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Improving Student Learning in a Capstone Design Course Using Specifications Grading

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Abstract

Classroom interventions are commonly used to improve student learning. Changes in assessment methodology are less common, but can be equally impactful. Specifications grading, a new assessment method first introduced by Nilson, has attracted interest for its promise to restore rigor, motivate students, and save faculty time. In specifications grading, work is graded pass/fail based on a detailed rubric. The bar for a passing grade is relatively high, so students are allowed a limited number of revision opportunities. The literature contains a growing collection of case studies on the use of specifications grading in STEM courses. Specifications grading seems well-suited for capstone courses that prepare students for the transition from academia to industry. In engineering practice, work is evaluated as satisfactory/needs-revision, with opportunity for revision. Despite the obvious parallels between specifications grading and engineering practice, few instructors have adapted specifications grading for use in capstone design courses and none have documented its impact on learning.

This Academic Practice / Design Intervention paper explores the impact of specifications grading on student learning in a capstone design course. The instructors have developed and provided a clear, detailed set of requirements for the technical content and quality of communication of each major deliverable. Student work is graded satisfactory/needs-revision, with the bar for satisfactory work equivalent to a “high 80’s” grade in a traditional grading system. Full credit is awarded for “satisfactory” work and no credit is given for work that does not meet that standard. Students are allowed unlimited revision to the first of each type of deliverable, but the time frame is limited to one week. To encourage quality, timely work, students are only allowed to revise two subsequent deliverables.

The impact of specifications grading on learning is measured both qualitatively and quantitatively. Student attitudes and behaviors are documented to determine whether the use of specifications grading improves teamwork and yields a shift from grade-centric to learning-centric behaviors. The quality of major deliverables is measured using percentage scores. Both qualitative and quantitative results are compared to a control group composed of two years of prior capstone courses that used traditional assessment methods.

The introduction of specifications grading fostered substantive conversations between students and instructors on expectations for quality. Students proactively requested formative assessments to guide them in preparing their first major written report. Scores on major design reports were better than those of the control group. Students shifted from grade-centric to learning-centric behaviors, enabling instructors to serve as mentors rather than mediators and judges.

Introduction

Embry-Riddle Aeronautical University’s Aerospace Engineering program concludes with a major, team-based capstone design project. This two-semester, four course, 11 credit hour sequence includes both engineering and technical communication courses and is co-taught by engineering and communications instructors. Each student invests nearly 500 hours in a team-based project. Each team of six to nine (or more) students completes the design, fabrication and flight testing of an unmanned aerial vehicle. Students document their work through four written reports and eight oral presentations (i.e., design reviews and test readiness reviews). While each team member has a distinct technical role, all work is completed collaboratively [1], [2].

The intensity of the project and its collaborative nature present unique challenges for both capstone students and instructors. Motivation varies significantly from student to student, as is common in many courses. Yet, most deliverables are collaborative, with all team members earning the same grade. Students with high GPAs who track every point are never satisfied with their teammates' performance because anything short of perfection from all teammates reduces their own percentage score on reports and presentations. This unnatural pressure wreaks havoc on team dynamics. The pressure also strains the student-instructor relationship. Students haggle for points [3], beg for extensions, and/or make poor design decisions in an effort to maximize their grade. And, when a team has achieved their desired grade prior to the end of the semester, they are inclined to submit a poor-quality final report, relying on partial credit for work that would be unacceptable in the workplace and undermining the accuracy of summative assessments that document learning for accreditation purposes. In the context of a capstone course, the combination of traditional grading practices and team deliverables encourages grade-centric behaviors rather than learning-centric behaviors.

One way to refocus students on learning is to adopt specifications-based grading. This assessment method was popularized by Nilson in her 2015 book entitled *Specifications Grading: Restoring Rigor, Motivating Students, and Saving Faculty Time* [4]. Core elements of specifications grading, as described by Nilson, Townsley [5], and Howitz [6] are:

1. Course assessments align with learning outcomes
2. Assessment rubrics use pass/fail specifications to determine content mastery
3. Letter grades are based on the number of activities completed at a satisfactory level (a.k.a., mastered), or the level of competence with which activities are completed
4. Students are afforded opportunities for revision and resubmission of work that initially does not meet specifications

Specifications grading builds on mastery learning, competency-based grading, and contract grading. As such, it shares many of the learning benefits of these three assessment methods.

A growing body of literature [7] documents many benefits of specifications grading and other similar forms of mastery-based assessment. First, mastery grading reduces student stress. Morris [8] found that students "experienced reduced test anxiety, achieved higher letter grades through penalty-free reattempts, and felt more confident about their math abilities." Second, specifications grading creates a more positive dynamic between instructors and students. In points-based grading, "the instructor is set up as both a coach and a judge. This mixing of roles makes both ineffective [9]." In contrast, in specifications grading, student-instructor interactions focus on course content rather than bargaining for better grades, facilitating positive communication [10]. Third, mastery grading encourages a growth mindset by inviting students to revise and improve their work. This allows students to focus on areas of weakness [10]. It also rewards learning gains rather than just consistently high performance [11]. Fourth, mastery grading enhances student motivation. It taps into three social-contextual factors – competency, relatedness (a.k.a., relevance), and autonomy – identified by Self Determination Theory as enhancing intrinsic motivation [9]. Mastery grading enables students to achieve competency by creating opportunities to revise work and/or repeat assessments. Mastery grading also affords students the autonomy to focus their learning on the course outcomes they deem most interesting and relevant. Fifth, specifications grading improves the quality of student work. In a 2020 study, students acknowledged that "specifications grading pushed them to be more attentive to requirements and that it raised the quality of their work." Their instructor noted that specifications grading "improved report quality" and "students were less likely to submit incomplete work [12]." Sixth, mastery grading encourages students to learn at a deep level. It "allows students to feel the accomplishment of learning and getting good grades. It teaches skills of perseverance and success [9]." In summary, the literature suggests specifications grading can reduce stress, improve student-instructor interactions, encourage a growth mindset, enhance motivation, improve quality of student work, and strengthen learning.

The literature also notes two challenges to successfully implementing specifications grading. First, "specifications grading requires an extensive time investment prior to starting the course to ensure that all aspects (assignments, assessments, resubmission requirements, alternative exams, etc.) are well aligned to the learning objectives and that bundles (or tiers) used for grades are correctly formed to accurately assess student learning [5]." Second, the instructor must diligently foster buy-in among students [13]. "For most students, specifications grading will be new and different from the types of grading they have experienced for most of their education. Students may be confused, frustrated, anxious, or otherwise resistant to this system of grading if instructors do not explain the grading process often and with detail [6]." While both challenges can be overcome, they require careful planning and a significant investment of time when creating the course or when adapting the course for specifications grading.

Specifications grading can be tailored to support the learning outcomes of an individual course and the course's role in the curriculum. For example, Tsoi [14] describes the development of three specifications grading variants for undergraduate science and mathematics courses. In courses with "core" learning objectives foundational to subsequent courses, students were required to master all core objectives to pass the course. Students could earn a higher grade by completing additional (non-core) learning objectives. In other courses, all learning objectives were deemed equally important. Students earned grades based on the number of objectives they mastered. This afforded significant freedom for students to customize the course to their learning interests. In a third set of courses, learning objectives were grouped by theme in modules. Students completed a module by mastering a predetermined number of objectives within the module. Students earned grades based on the number of modules completed. Modules were used primarily for organizational purposes, while also guiding students toward a balanced study of the course's main themes. Tsoi's paper illustrates that specifications grading is adaptable to the unique purposes of each course.

This paper introduces a specifications grading assessment methodology customized for project-based courses such as engineering capstone design. Using this methodology, the paper seeks to answer three questions. Will the transition from traditional assessment to specifications grading:

1. Shift students' focus from grades to learning?
2. Improve the technical quality of students' work?
3. Improve interpersonal dynamics among team members and between students and instructors?

The answers to these questions are found through comparing the outcomes of test and control groups. In specific, the paper reviews the results of two major design reports and student behavior. It also reviews students' own assessment of teamwork, behavior, and technical achievement.

Methodology

ERAU's first semester of aircraft capstone includes AE 420 Aircraft Preliminary Design and COM 420 Advanced Technical Communication. These courses have four learning outcomes.

1. Students will grow their oral and written communication skills through individual and team-based presentations and reports.
2. Students will grow their teamwork skills through close coordination with their design team.
3. Students will learn to contribute as disciplinary experts on a multidisciplinary team. In this role they will (1) become effective teammates, (2) clearly communicate their disciplinary perspective, (3) develop and apply disciplinary analysis tools, (4) proactively augment their knowledge and skills in response to unique project needs, and (5) support the integration of the team's collective knowledge in the design of a flight vehicle.
4. Students will demonstrate an understanding of the broader context of their work by applying their knowledge to create a design compatible with safety (i.e., public health, safety, and welfare), regulatory (i.e., codes and standards), societal (i.e., global, cultural, social) and business (i.e., manufacturing, economic, and environmental) norms.

In support of these broad learning outcomes, students engage in a structured sequence of design activities. During the first semester, these activities include defining performance requirements, analyzing the market, sizing a flight vehicle, completing a preliminary design, and developing plans for manufacturing and testing. Activities are documented and assessed through written reports and design review presentations.

Control Group – Traditional Assessment

Aircraft design capstone courses at ERAU typically use a traditional assessment methodology, as shown in Table 1. Major deliverables such as reports and design reviews are scored out of 100 points and contribute a fixed percentage to the final grade. Smaller deliverables such as weekly briefings and team evaluations are grouped into categories, with each category contributing a fixed percentage to the final grade. Reports, reviews, and other deliverables are guided by detailed rubrics and evaluated against professional standards for technical sufficiency and accuracy and technical communication. The course includes a mix of individual and team-based activities to encourage individual accountability and team-wide collaboration. Letter grades are assigned based on cumulative scores with A ≥ 90 %, B ≥ 80 %, C ≥ 70 %, and F < 70 %. This assessment strategy was used for two cohorts of students who form the control group. These cohorts were taught by the author in 2022-2023 and 2023-2024.

Table 1: Traditional Assessment Method

Individual Scores		**35%**
Individual Tasks (e.g., team evals)	10%	
Teamwork	25%	
Team Scores		**65%**
Weekly Status Reports and Briefings	10%	
System Requirements Review	5%	
Design Concept Review	10%	
Design Concept Report	10%	
Interim Design Review	5%	
Drawing Package or Prototype	5%	
Preliminary Design Review	10%	
Preliminary Design Report	10%	
Total		**100%**

Test Group – Specifications Grading

Specifications grading is a customizable assessment methodology that provides students with flexibility to focus their learning on areas of personal interest while ensuring that they achieve competence in all core learning outcomes. The nuances of defining and communicating specifications grading make a substantial difference in the ultimate success of this assessment methodology [15]. The following paragraphs explore how one might customize specifications grading to address the unique needs of a capstone design course. Similar choices would support other project-based courses.

The first step in implementing specifications grading is to define course assessments that align with learning outcomes. One of the challenges is that typical design-oriented assessment activities such as reports and reviews target multiple learning outcomes, creating a complex mapping from activities to learning outcomes. (One can envision a scenario where a design report demonstrates mastery of one learning outcome and simultaneously fails to show mastery of another learning outcome. Imagine the student confusion when their report simultaneously passes and fails.) When an assessment is linked to multiple learning outcomes, it is more difficult to isolate and assess students' mastery of individual learning outcomes. More significantly, students will struggle to see how assessment activities align with learning outcomes. An alternative way of expressing capstone learning outcomes is through ABET's Student Outcomes [16], all seven of which are assessed in ERAU's capstone courses. Those outcomes can be paraphrased as (1) complex problem solving, (2) design, (3) communication, (4) ethical and professional action, (5) teamwork, (6) experimentation, and (7) acquiring and applying new knowledge. If Student Outcomes (SO) 2, 3, and 4 are grouped, they yield a straightforward mapping between course assessments and learning outcomes, as shown in Table 2.

Table 2: Mapping Between Learning Outcomes and Assessment Activities

Learning Outcome(s)	**Assessment Activities**
Problem solving (ABET SO 1)	6 Weekly briefings
Communicating design and ethical considerations (ABET SO 2, 3, and 4)	2 Design reports 4 Design reviews
Teamwork (ABET SO 5)	5 Teamwork competencies
Experimentation (ABET SO 6)	1 Drawing package and prototype(s)
New knowledge (ABET SO 7)	5 Professional consultations

The migration to specifications grading inspired several small yet impactful changes in assessment activities. For example, students often consult with faculty members and other professional engineers to gain new technical insight and solve project-specific design problems. This activity was formalized and linked to the learning outcome of acquiring and applying new knowledge. Additional details are provided in the Specifications Grading Policy in the appendix.

The second step in implementing specifications grading is to define assessment rubrics that use pass/fail specifications to determine content mastery. Capstone courses often rely on detailed lists of requirements for each design report and design review, and templates are provided for design briefings. For example, the preliminary design report in this capstone course included 36 distinct requirements or specifications. These requirements are easily adapted for use as grading rubrics, ensuring completion of all required elements while allowing minor mistakes in technical content, writing style, and formatting. (A list of specifications for each deliverable is provided to students via Canvas, an online learning management system.) Students are informed that mastery is approximately equivalent to earning 87% in a traditional grading system.

The third step in implementing specifications grading is to define how course content mastery maps to letter grades. One option is to base grades on the number of learning outcomes mastered. However, this option would allow students to opt out of one or more ABET outcomes, undermining program-level assessment. A second option is to base grades on the level of competence demonstrated for each learning outcome. In specific, a student's grade is determined by the learning outcome with the lowest demonstrated competence. To pass the course, a student must demonstrate a minimum level of competence on every learning outcome. The second option was chosen to ensure that students focus effort on all learning outcomes. Students retain autonomy and flexibility to prioritize specific learning activities and to choose the level of competence they wish to demonstrate for each learning outcome. Competence is measured by the number of activities mastered. For example, to earn an 'A', a student must master all five teamwork competencies. To earn a 'B', a student must master four teamwork competencies. Etc. Details are provided in the Specifications Grading Policy in the appendix.

The fourth step in implementing specifications grading is to afford opportunities for revision and resubmission of work that initially does not meet specifications. Four opportunities for revision were incorporated into the capstone courses. First, students were provided "free" (unlimited quantity, but time-limited) revisions on the first of each type of deliverable. This created a low-stress environment as students adapted to the rigors of specifications grading. Second, students were allowed to revise and resubmit two subsequent deliverables. In many specifications grading formulations, these are referred to as tokens. Third, students were allowed to delay one major deliverable by one class period. Compiling and editing team-based deliverables often takes more time that students anticipate, so this flexibility encourages students to prioritize quality work over rushing to meet a deadline. Fourth (and perhaps most impactful), instructors took proactive steps to decrease the need for redoes through formative feedback. Instructors sign-posted common pitfalls and offered support. Students and instructors reflected on lessons learned after each major deliverable. Instructors provided formative feedback on teamwork competencies and scheduled class time to offer formative feedback on reports and reviews prior to the submission deadline. Through a combination of formative feedback and opportunities for revision and resubmission, the capstone courses were designed to help students master each learning outcome.

In summary, specifications grading offers a flexible framework to help students achieve mastery of course learning outcomes. Specifications grading was adapted for use in capstone courses as follows. First, given the significant role that capstone courses play in program assessment, the author chose to align course assessments with ABET's student learning outcomes. Second, student work was graded satisfactory/needs-revision, with the bar for satisfactory work equivalent to a "high 80's" grade in a traditional grading system. The author used the phrase, "needs revision", instead of "fails" because "needs revision" encourages a growth mindset. "Fails" would convey the wrong message, because work is only a failure if the student chooses not to learn from it. Third, students must demonstrate minimum competence in all five learning outcomes to pass. Students can earn a higher grade by satisfactory completion of additional activities within each learning outcome. Fourth, students are afforded several opportunities to revise a major deliverable. Students are also provided formative feedback at regular intervals and urged to seek additional feedback whenever desired. This assessment strategy was used for one cohort of students who form the test group. This cohort was taught by the author in 2024-2025.

Assessing the Impact of Specifications Grading

The impact of specifications grading was measured in several ways. These included student achievement on major design reports, student perception of teamwork, technical achievement, and behavior, and instructor perception of behavior.

Student achievement was measured using two major design reports. A design report is a holistic measure of learning, as it captures students' competence in communication, in design, and in ethical considerations. Since the report is a collaborative effort, it also indirectly reflects students' teamwork ability. Students in the test group received a score of "satisfactory" or "needs revision" for their reports. To enable performance comparison between the control and test groups, design reports for the test group were also scored using the same numerical scale as the control groups.

Student perception of teamwork, technical achievement, and behavior was captured through an end-of-semester survey with quantitative questions using a Likert scale. Teamwork was assessed using two sets of questions. The first measures team satisfaction:

- I am satisfied with my teammates
- I am pleased with the way my teammates and I worked together
- I am very satisfied with working in the team

The second set of questions measures interpersonal cohesion:

- Team members like each other.
- Team members got along well.
- Team members enjoyed spending time together.

These two sets of questions are based on Ohland, et. al., [17] and incorporated into CATME, a well-known and widely used web-based tool for team formation and peer evaluation.

Student perception of behavior was measured using two questions. These questions sought to determine whether specifications grading shifted students' focus from grades to learning.

- I often worried about my grade in the course. (scale reversed)
- My primary focus in the course was on learning rather than grades.

Student satisfaction with technical achievement was measured using three questions.

- My teammates and I had similar expectations for project quality.
- I am satisfied with the quality of my team's project (e.g., reports and/or models).
- My team achieved excellent results on our project.

Students answered all questions twice: (1) based on their experience with specifications grading in their capstone course, and (2) based on their experience in previous project-based courses with traditional assessment methods. Students' experience in capstone formed the test group, and students' experience in previous courses formed the control group.

Results

This section explores the impact of specifications grading on student learning and classroom experience in capstone design courses. We assess learning based on the quality of design and analysis, as communicated in major reports. We consider the classroom experience from the perspectives of the instructor and the students.

Scores for the conceptual design report (a mid-semester deliverable) and the preliminary design report (an end-of-semester deliverable) are provided in Table 3. Results illustrate that students in the test group achieved a higher level of competence than students in the control group. If the test group's reports had been assessed based on overall score, then the reports would have been deemed "satisfactory". However, in specifications grading, students must meet standard for every specification. In the conceptual design report, students' first submission failed 5 of the 16 specifications, necessitating revision and resubmission. All students exhibited a desire to continue learning (or, at least, to earn credit) by taking advantage of the opportunity for revision.

After revision, students met 15 of the 16 specifications. (One student still failed to meet standard on their section of the report.) To boost accountability, students receive individual grades for the first report. Thus, all except one student received full credit for the report. The remaining student received no credit. For the preliminary design report, students in the test group met all 36 specifications and received full credit. In summary, students in the test group (with specifications grading) demonstrated higher competence in learning outcomes than students in the control group, as measured by their two major design reports.

Table 3: Student Performance on Design Reports

	Control Group Avg	**Test Group Avg**	**Test Group Avg** (after revision)
Conceptual Design Report	79.8%	88.6%	90.2%
Preliminary Design Report	84.1%	90.8%	---

Specifications grading promotes learning by shifting student behavior. In the capstone course described in this paper, students understood and strove to meet the high bar set by specifications grading. Students began writing early – a shift in behavior from the control groups. In addition, students sought early formative feedback on their writing. This also marked a shift in behavior from the control groups. Deeper engagement in the learning process led to improved learning outcomes, as demonstrated in student achievement on major design reports.

Students were invited to reflect on the impact of assessment method on their learning, both in their capstone course with specifications grading (i.e., test group) and in previous courses with traditional assessment methods (i.e., control group). Results are shown in Table 4.

Table 4: Student Perception of the Impact of Assessment Method

	Test Group		**Control Group**	
	Mean	Std. Dev.	Mean	Std. Dev.
Team Satisfaction	4.60	0.50	3.29	0.73
Interpersonal Cohesion	4.84	0.37	3.33	0.85
Learning Focus	4.57	0.73	2.88	0.88
Technical Achievement	4.76	0.48	3.24	0.63

Survey results suggest that specifications grading yielded higher team satisfaction, more interpersonal cohesion, a stronger focus on learning, and better technical achievement. Table 5 evaluates the statistical significance of these results.

Table 5: Statistical Significance of Differences Between the Test and Control Groups

	t-value	**Significance**	**Specifications grading yielded:**
Team Satisfaction	5.77	0.000	Higher team satisfaction
Interpersonal Cohesion	6.31	0.000	More positive interactions with teammates
Learning Focus	5.71	0.000	Stronger focus on learning
Technical Achievement	7.37	0.000	Better technical achievement

All four survey metrics show strong statistical significance for the benefits of specifications grading. Student comments support these numerical survey results.

- “I really liked the pass/fail grading style of this course. I felt like I could trust my teammates a lot more because poor work wouldn't drag me down as much. This grading system helped relieve a lot of my stress.”
- “Not worrying about grades helped me focus on learning!”
- “This has been, by far, my favorite project at ERAU. For the first time, the vast majority of members can achieve or desire to achieve a similar project quality.”
- “Having the class based on a professional workplace instead of a classroom setting helps shift the mindset of the class away from grades and more on performance.”

Student comments illustrate that specifications grading yields alignment among team members on expectations for quality, and it shifts the focus from grades to learning.

Specifications grading also positively impacted the instructors. One of the reported benefits of specifications grading is a reduction in grading workload. That benefit was not realized in the context of our design-oriented capstone courses. When grading reports, the instructors focus on providing substantive formative feedback to help students mature their design and communication. That feedback is important in both traditional and specifications grading systems. The instructors did experience benefits in three other areas. First, specifications grading substantially reduced tension between student team members. In courses with traditional assessment methods, students struggle to agree on a common standard of quality for shared submissions, creating significant tension within the team. Specifications grading alleviates that tension by reducing grade discretization from percentage scores to a binary credit/no credit. Every student wants to submit work of sufficient quality to earn credit, yielding a team-wide standard for quality. In the control group, tensions created by the traditional grading system necessitated weekly mediation among team members. In contrast, the test group only required two brief interventions by the instructors to support positive team dynamics. Another benefit of specifications grading is that it eliminated grade-induced negotiation. In the control group, students frequently sought to negotiate extensions and/or reductions in work scope to enhance their chances of an ‘A’. Students in the test group never requested an extension for major deliverables nor argued for a smaller scope. In fact, students even recommended adding new topics to their preliminary design report. The reduction in mediation and grade negotiation enabled instructors to focus on their role as mentors (rather than judges), improving their relationship with students. In summary, while specifications grading did not substantially reduce instructor workload, it yielded more enjoyable work.

Conclusions

This paper introduced a specifications grading assessment methodology customized for project-based courses such as engineering capstone design. The assessment methodology was designed to achieve two goals. First, it sought to focus students on learning rather than grades. In contrast to the control group, students in the test group did not engage in grade-centric behaviors such as negotiating for extensions and project scope reduction. Instead, students exhibited learning-centric behaviors such as proactively seeking formative feedback on major deliverables. This shift from grade-centric behavior to learning-centric behavior yielded significant improvement in student learning, as measured by the quality of two major design reports.

The second goal of the specifications grading assessment methodology developed and tested in this paper was to improve interpersonal dynamics among team members and between students and instructors. In the control group, students had difficulty agreeing on a common standard of quality for shared submissions, creating significant tension within the team. In the test group, students shared a commitment to meet the standard for "satisfactory" work. This yielded far fewer interpersonal conflicts among students. The reduction in tension also enabled instructors to focus on their role as mentors rather than mediators or judges. Hence, specifications grading improved interpersonal dynamics among team members and between students and instructors.

Though the methods described in this paper were developed and implemented for aerospace engineering capstone courses, they have natural applicability to any project-based course. For example, the specifications grading formulation described in this paper could be adopted with little modification in project-based courses such as Introduction to Engineering and Cornerstone Design.

Future Work

A natural next step is to test the specifications grading formulation outlined in this paper in other project-based courses such as Introduction to Engineering and Cornerstone. Another valuable step would be to expand the use of specifications grading to other capstone courses and to assess whether the benefits identified in this paper can be replicated on a broader scale.

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Specifications Grading Policy

This course is designed to prepare students for the transition from university to industry. In engineering practice, design and analysis work as well as the resulting products are evaluated based on standards for safety, reliability, and performance. Work either meets standards or is returned for revision. Our course mirrors industry practice by adopting a specifications grading method. All work is evaluated using detailed rubrics. If the work meets all requirements (a.k.a., specifications), then it "meets standard" and receives full credit. If it does not meet all requirements, no credit is earned. Consistent with engineering practice, students have a limited number of opportunities to revise and resubmit work, as outlined below.

To earn an 'A', a student must:

- Meet standard[1] on all 6 design briefings
- Meet standard[1] on all 6 team reports and presentations
- Demonstrate all 5 teamwork competencies[2]
- Meet standard on drawing package and prototype
- Complete 5 consultations[3] with a professional engineer

To earn a 'B', a student must:

- Meet standard[1] on 5 of 6 design briefings
- Meet standard[1] on 5 of 6 team reports and presentations
- Demonstrate 4 of 5 teamwork competencies[2]
- Meet standard on drawing package or prototype
- Complete 3 consultations[3] with a professional engineer

To earn a 'C', a student must:

- Meet standard[1] on 4 of 6 design briefings
- Meet standard[1] on 4 of 6 team reports and presentations
- Demonstrate 3 of 5 teamwork competencies[2]
- Complete 1 consultation[3] with a professional engineer

[1] Meeting standard is approximately equivalent to earning 87%. Grading is based on a detailed list of specifications that ensure completion of all required elements while allowing minor mistakes in technical content, writing style, and formatting. See Canvas for details.

[2] See Canvas for Teamwork Competencies and a Teamwork assessment form.

[3] To receive credit for a consultation, a student must submit a one-page report that includes (1) a plan for the consultation including a list of project-relevant questions, (2) a description of the meeting (who, when, why), and (3) a reflection on technical and communication lessons learned.

Notes:

- Teams receive unlimited opportunities to redo their first report, presentation, and briefing. However, resubmissions must meet standard within one week of the due date to receive credit.
- After their first report, presentation, and briefing, teams receive two opportunities to redo a submission. Teams should self-assess whether their work meets standard prior to submission.
- Teams receive one opportunity to delay a report or presentation by one class period.