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## **Work in Progress: Specifications Grading in Mechanical Engineering Design Courses**

**Dr. Julie Mendez, Indiana University-Purdue University Columbus**

Julie Mendez is a Clinical Associate Professor of Mechanical Engineering at IUPUC, where she teaches a variety of undergraduate courses, primarily in the areas of thermal-fluid science and design. Julie earned a Ph.D. in chemical engineering from Case Western Reserve University and a Bachelor of Science in chemical engineering from Rose-Hulman Institute of Technology. Her scholarly interests include active learning strategies and alternative grading practices.

# Work in Progress: Specifications Grading in Mechanical Engineering Design Courses

## Introduction

Alternative grading methods are becoming more prevalent in higher education. Key aspects of alternative grading systems include clear standards, helpful feedback, marks that indicate progress, and reassessments without penalty [1]. The last several years have seen an increase in the use of alternative grading methods in higher education engineering courses, including recent examples in first-year engineering [2], [3], engineering physics [4], engineering computer applications [5], electric circuits [6], a linear circuits laboratory [7], engineering mechanics [8], fluid mechanics [9], biomedical engineering statistics [3], software engineering [10], system modeling [11], a chemical engineering laboratory [12], a bioengineering laboratory [13], a biomedical engineering elective course [14], and capstone design [3], [15]. Alternative grading strategies have been shown to reduce student text anxiety [16], increase student self-efficacy [17], [18], and result in similar or higher learning outputs [19]. Students who took an alternatively graded prerequisite course earned higher grades in a subsequent course compared to students who took a traditional grading version of the prerequisite [20]. In a recent study surveying students from a variety of disciplines in courses using alternative grading methods, most of the students reported enjoying the alternative grading course more than other courses [21].

One type of alternative grading method is specifications grading. In this method, student work is evaluated on a pass/fail basis, based on adherence to the assignment requirements, saving time in grading. Students are provided opportunities for resubmission or reattempt of failed assessments. The final course grade is determined by students' successful completion of predetermined assignment "bundles," with higher course grades requiring additional assignments or completing some assignments at a higher level [22].

Specifications grading was implemented in two undergraduate mechanical engineering design courses to provide transparency in assignment requirements and to put more emphasis on course outcomes with less emphasis on grades. The purpose of this paper is to describe the application of specifications grading in the two courses during 2023 and report on preliminary student perceptions of this grading method.

## Pedagogical approach

Two undergraduate courses are the focus of this study: an introduction to the mechanical design process, usually taken by students during the second year in the program, and a capstone design course that students typically take in the final semester. Seven students were enrolled in the second-year course, and the capstone course had an enrollment of 12. The work described here corresponds to the first time this instructor taught the capstone course and the fifth time teaching the second-year course (using specifications grading each time). The courses were previously taught by other instructors using traditional weighted-average grading schemes with partial credit.

Both courses involved semester-long team design projects. Each student team in the second-year course was tasked with designing an original product. In the capstone course, teams were assigned real-world design problems provided by local companies. Both courses included individual and group assignments, which were scored as “Pass” or “No Pass”. Feedback, either written or discussed with the team during class, was provided for most assignment types. Some small assignments were only checked for completion. To earn a score of “Pass” on an assignment, a team/student had to submit work that met all requirements specified in the assignment description provided in the learning management system. Students were able to revise and resubmit most types of assignments if a “No Pass” score was earned.

In the second-year course, the major assignments in the course were a team project report and final presentation, an individual design notebook, and an individual case study assignment related to engineering ethics. The project report specifications are given in Appendix A. The individual design notebook could not be revised or resubmitted because entries were meant to be documented throughout the course as work was completed. There were two categories of smaller assignments: guided practice assignments, meant to prepare students in a flipped classroom for the group activities [23], [24], and individual homework assignments related to the design project which would be used as a basis for the team project discussions that occurred during class. For the guided practice and homework assignments, a student earned a score of “Pass” on each assignment by attempting each problem/question and submitting the assignment prior to the class period corresponding to the assignment. Guided practice and homework assignments could not be revised or resubmitted because these assignments were meant to be completed prior to class. Table 1 lists the assignments required to earn a particular grade. A grade of “F” was earned if the requirements for the “D” were not met. Since grades with “+” or “-”, such as “B+”, could be assigned, a plus was added to the base grade if a student earned “Pass” scores on at least 15 (out of 16) guided practice assignments and at least 11 (out of 12) homework assignments. A minus was added to the base grade if a student earned “Pass” scores on fewer than 8 guided practice assignments or on fewer than 6 homework assignments.

Table 1. Second-year design course grade requirements.

Grade	Assignment Requirements
A	Earn Pass scores on the Design Notebook, the Product Development Report, the Project Presentation, and the Ethics Case Study.
B	Earn Pass scores on the Design Notebook, the Product Development Report, and the Project Presentation.
C	Earn Pass scores on the Design Notebook, and the Product Development Report.
D	Earn a Pass score on the Design Notebook.

More assignments were required in the capstone course, including four individual assignments, 11 team design assignments, 10 team weekly progress report meetings with the instructor, midterm presentation, midterm project report, individual design notebook, product development file covering the history of the design, final presentation, final project report, prototype, promotional video, final project poster, and peer evaluations. Individual assignments could not be revised or resubmitted because these assignments were meant to be completed prior to class.

The individual design notebook also could not be revised or resubmitted. Table 2 lists the requirements for earning each letter grade, and requirements for “+” or “-” grade modifications are given in Table 3. Also given in these tables are grade requirements for the next time the course was offered, described later.

Table 2. Capstone design course base grade requirements.

Grade	Assignment Requirements (initial 2023 course)	Assignment Requirements (revised 2024 course)
D	Lead 1 weekly progress report meeting, submit final presentation peer evaluations, and earn Pass scores on the following: <ul style="list-style-type: none"> <li>• 6 team design assignments</li> <li>• midterm presentation</li> <li>• midterm report</li> <li>• product development file, and</li> <li>• final presentation.</li> </ul>	Earn Pass scores on 6 team design assignments, the midterm presentation, and the product development file.
C	Complete all requirements for “D”, submit team member evaluations, and earn Pass scores on the following: <ul style="list-style-type: none"> <li>• final report</li> <li>• prototype, and</li> <li>• design notebook.</li> </ul>	Complete all requirements for “D”, earn Pass scores on the design notebook, the final report, and the final presentation, and submit team member evaluations.
B	Complete all requirements for “C”, lead 1 additional weekly progress report meeting (for a total of 2), and earn Pass scores on the following: <ul style="list-style-type: none"> <li>• 2 additional team design assignments (for a total of 8),</li> <li>• 2 individual assignments, and</li> <li>• promotional video.</li> </ul>	Complete all requirements for “C” and earn Pass scores on 1 additional team design assignment (for a total of 7), the prototype, and the promotional video.
A	Complete all requirements for “B”, submit midterm presentation peer evaluations, submit promotional video peer evaluations, and earn Pass scores on the following: <ul style="list-style-type: none"> <li>• 2 additional team design assignments (for a total of 10),</li> <li>• 2 additional individual assignments (for a total of 4), and</li> <li>• poster.</li> </ul>	Complete all requirements for “B” and earn Pass scores on 3 additional team design assignments (for a total of 10) and the poster.

At the end of the semester, anonymous online surveys were conducted to assess the students’ perceptions of the grading method in each course. The survey consisted of Likert-type and open-response questions based on other work examining student perceptions of grading [14], [15],

[25], [26]. This work was determined to be exempt from further review by the Indiana University IRB.

Table 3. Capstone design course grade modifications.

Grade modifier	Requirements (initial 2023 course)	Requirements (revised 2024 course)
Add a plus (+)	Meet at least one of the following: <ul style="list-style-type: none"> <li>• lead at least 3 weekly progress report meetings,</li> <li>• the team’s final presentation receives reviewer scores* above the class average, or</li> <li>• complete all requirements for the base grade and one of the requirements for a higher grade.</li> </ul>	Earn Pass scores on at least 4 (out of 5) individual assignments.
Add a minus (–)	All but one of the requirements for the base grade was completed.	Earn Pass scores on fewer than 2 individual assignments.

\*Project sponsors, faculty, and other guests were invited to attend the final presentations and complete evaluation forms.

## Results and discussion

Four of the seven students in the second-year course completed the survey (57% response rate). In the capstone course, six of the 12 students completed the survey (50% response rate). Two survey prompts were related to implementing the design process and completing design projects. The responses, shown in Figure 1, indicate that all respondents from the capstone course and most respondents in the second-year course strongly agreed that the grading method increased their ability to implement the design process. However, when asked about whether the grading method increased their ability to complete a design project, all the respondents from the capstone course agreed, but only 50% of the respondents in the second-year course agreed, with the remaining 50% neither agreeing nor disagreeing.

Additional differences were seen among the two courses in the student opinions related to communicating and writing project reports (Figure 2). All respondents from the capstone course agreed that the grading method increased their ability to communicate effectivity and write organized project reports, but opinions were mixed in the second-year course. Similar results were seen in response to the survey item about writing organized project reports.

All respondents from both courses agreed that they liked the learning environment in the course (Figure 3a). Differences were reported between the two courses as to whether the students preferred the grading system in this course to the ones in other courses. As shown in Figure 3b, all respondents from the capstone course strongly agreed that they preferred the grading system in this course. Of the respondents from the second-year course, 50% strongly agreed, 25% somewhat agreed, and 25% somewhat disagreed that they preferred this grading system.

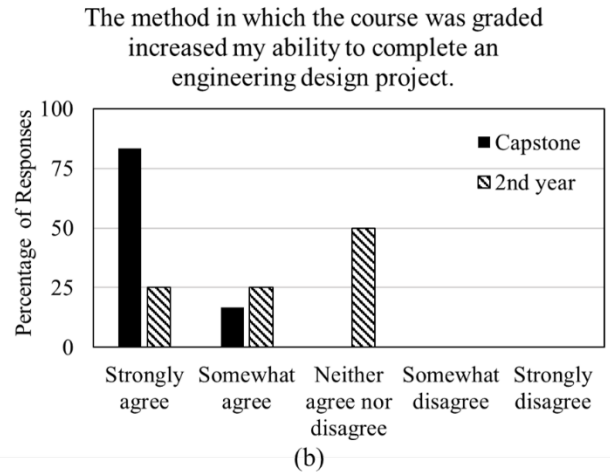
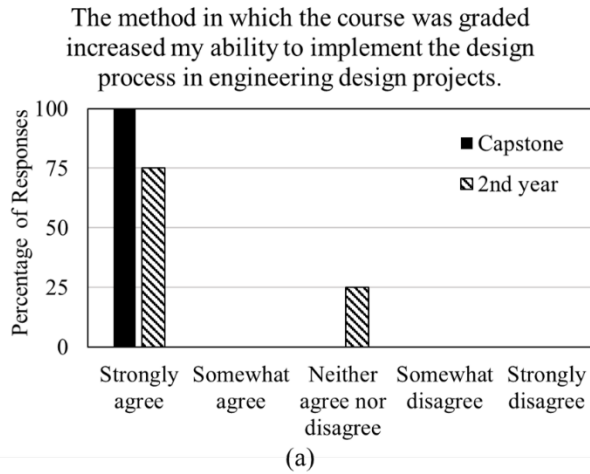


Figure 1. Engineering design.

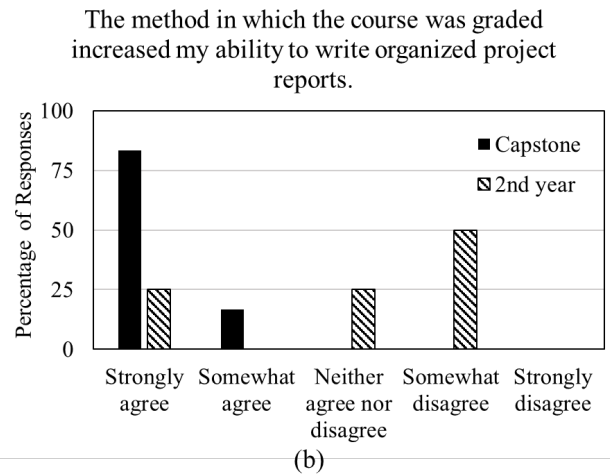
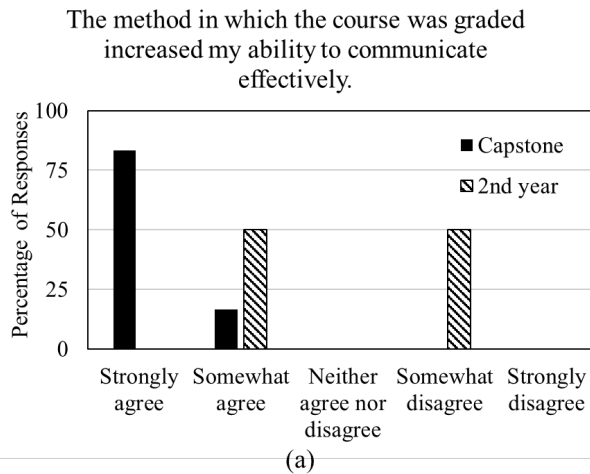


Figure 2. Communication and project reports.

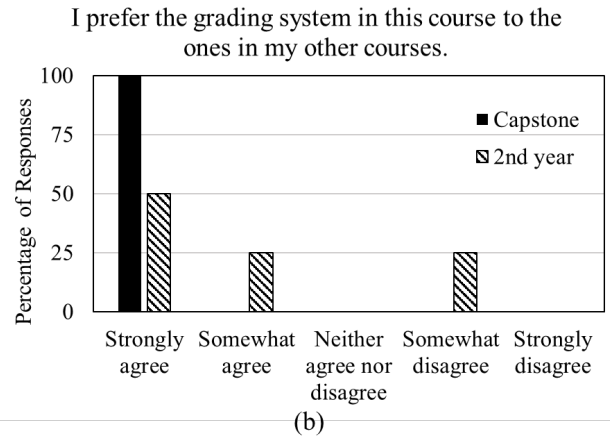
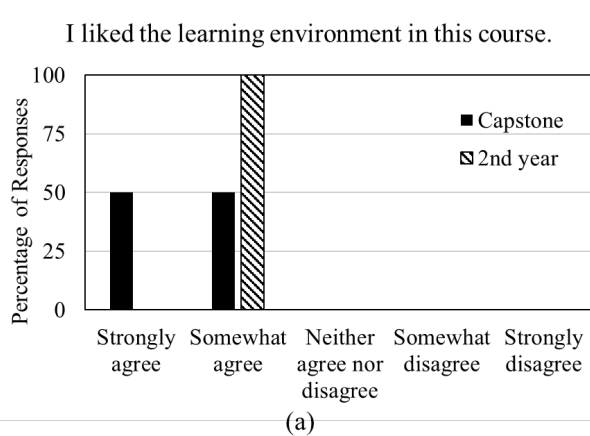


Figure 3. Learning environment and grading system.

In addition to the quantitative questions, the survey contained three open-response items. From the students in the capstone course, of the 5 responses to “What aspects of the grading method used in this course did you think worked well”, four responses mentioned feedback and/or revisions. One student highlighted the value placed on learning over grades by stating, “The pass or no pass is usually scary to deal with, expecially [sic] if you make a mistake there is no partial credit, but Dr. Mendez allows retakes, so the information is substantially more valuable that [sic] the grade.” Five responses were also received for the item “What aspects of the grading method used in this course would you change and why?” Most students indicated no changes should be made. One student suggested that this grading method should be used for all other courses in the program. Only one response was given for the prompt “Please provide any additional feedback about the grading method used in this course.” The student indicated that it was “really decent.”

From the respondents in the second-year course, three responses were given in response to “What aspects of the grading method used in this course did you think worked well?” Positive aspects noted by students were that having criteria was helpful in completing assignments, allowing for flexibility in what was considered a passing score, and the grading system got “students to do the work.” In response to what they would change about the grading method, one student wanted specific criteria for each homework assignment, one student wanted more than two levels (pass or no pass) on the proficiency scale, and one student said no changes. Only one response was given for the prompt “Please provide any additional feedback about the grading method used in this course.” The student indicated that it was their first experience with this grading method and that it “felt similar to real life.”

For most students in the second-year course, this was their first exposure to an alternative grading method. The students in the capstone course had previously taken courses using an alternative grading method with the same instructor; this may have influenced their perceptions of the grading method. Other studies have reported negative student feedback about alternative grading early in a course that turned to more positive feedback by the end [10], [26].

From the instructor’s perspective, the grading scheme for the capstone course included too many assignments. Additionally, there was potential for a student to earn both “+” and “-” grade modifications. To simplify the final grade determination, the grading scheme was modified for the 2024 capstone course. Weekly progress reports and the midterm report were still required but not graded. See Table 2 and Table 3 for the revised grade requirements. No changes were made to the grading scheme for the 2024 second-year course.

## **Conclusions and future work**

From the limited data collected at this point, the students from the second-year course were less likely than the students in the capstone course to agree that specifications grading helped them achieve course outcomes, particularly those about effective communication and writing project reports. The qualitative data from the students in the capstone course highlighted the importance of instructor feedback and opportunity for revisions. Students in the second-year course also offered positive comments about what worked with the grading scheme. The survey will be administered again in the two courses at the end of the Spring 2024 semester. The survey results will inform questions for future qualitative study of how specifications grading affects student perceptions of learning.

## Appendix A

Project report requirements for second-year design course:

You will earn a score of “Pass” by meeting all of the following requirements:

- The title page contains the project title, course number and name, department and campus names, student names, and date submitted.
- The summary (1-2 paragraphs)
  - lists the objectives.
  - describes concisely what the product described is intended to accomplish.
  - summarizes the accomplishments of the final design.
- In the introduction section
  - briefly describe the background of the project.
  - state the project objectives.
  - clearly present the design requirements and expectations.
  - identify project boundaries or constraints.
- In the planning section
  - demonstrate project management tools and methods used.
  - specify the distribution of tasks among group members.
  - explain any deviations from the proposed schedule.
- In the design section
  - describe engineering specifications and targets.
  - critically evaluate existing benchmarks and specifically identify the gaps which the project is intended to fill.
  - show how the concepts evolved and were evaluated.
  - describe and justify the formation of the final product.
  - demonstrate the analyses used for product evaluation. Show the details of the analysis, experiment, or field test results.
- All tables and figures should be accompanied by comments or discussions in the text of the report.
- All figures and tables must have numbers and captions. While the table captions should be placed over the table, figure captions should be placed below the figure.
- In the impact statement section, state the potential impact of the designed product on the environment and society as a whole, and comment on any potential safety-related issues in the use of the product. Explicit statements to each need to be made here, even if there are no environmental, societal, or safety concerns.
- In the conclusions section, demonstrate that the final product satisfies the engineering specifications.
- In the recommendations section, provide clear, specific recommendations based on the design work.
- Provide a complete list of literature used in completing the design (all must be referenced in the text). See the report template for examples of reference formatting.
- In the appendices, include programming, detail drawings, assembly drawings, and product development files (such as meeting minutes and other files created as you developed the final product).



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