Engineering Educators Bringing the World Together
2025 ASEE Annual Conference & Exposition
Palais des congrès de Montréal, Montréal, QC • June 22–25, 2025 ASEE
Paper ID #48307

Changing the Grading Narrative in a Sophomore Biomechanics Course

Dr. Jennifer Currey, Union College

Changing the Grading Narrative in a Sophomore Biomechanics Course

Introduction

The history of grades in education can feel a bit mythical. Some sources state that grades came about with the industrialization of education in the US. Assessment of student learning moved from oral or written assessments in the era of one room school houses to more systematic ways of communicating students' learning with the advent of larger school systems [1]. Our current system of ABCDF was first adopted in 1897 at Mount Holyoke College [2]. Letter grades began being used in secondary schools in the early 1900s as a way to show students' knowledge relative to others. At this time in history, it was believed that intelligence was normally distributed across a population similar to height. It was therefore believed that grades should be normally distributed, thereby making them more objective [1]. Over 125 years later, with a greater understanding of student learning and innovation in pedagogical techniques, higher education still uses grading systems that were designed for a different era.

The use of letter grades or traditional grading systems and by extension traditional lecture-based teaching has been justified as maintaining academic "rigor." Nelson [3] outlines ideas and beliefs around grades (the focus of students) and learning (the focus of faculty) as "dysfunctional illusions of rigor." Two key areas of dysfunctional illusions outlined by Nelson are: "Traditional methods of instruction offer effective ways of teaching content. Modes that pamper students teach less." and "Massive grade inflation is a corruption of standards." He outlines the ways in which traditional lectures are less effective than alternative methods of instruction and that "good grade inflation" is the result of more effective pedagogy resulting in improved student achievement.

Delving further into understanding these two areas of "dysfunctional illusions of rigor," we can focus on pedagogical innovation such as social support for learning, understanding metacognition when designing a course, and alternative student assessment or grading. Treisman [4] was able to demonstrate that students' learning significantly improved when they moved from working alone to working in study groups where they could debate problem solving methods and answers. McGuire [5] has described metacognition in learning as involving planning, assessing, controlling, and adjusting techniques of learning. Incorporating metacognitive strategies of reflection and self-questioning into a course leads to improved learning. Incorporating peer-to-peer learning, metacognition, as well as other pedagogical techniques can disrupt the illusion that traditional methods of instruction are effective teaching. This can ultimately impact students' grades in a course leading to "good grade inflation."

Grade inflation is often an argument against forms of alternative grading. The idea that students' grades in a course must fit a normal distribution is antiquated. Nelson notes another

"dysfunctional illusion of rigor" in that students must hand work in on time and take exams at a specific time. Flexibility or second chances pamper students. He discusses that giving flexibility and a limited number of repeats on exams, components of some alternative grading systems, can increase fairness and student achievement..

Alternative grading in higher education, which can have several forms such as standards-based grading, proficiency-based grading, or contract grading, has been growing in popularity over the last 30 years [6]. In spite of its long history traditional grading is not an accurate tool in assessing students' learning nor does a traditional grade accurately communicate to others the level of understanding a student achieved. In traditional grading points are assigned to students' work, but those points are not numerical data, but rather categorical data. Therefore, the application of statistics (averages, means, standard deviations, etc) to these data and interpretation of comparisons between students become flawed [7].

Beyond the inaccuracy of assessing student learning, traditional grading has been shown to be biased against students with a weaker educational background which impacts underrepresented groups or students with learning disabilities [1]. Feldman states that traditional grading is "oriented towards failure and yields inaccurate scores, but also disproportionately harms students who have intermittent, catastrophic failures – something historically underserved groups are more likely to experience."

Another effect of traditional grading is test anxiety, which has been well studied for over 50 years. Through a meta-analysis, von der Embse et al. [8] found that test anxiety disproportionately affects women compared to men. Their analysis also found that minority students (Black/African American) are also disproportionately affected, reporting higher levels of test anxiety when compared to majority students (White/Caucasian). The negative impacts of test anxiety are heightened when students perceive the exam to be critical. Lewis [9] further explored the impact of standards-based grading on test anxiety and found that with standards-based grading, test anxiety was decreased and gender-based differences were eliminated.

Considering the "dysfunctional illusions of rigor", peer-to-peer learning, metacognition, and issues with traditional grading, we set out to redesign a sophomore biomechanics course (Biomechanics I: statics). The main focus of our redesign was using alternative grading in the form of proficiency-based grading, however, we did incorporate peer-to-peer learning and metacognition strategies. In redesigning our course, we were interested in exploring the following questions related to proficiency-based grading:

1. Does proficiency-based grading lead to a decrease in grade-related stress?
2. Do students gain a deeper understanding of the course content?

3. Do students develop confidence in their abilities to try challenging problems?

Methods:

Development of Proficiency-Based Assessment:

In an effort to answer these research questions, our course was redesigned with a focus on proficiency-based grading. We started by focusing on the skills we wanted students to be proficient in by the end of the course. This led to the development of 14 learning goals for the course (Fig. 1). These skills are important for subsequent courses in the biomechanics sequence. These learning goals grew in complexity as the course unfolded coinciding with more complex topics. The idea being that as students become proficient in earlier learning goals, they will have the foundational skills to address more complex problems.

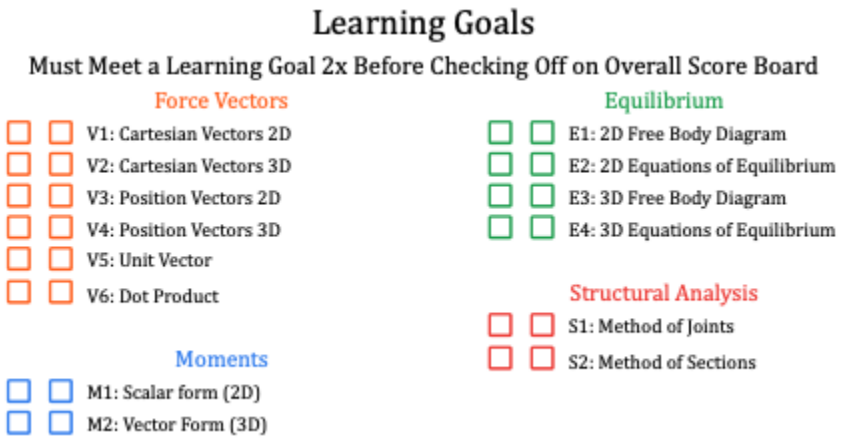

Figure 1: Learning goals for the Biomechanics I course. Students must "score" a learning twice by earning a P/AP in the goal before they can check off the learning goal in their overall grade tracker.

After identifying these learning goals, the methods of assessing these goals and the method of determining the course grade was developed. Since we were using a new system of assessment in this course, we wanted to change the names associated with each assessment instrument. We decided to use a soccer analogy whereby homeworks became "trainings," quizzes became "skills drills," and exams became "match day" with the final being "Boxing Day match day." We also had four problem seminars throughout the course where students worked in pairs to solve complex problems and develop a narrative alongside their solution. This narrative focused on their problem solving process and highlighted places where they may have gotten stuck and unstuck while working through the problem. This change in terminology was also meant to demonstrate to students that the homework was a chance for them to train/practice with their peers and receive feedback. They would then demonstrate their skills through the skills drills and match days.

For the grade, we used a 3-level scale to assess proficiency on each of these assessment instruments; In Progress (IP) meant there were conceptual errors and this skill was still developing, Proficiency (P) meant there was fundamental understanding of the goal with a very minor error, Above Proficient (AP) meant the work demonstrated clear understanding of the goal and was free of all errors. The trainings and problem seminars provided opportunities for students to practice the learning goals by working with peers while receiving real-time substantive feedback on their work. If students earned an IP on these assignments, they were provided opportunities to revise their work and resubmit to earn a P.

Students' proficiency in the learning goals was assessed through skills drills and match days. Students could earn an IP, P, or AP on learning goals. In order to achieve proficiency in a learning goal, students needed to demonstrate proficiency on that learning goal twice. If they earned an IP on a learning goal, they would have more opportunities to try again given that each learning goal appeared a minimum of 4 times throughout the course on skills drills or match days. This method enabled students to learn at their pace while still building complexity (problems later in the course often included multiple learning goals).

A student's overall grade for the course was earned by scoring learning goals as well as earning a P/AP on trainings and problem seminars. We drew inspiration for the course grading and the use of a grade tracker (Fig. 2) from a post on the blog, Grading for Growth [10]. Students start at a D level and check off boxes when they earn a P or AP on a training, P or AP on a learning goal twice, and P or AP on a problem seminar. A tracking sheet was kept for the course that students had access to at all times (students were anonymized using an assigned color in place of their name). They were also able to keep track of their own progress using the grade tracker in Fig.2.

Figure 2: An example of a grade tracker in the Biomechanics I course.

Observational Study of Research Questions

An observational study was done using surveys for two terms of this course. The first term was a pilot study in the fall of 2023 (33 students) and the second term with a refined survey was in the fall of 2024 (16 students). The second section was smaller due to departmental decisions to offer multiple sections thereby reducing the size of the class. Union College is a liberal arts

college with engineering with small class sizes. We are on a trimester system and courses are typically offered once or twice a year.

Students were surveyed at the beginning and end of the terms using anonymous surveys regarding the grading system (exempt from review by the Union College Human Subjects Review Committee as per 45 CFR 46.104(d)(1)). The survey at the beginning of the course was focused on questions or concerns students may have about proficiency-based grading. For the first pilot course offering in the fall of 2023, a short end of term survey was developed that focused on the students' experiences with proficiency-based grading. The second course offering in the fall of 2024 used a more refined survey building off the results of the pilot study. The pre-term survey will not be discussed as it was not focused on the research questions.

Fall 2023 end of term pilot survey

We piloted the use of proficiency-based grading in the fall of 2023 and as such created a brief end of term survey. The survey consisted of two yes/no questions as well as three open-ended questions for students to reflect more deeply on their experiences. The questions were as follows:

1. Do you think your grade accurately reflects your knowledge of the course's learning goals? Y/N
2. Do you feel that this method of proficiency grading enabled you to focus on learning the course material? Y/N
3. Please discuss in which ways proficiency grading impacted your learning (positively, negatively, or not at all).
4. What aspects of this course did you like?
5. What suggestions do you have for the next time proficiency-based grading is used?

As a pilot for proficiency-based grading, we focused on a qualitative assessment to understand the impact this system had on students' learning, stress, and confidence. The questions were basic, however, the responses did address the research questions. To analyze the open-ended questions in this survey, a sample of responses was read and a list of codes was developed. The remainder of the comments were read and the list of codes were applied. The comments were coded for the following terms: "less stress," "confidence," "motivate/learn," and "more stress."

Fall 2024 end of term survey

After piloting proficiency-based grading in the fall of 2023, we consulted with the Union College Learning Design and Digital Innovation (LDDI) staff who have expertise in pedagogical research to further develop the course survey. The survey consisted of four questions with a 1-5 scale (1 being "not at all true for me" and 5 being "very true for me"):

1. After this proficiency-based grading course, I am confident in my ability to take risks and learn from mistakes.
2. In this proficiency-based course, I felt that my stress around grades was decreased.
3. In this proficiency-based course, I felt I was able to focus on my learning rather than my grade.
4. In this proficiency-based course, I felt motivated to learn the course material.

Each question was followed by an open-ended question asking students to explain more deeply how proficiency-based grading impacted the previous question.

A. Can you explain how your confidence was impacted by proficiency-based grading?
B. Can you explain how your stress around grades was impacted by proficiency-based grading?
C. Can you explain how proficiency-based grading impacted your learning?
D. Can you explain how proficiency-based grading may or may not have motivated you to learn?

There were also two open-ended questions at the end of the survey asking which aspects of the course were helpful and suggestions for the next time the course was offered.

The data for the follow-up questions were coded using deductive and inductive codes [11]. First, we developed a set of codes for each survey question (deductive). Next, each set of responses were reviewed and the codes for each question were adjusted based on the responses (inductive) if necessary. If there were multiple codes that were applicable to a response, it was coded into both categories. Samples of the codes for the responses are as follows: The responses to the question “Can you explain how your stress around grades was impacted by proficiency-based grading?” were coded as “less stressed” or “still concerned.” The responses to the question “Can you explain how proficiency-based grading impacted your learning?” were coded as “easier to learn”, “focused on understanding,” and “learned from mistakes.” The coded responses were then visualized using pie charts to help quantify the distribution of responses. The researcher created the codes and coded the survey data with consultation of a colleague who has also taught the course.

Results:

Fall 2023 end of term pilot survey results

We first piloted proficiency-based grading in the fall 2023 with 33 students. We had a response rate of 50% (16 out of 33 students). Of those that completed the survey, when asked the question

“Do you feel that this method of proficiency grading enabled you to focus on learning the course material?” 14 students responded “yes,” one “maybe,” and one “no.”

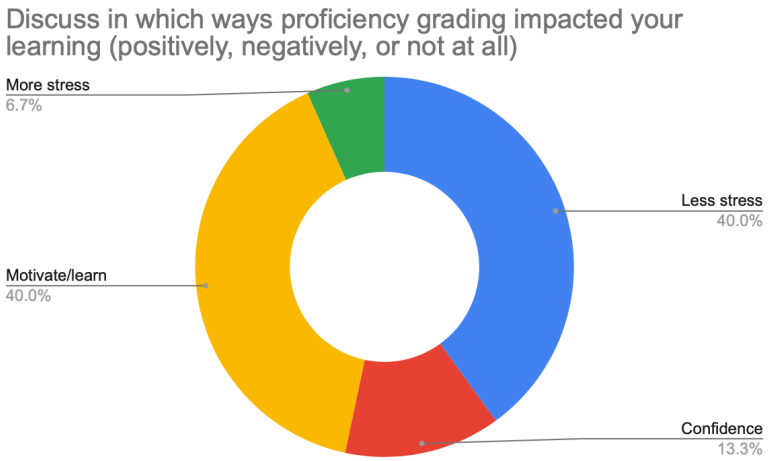

Figure 3: Coded responses for the survey question, “Please discuss which ways proficiency grading impacted your learning (positively, negatively, or not at all)?”

The coded responses for the open-ended question can be seen in Fig. 3. The responses were largely positive with 93% of respondents indicating a positive impact on their learning. One student commented “I thought this was awesome. Very low stress learning environment which encouraged just trying the problem to the best of your ability and learning from your mistakes. I felt I learned a lot through the proficiency grading and gained a lot of confidence as a learner.” Another student commented that “It was much easier to study and grasp the material when I never needed to worry about my grade. I've focused on grades way more in other courses that are exam heavy, and I always seem to do worse. It was really comforting to know that I could study as best as I could for an exam but it wasn't (the) end all be all.”

A couple of students noted that they preferred the “competition” of grades with comments such as “The proficiency grading system definitely lowered my stress for the term. I do think that the proficiency grading and the low stakes it created negatively impacted my learning because I am generally very competitive and the numbers fuels me to put more time and effort into learning. I understand that this is a more traditional mindset and would certainly figure out other modes of motivation.”

Fall 2024 end of term survey results

Fall 2024 quantitative results

There were 16 students in the course in the fall of 2024. We had a response rate of 68% (11 out of 16 students). The survey consisted of four questions with a 1-5 scale (1 being “not at all true

for me" and 5 being "very true for me"). The quantitative questions and their average responses are shown in Table 1.

Table 1: Average responses to survey questions using a scale of 1 to 5

Survey Question	Average Answer
After this proficiency based grading course, I am confident in my ability to take risks and learn from mistakes.	4.8
In this proficiency based course, I felt that my stress around grades was decreased.	4.7
In this proficiency based course, I felt I was able to focus on my learning rather than my grade.	4.8
In this proficiency based course, I felt motivated to learn the course material.	4.9

Fall 2024 qualitative results

The responses for the open-ended follow-up questions can be seen in Figures 4-6.

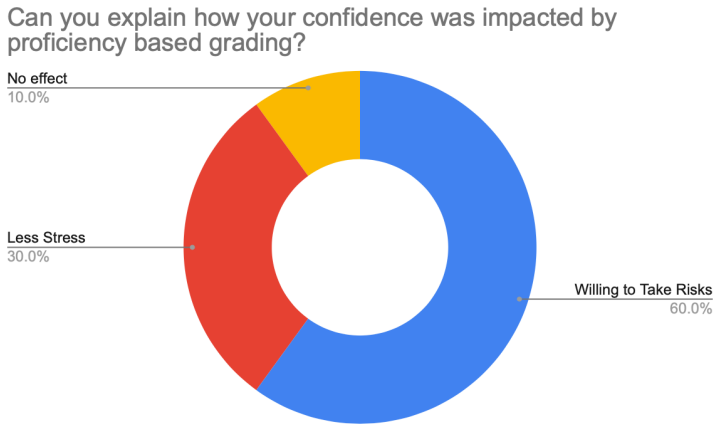

Figure 4: Coded responses for the survey question, "Can you explain how your confidence was impacted by proficiency-based grading?"

The coded responses to the question "Can you explain how your confidence was impacted by proficiency-based grading?," were overwhelmingly positive with 90% of respondents saying they were less stressed or willing to take risks (Fig. 4). One student commented "Proficiency-based grading positively transformed my confidence, especially as someone who struggles with test-taking anxiety. My exam grades have often not reflected my understanding of the material, despite performing well on coursework. However, with proficiency-based grading, I felt a significant boost in my confidence to take quizzes, tests, and exams. Knowing that I had opportunities to demonstrate my understanding without the pressure of a one-and-done assessment allowed me to approach tests with a calmer mindset. This confidence even carried

over to other courses I was taking during the term, where I felt more comfortable and prepared when taking tests."

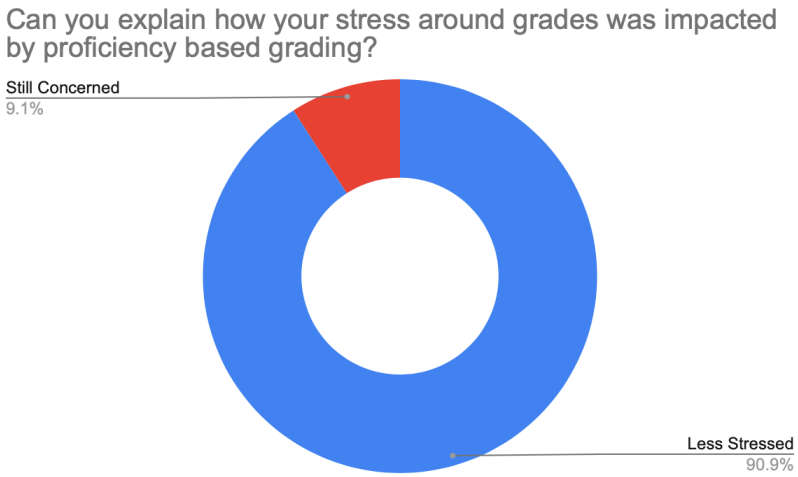

Figure 5: Coded responses for the survey question, "Can you explain how your stress around grades was impacted by proficiency-based grading?"

Coded responses to the question "Can you explain how your stress around grades was impacted by proficiency-based grading?," were overwhelmingly positive with 90% of respondents saying they were less stressed (Fig. 5). One student commented "In every other course I have taken, the center of attention becomes the grades I receive, whereas here my focus was on learning and understanding the material. I was not stressed about failing, but more focused on learning from my mistakes. In fact, getting an in progress on a question was very helpful because I was able to go back and understand where I went wrong. In other classes, if I did poorly on something, I often never want to look at it again because of the grade I received. I think this class had a very positive learning environment where a good grade was not the end goal."

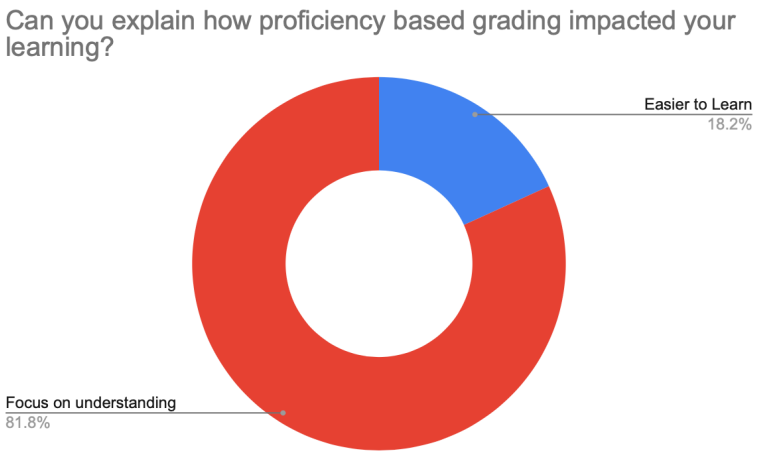

Figure 6: Coded responses for the survey question, "Can you explain how proficiency-based grading impacted your learning?"

Coded responses to the question "Can you explain how proficiency-based grading impacted your learning?," were overwhelmingly positive with 100% of respondents saying they found it easier to learn or they were focused on understanding (Fig. 6). A few students noted a secondary effect in that they were able to reflect on and learn from their mistakes. One student noted "I feel that proficiency-based grading allowed me to understand, learn, and apply the material so much better. Your teaching style, along with the structure of this course grading took the stress off of me and allowed me to just be engaged in the learning goals and material. My main goal was to be able to complete the problems and not to just get a good grade. I took my time and was for once okay with the fact that I learn at a different rate than others. I was able to learn the material eventually (not necessary on the first try) which is the goal of taking a class I think."

Overview of results

After a successful piloting of the proficiency-based grading in the fall of 2023, we conducted a more detailed survey of proficiency-based grading in the fall of 2024 which included quantitative and qualitative data. The survey responses across both course offerings were overwhelmingly positive. Overall, students felt more confident in their ability to tackle challenging problems and to make mistakes and learn from those mistakes. Students felt less stressed about the course, were able to focus on learning, and found it easier to understand the course material with a focus away from grades.

Discussion:

The impact of proficiency-based grading for the Biomechanics I course has been overwhelmingly positive based on students' responses to end of term surveys. This positive impact was also evident in the student work we saw as the course progressed. Students were

trying ideas and asking questions when they didn't understand a concept or their idea was not yielding the correct results. It is not a secret that the solutions to the problems from the textbook are relatively easily found on websites such as Chegg or even YouTube; however, we found that by removing a grade from homework students' focus shifted away from solutions and towards understanding the concepts and applying their knowledge. This was evident by the types of questions they were asking in class and in office hours. Students continuously expressed that their stress was decreased in this course and they were excited to learn, try, make mistakes, and learn from those mistakes. Some even stated that their stress decreased in their other courses which were traditionally graded courses. Our findings of decreased stress particularly around test-taking are in alignment with the work of von der Embse et al. [8] and Lewis [9].

The course design and proficiency-based grading also incorporated peer-to-peer learning and metacognition strategies through encouraging collaboration on trainings, allowing corrections on IP assignments, group problem seminars with narratives, and correction reflections for learning goals on skills drills/match days. Students commented that the ability to go back and look at their mistakes, discuss them with peers and faculty, then correct their errors led to deeper understanding of the learning goals. This is in alignment with the metacognitive strategies outlined by McGuire which include reflection and self-questioning [5].

One of the flaws that has been noted with traditional grading is that it does not always convey a student's level of understanding. Points are assigned in a subjective manner and curves can be implemented with traditional grading. In proficiency-based grading, clear standards were set for the students in terms of earning a proficient or above proficient and substantive feedback was provided on students' work [6]. Students were given multiple opportunities to earn proficient or above proficient on their learning goals once again implementing metacognitive techniques of reflection and making adjustments to their problem solving. The grade distribution for the two sections, fall 2023 and fall 2024, was predominately in the B to A range, far from a normal distribution. Of the 49 students taught across two sections, only two students earned an A in the course which didn't accurately reflect their understanding of the material. This was due to corrections on skills drills and match days which enabled them to raise their grade; however, their understanding was not consistently demonstrated on in-class assessments. Despite this, we believe that incorporating corrections in some fashion is important for students' learning as it facilitates reflection.

Limitations and Future Work

The class sizes for each survey group were relatively small, 33 students in the fall of 2023 and 16 students in the fall of 2024 with a survey response rate for both terms of 50%. We plan to continue to collect data each time the course is offered to strengthen the sample size. That being said, the results are no less valid in the students' experiences in this course. This has encouraged

us to use proficiency-based grading in other courses. We also acknowledge that two different surveys were used across the two courses. The first pilot survey was quite simple and was used to determine whether further research would be done on student learning with proficiency-based grading. Given the positive responses, a more thorough survey was developed for the second offering. This survey will be used in future course offerings enabling us to aggregate our data.

Another limitation of our work is that we do not have longitudinal data. One of the research questions considered was whether students gain a deeper understanding of the course content. Throughout the term, students demonstrated deeper understanding and their survey responses indicated that they felt they were able to better understand the concepts. However, this course is the first in a three-course sequence and one of our goals is to see if students are able to carry forward their understanding of the course learning goals into subsequent courses. We plan to implement proficiency-based grading in the subsequent course, Biomechanics II. We plan to implement pre-course surveys asking students to reflect on their understanding of the concepts learning Biomechanics I. We will also implement a post-course survey. The specifics of these surveys have yet to be developed, but will be done in conjunction with the Learning Design and Digital Innovation staff who have expertise in pedagogical research.

Summary

The use of proficiency-based grading in conjunction with peer-to-peer learning and metacognition techniques had a positive impact on student learning in a sophomore level biomechanics course. Students demonstrated the ability to reflect on mistakes and adjust their problem solving methods and reported that they had more confidence in their problem solving skills, felt less stressed with their focus shifting away from grades and towards learning.

References

[1]Feldman, J. (2019). *Grading for equity: What it is, why it matters, and how it can transform schools and classrooms*. Corwin, a SAGE Company.

[2] Blum, S. D., Kohn, A., & Saffel, T. (2020). *Ungrading: Why rating students undermines learning (and what to do instead)*. West Virginia University Press.

[3] Nelson, C.E. (2010). *10: Dysfunctional Illusions of Rigor.* To Improve the Academy. 28: 177-192. https://doi.org/10.1002/j.2334-4822.2010.tb00602.x

[4] U. Treisman, “Studying Students Studying Calculus” A Look at the Lives of Minority Mathematics Students in College,” *The College Mathematics Journal,* vol. 23, pp 362-372. Nov. 1992

[5] S.Y. McGuire, “Close the metacognitive equity gap: Teach all students how to learn.” *Journal of College Academic Support Programs*, vol. 4(1), pp. 69-72. 2010 .

[6] Clark, D., Talbert, R., & Nilson, L. B. (2023). *Grading for growth: A guide to alternative grading practices that promote authentic learning and student engagement in Higher Education*. Routledge.

[7] R. Talbert. “When is a number not a number?.” Gradingforgrowth.com. Accessed: December 17, 2024. [Online.] Available: https://gradingforgrowth.com/p/when-is-a-number-not-a-number

[8] N. von der Embse, D. Jesters, D. Roy, and J. Post, “Test anxiety effects, predictors, and correlates: A 30-year meta-analytic review,” *Journal of Affective Disorders,* vol. 227, pp. 483-493. 2018

[9] D. Lewis, “Impacts of Standards-Based Grading on Students’ Mindset and Test Anxiety,” *Journal of the Scholarship of Teaching and Learning*, vol. 22, No. 2, pp. 67-77. June 2022

[10] D. Clark. “How to make and use grade trackers.” Gradingforgrowth.com. Accessed: December 17, 2024. [Online.] Available: https://gradingforgrowth.com/p/grade-trackers

[11] J. Rouder, O. Saucier, R. Kinder, and M. Jans, “What to Do With All Those Open-Ended Responses? Data Visualization Techniques for Survey Researchers,” *Survey Practice,* August 2021. [Online]. Available: https://doi.org/10.29115/SP-2021-0008. [Accessed Jan 6, 2025.]