slight contrast, do not suppose the origin of the instruction of an educational outcome, and go further to define levels of performance, breaking down complex mastery of a discipline into more easily demonstrable pieces. As such, competencies are required to be measurable just as good educational outcomes are. A competency-based assessment is meant to identify areas of required improvement through additional practice, instruction, or training. The Council for Adult and Experiential Learning notes competency-based programs, among others, at Peirce College, Bachelor of Science in Information Technology; Valdosta State University, K-5 Science and Mathematics Teaching Endorsements; and Davenport University, Master of Business Administration [9]. The models are to provide students, typically non-traditional, a modality to demonstrate ability in a skill or knowledge set in an attempt to earn credentials outside of the credit hour system. Each competency can be evaluated as not-proficient through

mastery with those competencies in need of improvement receive additional instructor support. While many instructors utilize a student-centered approach in developing educational outcomes, a competency-based approach explicitly places ownership and agency on the student for attaining and demonstrating the desired performance level of the competency.

The advantages and disadvantages of the specifications grading and competency-based approaches are shown in Tables 1 and 2, respectively. While this grading approach is transparent and allows the students to have more ownership of their learning, there can potentially be a lack of buy in from students and more work for the faculty up front. Despite these disadvantages, the faculty work-load during the semester is significantly less than when traditional grading approaches are used [2]. Neither of these grading approaches have been used in the contexts we present here. Specifications grading was implemented in a laboratory course and a research course, while the competency-based approach was implemented in a capstone design course, consisting of students with a vast array of preparations.

Table 1: Advantages and disadvantages of the specifications grading approach.

Advantages	Disadvantages
Transparency	Potential lack of buy-in from students
Student ownership	Potentially more work up front for faculty
More student choice	Less flexibility for poor performance
Students learn time management and prioritization	
Faculty save time grading	
Better representation of “real world”	

Table 2: Advantages and disadvantages of competency-based grading.

Advantages	Disadvantages
Enables faculty to be more adaptive in their courses	Requires students to be self-motivated
Student ownership and control	Potentially more work up front for faculty
Faculty save time grading	Identifying the most important skills
Flexibility	

specifications grading implementations: laboratory and research courses

The specifications grading approach was implemented in two semesters of a large undergraduate research course and a co-instructed chemical engineering senior laboratory course at the University of Connecticut both had a variety of individual and group assessments. The grading scheme was explained to the students on the first day of both courses along with a due

date matrix for assessments. The student evaluations of teaching after the first semester indicated mixed feelings regarding the grading scheme. Based on this feedback, the instructors made the motivation for using specifications grading more transparent and provided handouts with checklists to the students during the second semester offering of the course during the Spring 2019 semester. The broad learning objectives of this course included: (1) research skills, (2) technical communication, and (3) environmental health and safety. This course was broken into two sections, one focused on mixtures and reactions and the other on bioengineering applications. Students worked on teams in both sections to conduct three laboratory experiments. The corresponding major assessments for each experiment were a lab report (individual), video article (team), and poster (team). All team-based assignments had to be completed at a satisfactory level in order to pass the course. Additionally, all students were required to go through safety training. Quizzes on statistics, writing, and scientific figures were required to earn a B in the course. This course also contained additional formative and summative assessments associated with each grade level shown in Table 3. In order to earn credit for each assessment, students had to complete the assignments at a minimum level of B+. A complete list of assessments and associated grades are given in Table 3.

Table 3: Specifications with associated grades for senior laboratory course.

Grade	Deliverable/Specification
D	Safety Quiz
D	Pre-Lab Worksheets 1, 2, 3 (TEAM)
D	Poster (TEAM)
D	Short Report
D	Video (TEAM)
D	Peer Evaluations
C	Statistics I Quiz
C	Data Analyses 1, 2, 3
C	Standard Operating Procedure (SOP)
C	75% Lab Notebook Check
B	Writing Quiz
B	Statistics II Quiz
B	Figure Quiz
B	Lab Memos 1, 2
B	Lab Cleaning
B	Full Report in lieu of Short Report
A	100% Lab Notebook Check
A	Full Lab Report Draft
A	Cost Analysis for Process Scale Up
A	AIChE Safety Module (full Level I Curriculum)
A	Oral Data Quiz

The instructors found the specifications grading approach saved time compared to traditional grading schemes. Due to the transparency of this approach, the instructors also received significantly less complaints and appeals about course grades. The students also took

ownership of their grades and determined the very first day of the course which assessments they wanted to complete. Meeting deadlines, despite the students being given a detailed due date matrix, was the biggest challenge observed by the instructors. The data analysis assignment was the assessment students most likely did not meet the minimum B+ level to earn credit. This is likely due to poor time management and underestimating the amount of work required to satisfactory complete data analyses.

One co-author also implemented specifications grading to assign grades for undergraduate researchers in the lab. In a given semester, 15-30 students participate in undergraduate research in the lab in question working on projects that are undergraduate-led rather than shadowing a graduate student. The broad course objectives include (1) students developing skills in research, (2) technical communication, (3) project management, (4) teamwork, (5) environmental health and safety, and (6) research ethics. Students can elect to take 1, 2, or 3 credits of research each semester.

Developing a concrete grading scheme that is both effective and efficient has long been a difficult task. To combat this problem, the co-author has implemented a specifications grading approach during the last three semesters (starting in Fall 2018). The defined specifications are made up of two components: deliverables and hours of effort.

The deliverables are comprised of mandatory university safety trainings to gain access to the lab, responsible conduct of research training, educational and skills modules, reflections, planning memos, and a presentation. Some of these deliverables are dependent on how many semesters a student has been in the lab with students who have been in the lab longer not needing to complete as many safety trainings and completing more advanced skills modules. Students are given the freedom to only complete the deliverables necessary to achieve their desired grade. A complete list of the assessments and associated grades are given in Table 4.

Table 4: Deliverable specifications for the undergraduate research course. To obtain a specific grade, students must complete everything listed for that grade and the grades below it (e.g., to earn an A, students must complete everything). Items in italics are submitted as a team.

Grade	**Deliverable/Specification**
D	CITI Responsible Conduct of Research Training
D	Biosafety General Training Completion
D	Chemical Laboratory Safety & Waste Management Training Completion
D	Team Evaluation
D	*Presentation*
C	Beginning-of-semester reflection
C	*Semester planning memo*
C	*Mid-semester update memo*

C	*End-of-semester memo*
C	End-of-semester reflection
C	Average rating of good or above on team evaluation
B	Enrichment/skills module
A	One journal paper overview per credit

The second component of the specifications grading is the actual time spent on the research project. To address this, the instructor developed a simple formula (equation 1) to calculate the number of hours expected of students over the course of the semester depending on the number of credits they elect to enroll in. Students were graded on total number of hours in the semester rather than weekly to allow them flexibility to plan around other major assignments and exams in their other courses.

$$Hours = 14\ (1+i*Credits) \qquad \text{(equation 1)}$$

In equation 1, i is a multiplier associated with a target letter grade and is equation to 1, 1.5, 2, and 3 for grades of D, C, B, and A, respectively. Students log their hours on the project throughout the semester and the final total is used to assign the grades.

From the perspective of the instructor, this provided a concrete approach to assigning letter grades for students participating in independent undergraduate research for credit and was a more honest reflection of how grades were already being assigned. It also saved time during the grading stage. The feedback from students has been extremely positive because it makes the expectations clear and spells out the path to their target grade (typically an A) in finite, achievable steps.

competency-based grading implementation: capstone design course

A competency-based grading approach was implemented in a one semester Capstone Design course at the University of Notre Dame. One challenge associated with instructing Capstone Design is the wide variation in background students bring to the course, both in academic knowledge and internship or work experience. Additionally, a one semester Capstone has challenges of placing high academic demands on students due to both lecture material and the capstone project being completed in the same semester. Compounding this challenge is the division of duties among the team within the project. In an effort to increase student agency and decrease workload on the students, instructor, and teaching assistants, a competency-based grading approach was explored.

The complex mastery of a capstone course hinges on successful completion of the capstone project. This complex competency can be broken down into simpler demonstrable pieces around the topics of: communication, design diagrams, economic analysis, heuristics in design, safety in design, simulation, and teamwork. For instance, the background of students within the topic of economic analysis ranges from students who have not taken an economics or finance class, never being exposed to the concept of time value of money, to students who are

earning business or finance minors. It was chosen to implement competency-based grading on a small scale within the simulation topic.

There were three deliverables for students to show this competency: a proposal, execution of the proposal, and a self-assessment. To aid in proposal development, students were given a list of seven moderately complex abilities which may be demonstrated within the simulation to show competency. Complete agency was given to students over how many abilities to show, how to demonstrate them within simulation, and even due date (with some limitations). Students focusing on the simulation within their team capstone project were encouraged to utilize this simulation to demonstrate competency. Students were given suggestions of completion methods, among them, a 30 minute walkthrough and discussion with the instructor, creation of an instructional video explaining the use of the simulation, a written instructional document, and a written report. The proposal was due early in the semester and a maximum of one page. The instructor indicated a likely level of attainment of the competency upon the review of the proposal.

Students then executed their proposal followed by a self-assessment where they were given descriptions of "Superior," "Strong," "Acceptable," or "Still developing" competency levels. These levels corresponded to grades of A, A- or B+, B or B-, and C+ and below. They were to utilize no more than half of one page stating their assessment and defending their assessment.

results and discussion from specifications grading

A paper survey with the following questions was given to the 31 students enrolled in the laboratory course in which specifications grading was used with a response rate of 42% (R1 University IRB Protocol: H18-165).

1. How clear were the expectations of the specifications grading conveyed by the course syllabus and by the instructors?
2. Did you feel confident about where you stood in terms of progress towards earning your intended grade throughout the course?
3. Based on the specifications grading scheme for this course, what final grade do you expect to earn?
4. What do you think were the strengths of the grading approach for this course? Why?
5. What do you think were the weaknesses of the grading approach for this course? Why?

The responses for the first three questions are given in Figures 1, 2, and 3. The majority (85%) of the students felt that the specifications grading scheme was transparent and communicated effectively. All of the students who responded to the survey that they were confident in terms of progress towards earning their intended grade. As shown in Figure 3, 68% of the students surveyed expected to earn an A, while 38% a B for their final grades. The final grade distribution was 58% As and 42% Bs. This discrepancy could be due to the fact that the response rate was only 42% and the higher achieving students responded at a greater rate.

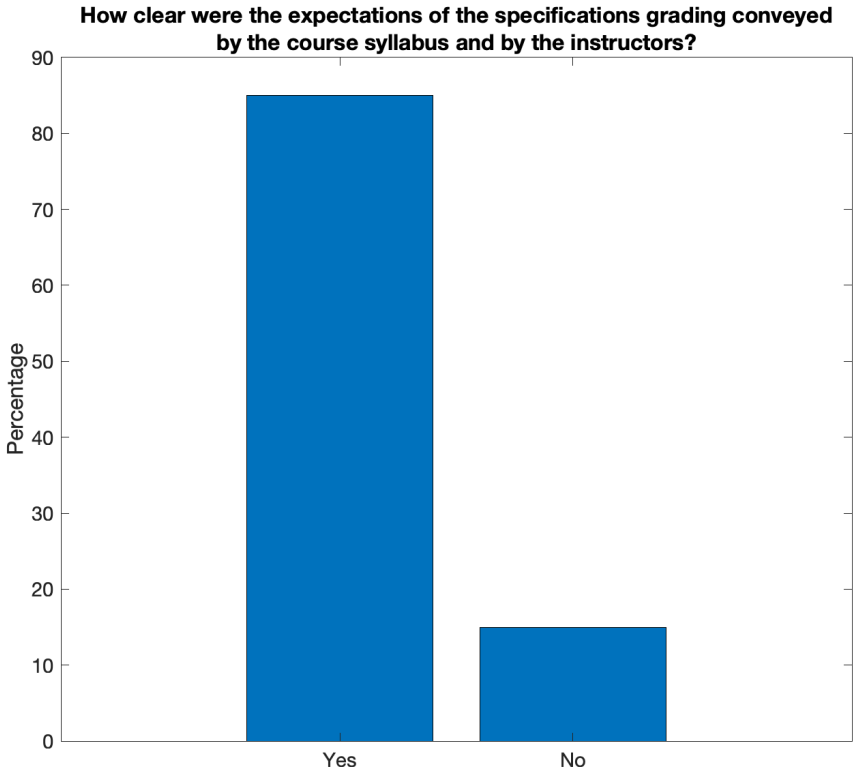

Figure 1: Responses to question 1 of survey administered to students enrolled in the laboratory course in which specifications grading was implemented.

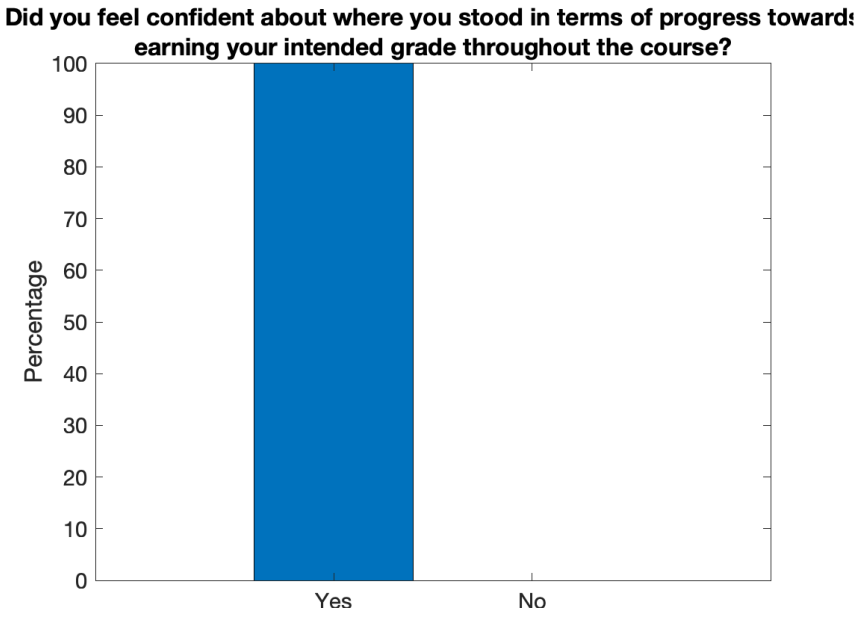

Figure 2: Responses to question 2 of survey administered to students enrolled in the laboratory course in which specifications grading was implemented.

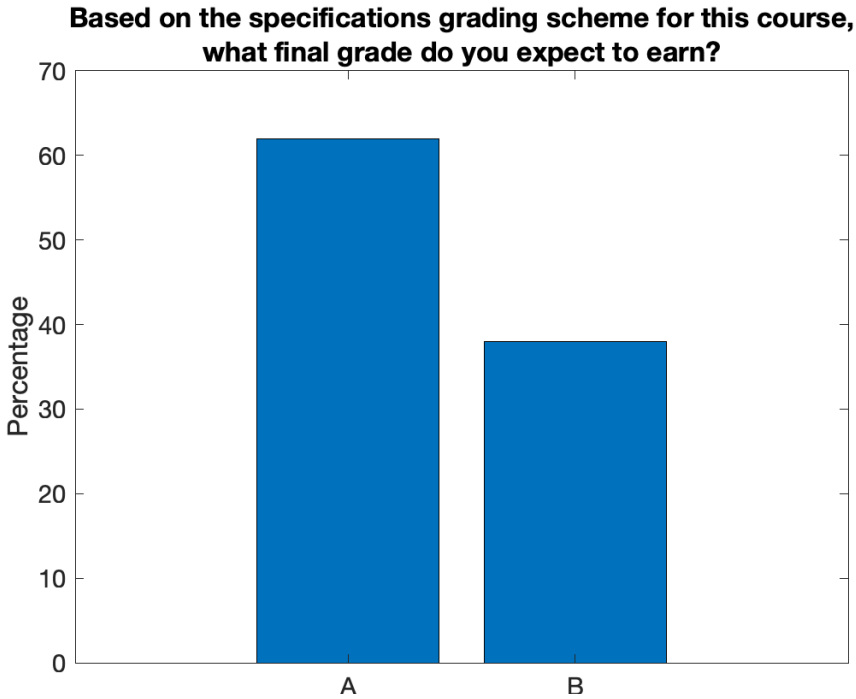

Figure 3: Responses to question 2 of survey administered to students enrolled in the laboratory course in which specifications grading was implemented.

Students who responded to the fourth question of the survey felt that the strengths of the grading approach included: lower stress, clear, more independence, similar to a real job, being able to choose a grade up front. On the other hand, students found it difficult to keep track of all of the deadlines, disliked the steep consequences for completing work late, thought there were too many assessments, and didn't have a clear idea of what B+ level work looked like.

Based on this feedback, improvements have been made to the specifications grading scheme currently being implemented in senior lab. More time is spent motivating students on the reasons for using this approach, handouts with checklists and the due date matrix are provided to the students the first day, less assessments are required to earn the grades of A and B, and students are allowed to earn more tokens by submitting work 24 hours ahead of the deadlines. Student evaluations of teaching will be used to obtain feedback on the current implementation.

results from competency-based grading

Approximately 75% of students completed a 30 minute walkthrough with the instructor. The instructor spent an additional approximately 5 minutes writing individual notes for justification of the competency level, and thus grade. Individual deliverables in previous semesters were in excess of 10 typed pages per student. The feedback given orally during the walkthrough was sufficient for the instructor and student to agree on the assessment of competency for more than 90% of students completing the walkthrough. This reduction in grading time and improved feedback was tremendous.

summary and conclusions

While quantitative data were not collected, the faculty for all three courses found that the new grading schemes decreased their time spent on grading and provided a more authentic assessment of student performance. Both students and faculty viewed these grading approaches as more representative of the way they will be evaluated in their future careers. The specifications grading approach also allowed students to better keep track of their current standing in the course.

Based on their experience, the faculty learned several lessons that would benefit other faculty hoping to apply these approaches to their course. In the specifications grading, the specifications and grading scheme need to be extremely clear and motivated, and, if possible, the instructor should include sample work and ways for students to resubmit work that did not meet the specifications.

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