Board 305: HSI Implementation and Evaluation Project: Commitment to Learning Instilled by Mastery-Based Undergraduate Program (CLIMB-UP)

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Background

Commitment to Learning Instilled by a Mastery-Based Undergraduate Program (CLIMB-UP) is an NSF IUSE:HSI project centered on re-designing courses with high non-completion rates (C- or lower) that have implications towards students' graduation, transfer ability and retention. Despite decades of effort to create active, inquiry-based learning practices in classrooms, our institution continues to see equity gaps and many required courses with non-completion rates exceeding 50%. Grading practices have been identified as one of the main culprits in the persistence of equity gaps. Feldman [1] asserted that "... the traditional system of evaluating students and reporting information about them has been part of the inequities, unfairness, and injustices built into our school." Our traditional grading practices communicate to students that "mistakes are unwanted, unhelpful, and punished" [1, p. 12]. Few college faculty have received formal training in grading approaches that could lead to demonstrable student mastery learning and are expected to adopt traditional point-based grading schemes. Traditional grading schemes encourage students to adopt a strategy of "grade-grubbing," which promotes strategies of earning enough partial credits to pass the course, requesting extra credit to obtain a specific grade, protesting "unfair" grades, etc. [2]. Yet, the "grade-grubbing" strategy does not motivate student learning or inspire a goal orientation towards mastering the course content, and it undercuts student interest in the content being taught [2]. Faculty also experience challenges in applying traditional grading schemes, specifically, deciding how many points to award a problem set that was not fully mastered, and struggle to apply a fair number of points to students' work that is comparable in quality but differs in content mastery. Creating and teaching mastery graded courses in STEM fields requires a fundamental shift in the mental model of instructors regarding what, why, and how to assess course material [14]. Everything from taking a deep dive look at the course's core required content to considering what it means to master content and working to restructure the course necessitates training in the principles of mastery grading.

As a Hispanic Serving Institution, we recognize and value the diversity of experience that our students bring to our campuses and are committed to utilizing their strengths by creating data-driven, equitable grading practices that give students space to take risks and bring alternative viewpoints to our classrooms and be rewarded. We believe a Mastery-Based Grading (MBG) approach can address problems that a traditional grading approach has caused. A mastery-based grading approach involves three key features: 1) providing students with a clear and comprehensive list of learning outcomes and required skills, 2) assessing students based on mastery of the targeted learning outcomes using a tier system, e.g., "mastery demonstrated/no mastery demonstrated" or "mastered/progressing/not assessable," and 3) providing students with multiple attempts to demonstrate mastery by revising, resubmitting, and/or retrying while not penalizing for failure to demonstrate mastery on earlier attempts. The CLIMB-UP project is building the infrastructure to support and train STEM faculty (both tenure-line and adjuncts) to redesign and teach a Mastery-Based Graded (MGB) course, and is conducting research on faculty experiences and on the change in student attitudes, mindsets, and outcomes.

Overview of Project

The institution in the Southwest has a large enrollment of Latinx students and is considered a Hispanic-Serving Institution. The majority of students, 54%, are first-generation college students and 58% come from low-income backgrounds. Only 20% of students have a parent who earned a bachelor's degree. The College of Engineering has a significant number of transfer students, some of whom may have been in the sophomore class sections under study if they didn't complete those courses before transferring. This institution awards the highest percentage of engineering degrees to Latinx students in the state of California. To be more than just Hispanic-enrolling, intentional efforts have been placed to become a Hispanic-serving institution [3]. The College has made significant efforts to build sustainable student success programs, increase course sections, and emphasize student success resulting in improvements to the four-year and six-year graduation rates. Despite these efforts, there are still concerns about low course pass rates, particularly in sophomore-level gateway courses in engineering, and anecdotal concerns about the lack of student preparation for follow-up courses.

The College of Engineering at Cal State LA is committed to promoting student success through various new directions and attitudes. The faculty actively foster a collaborative and supportive environment that values and celebrates the diverse strengths and lived experiences of the student population rather than focusing on academic deficits. The College aims to create learning environments that prioritize academic growth and mastery. This initiative is part of a larger effort to transform the College into an ecosystem that provides all students with equitable opportunities to thrive and grow. Therefore, in an effort to support our students, we have been implementing a Mastery-Based Grading (MBG) approach in three "gateway" engineering courses taken by students in their second-year, (i.e., Statics, Strength of Materials, and Embedded Programming I). These courses are required for students pursuing degrees in mechanical, civil, or electrical engineering. All targeted courses have historically high non-completion rates and an associated loss of students out of the majors, non-persistence to transfer, or delay in graduation times with significant costs to students. The low completion rates also frustrate and discourage faculty or create deficit-oriented faculty mindsets. All faculty engaged in the CLIMB-UP project have joined a single faculty-learning community to share efforts and challenges. The faculty include six at our institution and two additional faculty who teach at feeder community colleges.

The implementation plan involves three phases:

(1) Course Redesign by project team,
(2) Development of hybrid training course for future MBG adopters, and
(3) Course Adoption by additional instructors.

Table 1.
Timeline and Activities for CLIMB Project Implementation

	Summer (August)	Fall	Spring
Year 1 2021-2022		• Collected Pilot data to validate survey instruments.	• Project Team attended MBG 4-day interactive workshop; peer assistants attended training. • Five course redesign teams entered CETL cohort; Workshop materials development. • Collected baseline survey data from courses that will be redesigned.
Year 2 *2022-2023*	• Adopting faculty in community preparation. • Finalizing course redesign	• Redesign implementations • Collected student survey and longitudinal interview data to understanding MBG experience	• Second iteration of re-designed courses by original team • Adopting faculty in community preparation • Collect another round of survey data • Continue longitudinally interviewing participants from Fall 2022
Year 3 2023-2024	• New adopting faculty attend fully hybrid workshop; • 2 days interactive • New peer assistants attend training	• Adopting faculty continue; • New faculty in community preparation	• New adopting faculty teach courses

Progress to Date

The project is in Year 2 of our funding, and at this point we have implemented the first 4-Day interactive workshop to train new faculty. In January 2022, eight faculty members from several departments in the host university and two local community colleges attended a 4-day, 6-hour per day professional development workshop on Mastery-Based Grading held virtually. The initial workshop was designed to provide background knowledge, research evidence, and practical skills needed to enable participating faculty to redesign their courses to utilize a mastery-based grading structure. Five sophomore-level engineering courses were redesigned as part of this initial cohort—Statics, Strength of Materials, Dynamics, Fluid Mechanics, and Embedded Systems.

Elements of the initial workshop included a variety of best-practice activities: literature-to-practice sessions, time for hands-on group work, golden lines collaborative discussions, and a variety of introductions to the components of a mastery-based grading architecture. Interwoven through the workshop were topics such as universal design for learning and outcomes-based backwards design. Faculty participants worked both as a whole group and as course-based teams to begin the redesign process. After the initial workshop, course-based teams met approximately bi-weekly through the Spring 2022 semester to continue the development of the redesigned courses. Key grading

architectural decisions were made to align the courses of the different institutions and different departments involved. Additionally, the entire faculty learning community met several times to share progress on the course redesigns and allow for cross-course collaboration, as many of these courses are in a sequence.

In the Summer of 2022, faculty members began finalizing their course redesigns and building their courses in their institutional learning management systems in preparation for launching the redesigned course in Fall 2022. At least one section of each of the five redesigned courses ran in the next structure in Fall 2022. The Faculty Learning Community (FLC) continued to meet in both Summer 2022 and Fall 2022. Obstacles that were encountered throughout the redesign process and the initial implementation were discussed and solutions were developed and adopted. In December 2022, the project began preparing for the adoption of two of the redesigned courses by faculty who were not part of the initial redesign process. The adopting faculty attended a reduced version of the initial professional workshop that consisted of two consecutive 4–6-hour virtual training sessions. They received much of the same training as the initial group, including the research evidence for mastery-based grading and an overview of the grading architecture decisions that had been made. Additionally, one team member who was part of the initial redesign process began preparing for their first implementation.

Currently we are in year 2 of the project, having just begun the semester in which adopting faculty, who were not part of the initial design phase, have begun teaching the courses in the new structure. Additionally, some faculty who were part of the initial redesign have begun making changes to their designs as a result of learning what worked and what did not and implementing those changes in their courses this semester. Another key activity that began in the Fall 2022 semester was the hiring and training of instructional student assistants (ISAs), undergraduate or graduate students who are tasked with providing support to the instructors implementing the redesigned courses. This support comes in a variety of forms including: grading and feedback support, data analytics, development of assessment versions, and direct student support through tutorial services. Currently, in Spring 2023, we are hiring additional ISAs to support all the redesigned courses.

Overview of Activities

MBG Implementation: The initial professional development workshop was predicated on the assumption that all participating faculty had already "bought in" to the concept of redesigning their courses to utilize a mastery-based grading architecture as they had agreed to participate in the project. Therefore, the workshop began with an introduction and definition of Mastery-Based grading. This was followed with in-depth dives into the various components of a mastery-based grading redesign process including reading and discussing the research behind elements of mastery-based grading, i.e., the utilization of clearly defined and measurable learning outcomes and the neuroscience of feedback loops for learning. The time spent in course-based teams was designed to allow for initial exploration of the course content and how it would be looked at from the perspective of the place of the course in the curriculum and discussions of what should students know at the successful completion of a course.

The professional development team realized at the end of the workshop that despite the initial buy-in by faculty members to a mastery-based grading system, a lack of robust evaluation of the faults

of the traditional points-and-percentage based grading systems led to the unconscious reproduction of some of those faults in the initial redesign phase. Therefore, exploration of the faults of traditional grading was added to future versions of the professional development workshop, including in the workshop for the adopting faculty members.

Additionally, retention of the material covered in the initial training has been challenging for participating faculty. The initial intensive nature of the training followed by the lengthy development time overwhelmed faculty's ability to retain everything that was discussed. Therefore, repetition of some of the initial training material will be revisited in the ongoing Faculty Learning Community (FLC) meetings with the aim of improving future implementations. As of now, all of the training sessions and FLC meetings have been held virtually, therefore a comparison of an offline vs online structure is not possible. However, given the nature of the group of participants, informal in-person meetings of the course-based teams have begun. We will be exploring the usefulness of intentionally adding course-based in-person team meetings to the overall FLC structure.

Student data collection: We have been conducting longitudinal interviews with eight undergraduate students who were enrolled in the first MBG re-design. To date we have interviewed students twice and are currently in the process of conducting a third interview. The goal of the interviews have been to understand students' academic profiles and how these profiles might have changed as a result of the MBG learning environment. We conceptualize student's academic profile as a composite view of one's academic achievement which include: attitudes (i.e., beliefs of oneself in a particular situation/ circumstance), mindsets (i.e., beliefs about one's abilities and dispositions), and motivation (i.e., process that initiates, guides, and maintains goal-orientation behavior).We know from a recent systematic review that the experiences of first-generation college students are not often anchored within the contexts where learning is taking place (i.e., the classroom setting) [4]. Most studies on first-generation college students focus on why they are motivated to pursue a college degree (e.g., [4]–[8]) or focus on support interventions outside the classroom setting (e.g., [9]–[11]). While those efforts are important, studies examining pedagogical learning interventions (e.g., mastery-based learning) that can shed light on first-generation college students' learning motivation, mindset, and identity development remain sparse. Our longitudinal interviews aim to provide an understanding of how learning environments, focusing on experiences in specific engineering courses, alters first-generation college students' academic profiles. Additionally, we are collecting another round of survey data from courses that are adopting the MBG re-design with the aim of comparing results across semesters and across phases of the MBG implementation.

Faculty data collection: CLIMB faculty were interviewed by an external evaluator at the end of the first semester of MBG training. A second round of interviews were conducted at the end of the following semester. In addition, the external evaluator observed the Faculty Learning Community (FLC) sessions and conducted mini-surveys to obtain instant feedback on the training. In considering the experiences faculty reported at the end of each of the two semesters, it is important to consider that some FLC members had been implementing their own version of MBG for several semesters prior to the start of CLIMB. In fact, it was the encouraging outcomes and excitement these MBG pioneers felt about the changes they saw both in student engagement and in course pass rates that inspired the College to seek NSF support for the CLIMB FLC. During

the interactive workshop, the faculty members with MBG experience, along with the two MBG expert trainers, drew from their own experiences and case studies to bring to life the MBG core concepts and design. They also shared with other members of the FLC the blueprint they had developed for their original MBG courses.

Faculty Insights

During the first semester (Spring 2022), while the training was in progress, the two faculty members with previous MBG experience and two other members of the FLC implemented MBG in ME and EE/CS courses. The interviews at the end of the semester found these faculty members convinced that MBG could contribute to changing the mindset of students away from "merely" getting a passing grade toward learning. Faculty members agreed that the workload required to implement MBG is significant, particularly the task of providing students with detailed and individualized feedback on every quiz. The more quizzes and the more students, the greater the time commitment required by the faculty member. The guidance and support that FLC faculty members received from the expert trainers and from their FLC colleagues contributed to maintain focus and offered a forum where the MBG design advanced while reports from the field provided by those already implementing MBG added richness and authenticity to the conversations. The content of the FLC conversations and the end-of-semester interviews revealed how immersion in MBG was changing the mindset of faculty. One FLC member observed that he had started to examine in a completely new way what he was doing in the classroom. "I used to think mostly about my own course. Now I think much more about where my students come from and how ready they will be for the courses they take next." In addition to thinking more about the big picture, FLC members would find themselves questioning their learning outcomes: "Why do students need to learn this?"

In the end-of-semester interviews, faculty members underscored how important it was to embark on MBG as part of a faculty community, one faculty member summed it up: "Nobody should try to do this on their own." Overall, the first semester of MBG workshops and implementation guided by MBG expert trainers left the FLC team members encouraged both by the progress they made together designing and redesigning MBG courses and by reports of increased student engagement shared with them by FLC members already implementing MBG.

The next semester (Fall 2022) proved more difficult for the project. Interviews conducted at the end of the following semester found most members of the FLC team overwhelmed and, in some cases, frustrated about how much effort they had invested in MBG courses that ended up having limited student engagement and low pass rates. What happened? The interviews revealed that the faculty members with the most MBG experience had the most difficult semester experiences, possibly because they had added learning objectives and quizzes to their original designs and were offering students more opportunities to show mastery. Each addition increased the workload manyfold and –with instructional aides only added late in the semester – forced faculty members to spend time on grading and providing detailed feedback on more and more quizzes. But not all FLC members had a bad semester. The one faculty member from EE/CS reported that he had reduced the number of learning outcomes for the fall semester which "was good for my mental health this semester and made me less stressed out."

However, all interviewees agreed that students had not engaged in their MBG course until it was too late, for many students, to develop the level of mastery required to pass. Why was this? Interviewees felt that students had procrastinated in their MBG courses because many of them thought they could deprioritize MBG and focus on other courses until later in the semester. Faculty believed that students thought, "we can fail multiple times in our MBG course without failing the course or even getting a bad grade … So why not start the semester by concentrating on courses where failing the test means we fail the course," that is, focusing on non-MBG courses.

In addition to the tendency for students to engage too late to achieve mastery, faculty also speculated that students were not reading the feedback they were spending significant effort to develop. This added to MBG faculty's sense of frustration. Furthermore, most FLC members did not cover all the material they had included in their syllabus because they ran out of time. As a result, they worried how students would fare in the next course. In discussing the interview findings from the end of the semester, MBG faculty members acknowledged that their deep commitment to making students excited about learning and achieving mastery and the disproportionate amount of time they spent on MBG as opposed to other courses they taught, made the disappointing results more difficult to confront. "MBG is an emotional and very personal journey," one of the expert trainers observed. In the debriefing, the broader context of the Fall 2022 semester was also examined. Most importantly, there was widespread agreement that COVID fatigue hit students and faculty alike. During the end of 2022, the entire College was reporting students not engaging and failing at unprecedented rates.

Two new faculty members will be onboarded onto the FLC in Spring 2023; therefore, the task at hand is to learn from the past and move forward. As a first step, the team has developed a video for students where faculty members explain the importance of early engagement in MBG class assignments. The message is for students to start learning now. The opportunity to take tests multiple times means you can learn at your own pace but over an entire semester. In addition to reducing the number of learning outcomes, the FLC is also encouraging MBG faculty to limit the number of attempts students have on each exam. Additionally, the recommendation is to have more opportunities for the FLC community to grow and strengthen with additional collaboration and sharing of information and lessons learned. It emerged from the fall interviews that MBG faculty value opportunities to learn from each other's experiences and – as is the core principle of MBG—realize that making mistakes is part of the learning process not just for students in MBG classrooms, but also for those who teach MBG courses.

Insights into Students' Academic Profiles

In addition to learning about how faculty were experiencing the mastery-based grading training programs, we also sought to advance our understanding of the impact a mastery-based grading intervention can have on engineering students enrolled in three sophomore-level gateway courses. It will advance our understanding of how the new learning environment impacts engineering first-generation college students' achievement motivation, affective state, identity development, mindsets about their abilities to learn, and persistence beliefs (i.e., academic profiles). A recent systematic literature review found that there is a dearth of scholarship examining first-generation college students as academic learners, specifically noting that scholars focusing on first-generation college students are "often not anchoring their research within the contexts where learning is taking place (courses, disciplines, etc.)" [4, p. 11]. Most studies on first-generation college students focus

on why they are motivated to pursue a college degree (e.g., [5]–[8]) or focus on support interventions outside the classroom setting (e.g., [9]–[11]). While those efforts are important, studies examining pedagogical learning interventions (e.g., mastery-based learning) that promote academic achievement for first-generation college students remain sparse. Within the context of a mastery-based learning environment, much of the research has been largely focused on the K-12 setting, with some exceptions. The few studies using mastery-based learning in engineering [12]–[15] and mathematics college courses [16]–[18] demonstrate promising results on students' academic achievement. However, to date, no study has focused on the effect a mastery-based learning environment has on a predominately first-generation college student sample or how such a learning environment helps engineering first-generation college students endorse goal orientations that promote positive achievement motivation strategies, growth mindsets, and disposition towards persistence. Our primary research question was:

> RQ) How does participation in the mastery-based learning environment shift first-generation college students' academic profiles over time?

Method

To understand the impact a mastery-based grading learning environment has had on first-generation college students' academic profiles, we surveyed students at the beginning and end of semester in Spring 2022 ($n_1 = 38$) and Fall 2022 ($n_2 = 38$). During the Spring 2022 semester, instructors were in the middle of receiving training to help restructure their course that would be launched in Fall 2022. Therefore, we frame the Spring 2022 data as a baseline dataset of students who did not benefit from experiencing a curriculum developed through a formal MBG training program. In our sample, the majority of our students identified as first-generation college students 73% (27) in Spring 2022 and 74% (28) in Fall 2022. Since the institution is an HSI, with a very high enrollment of Latinx students, we expected to see more representation of students who identified as Latinx. In Spring 2022, 62% (23) of the students identified as Latinx, while in the Fall 2022 semester 74% (28) identified as Latinx. There were more male identifying students in our sample compared to female identifying students in both semester, Spring 2022 sample of male students 73% (27) and Fall 2022 sample of male students 66% (25).

A paired-samples t-test was used to determine if there were significant changes in students' mean scores at two different time points. The achievement goal theory measures (i.e., mastery goal, performance goal, classroom mastery goal, and classroom performance goal) were borrowed from the Patterns of Adaptive Learning Scale (PALS; [19]). The growth and fixed mindsets scales were borrowed from Dweck's work [20], [21]. A shortened version of the Fear of Failure scale was used in this study; an item from each of the dimensions identified by Conroy et al. [22] were borrowed to create a general scale. Engineering recognition and performance/competence beliefs were borrowed from the identity scale [23]. The Cronbach alpha values for all constructs were above the recommended value of 0.70.

Summary of Results from Student Surveys

When we compared the results from survey data collected in Spring 2022 and Fall 2022, summarized in Table 2, we first noticed that there were more changes in mean scores in the Fall semester where faculty implemented the MBG redesign compared to the Spring (i.e., before the implementation of the MBG redesign). As well, there was an equal number of desirable changes

compared to undesirable changes in the Fall 2022 dataset. However, we expect the first iteration to have growing pains, for many students it is their first time experiencing a mastery-based graded course in an engineering context and there is a general fear among students regarding the known difficulty level of the courses. Across both semesters, students demonstrated a constant mean increase in their fixed mindset views. That is, students' beliefs that their abilities and intelligence are fixed (i.e., cannot develop through effort or over time) increased from the beginning of the semester to the end in the Fall and Spring. Yet, it is worth noting that Spring 2022 students on average had higher post-response fixed mindset mean values (mean = 2.32) compared to those in Fall 2022 (mean = 1.93). In the Fall 2022 dataset, when the MBG redesign was implemented, we notice that students' growth mindset significantly increased. Another interesting comparison to highlight is that the Fall 2022 cohort had higher end of semester growth mindset scores (mean = 4.64) compared to those students in the Spring 2022 cohort (mean = 4.11). We know that students can endorse both a growth and a fixed mindset, Dweck's work [20], [24] has alluded to this phenomenon. Since the growth and fixed mindset scales are general scales, it is difficult to ascertain students' frame of reference while responding to these survey items. That is, it is unclear if students are thinking about certain topics within their course or their overall abilities in the course, nevertheless the preliminary comparisons across semesters are promising.

We also looked at three important goal orientations, defined in the Achievement Goal Theory literature [25], i.e., mastery goals, performance goals, and performance-avoidance goals. We observed that students in Spring 2022 did not show any changes in mean scores over the course of the semester. However, students in Fall 2022, who were experiencing the MBG curriculum, showed a significant decrease in their mastery goal orientation and a significant increase in their performance goal orientation over the course of the semester. It is worth noting that even though students' endorsement of a mastery goal decreased, their end of semester mean score is still higher (mean = 4.95) than the mean score for performance goals (mean = 2.56). While earlier research on achievement goal theory characterized performance goals as a maladaptive motivational response, revised versions of AGT have pushed towards endorsing performance goals as a desirable motivational response that also fuels achievement [26], [27]. Nevertheless, in a curriculum that is targeting mastery over performance, we would expect a mastery goal orientation to not be negatively impacted. We believe clearer communication to students regarding the goal of the retake opportunities might be warranted. For example, in the feedback instructors provide to students, clear language regarding the demonstration of mastery of the learning objective might help students focus their goal towards achieving mastery rather than performance.

In both datasets, we found that students' perceptions of being recognized as engineers by their peers and instructors increased over time. This finding further reinforces the importance of examining how students are being recognized as engineers in their classroom setting and the effects of this recognition. In Spring 2022, students demonstrated a significant increase in their abilities to perform well in their engineering courses (termed engineering performance/competence beliefs), however the same increase was not observed in Fall 2022.

In Fall 2022, we added a new scale to the survey intended to capture students' fear of failure. Throughout the Faculty Learning Community, there was a consensus regarding students' angst towards failure, which is an understandable sentiment given the implications failing a gateway course has on degree progression. Since an important tenant in MBG is providing opportunities to

retake assessments to achieve mastery of predefined learning objectives, we hypothesized that as a result of allowing multiple retake opportunities students would be less fearful of failing and conceptualize it as a learning opportunity. We found that students' fear of failure did significantly decrease at the end of the semester.

Conclusions

The CLIMB-UP project has been exploring a major shift in how engineering course are taught, involving significant faculty time and collaboration in a vulnerable setting. Early results indicate that it will take faculty several iterations of teaching using Mastery-Based Grading for them to feel confident in using this method, and for students to grasp the responsibility that this type of classroom bestows upon them for their own learning. The effect of the last few years of remote teaching and learning have undoubtedly affected both faculty and students, but as our study progresses into its final year, we expect to have clearer conclusions about how students experience mastery-based learning, and how their mindsets and attitudes change.

Table 2.
Summary of Students Academic Profiles

	Year 1 Spring 2022: before MBG Faculty Learning Community			**Year 2 Fall 2022: MBG Faculty Learning Community, First Iteration**		
	Mean	**t-test**	**Cohen's d**	**Mean**	**t-test**	**Cohen's d**
Mastery Goals	Pre: 5.38 Post: 5.33	t(37)= 0.42, p = .337	-	Pre: 5.28 Post: 4.95 ↓	t(37)= 2.60, p = .006595	0.42
Performance Goals	Pre: 1.97 Post: 1.95	t(37) = 0.10, p = .4622	-	Pre: 2.20 Post: 2.56 ↑	t(35)= -1.88, p = .0342	0.31
Performance-avoidance goal	Pre: 2.65 Post: 2.66	t(37)= -0.22, p = .415	-	Pre: 2.76 Post: 2.90	t(35)= -0.84, p = .2031	-
Classroom mastery goal	Pre: 5.45 Post: 5.30 ↓	t(37)= 1.78, p = .042	0.29	Pre: 5.34 Post: 5.13 ↓	t(37) = 1.69, p = .04971	0.27
Classroom performance goal	Pre: 4.76 Post: 4.73	t(38)= 0.51, p = .307	-	Pre: 4.62 Post: 4.40	t(35)= 1.40,p = .0845	-
Classroom performance-avoidance goal	Pre: 2.28 Post: 2.27	t(37) = -0.14, p = .444		Pre: 2.37 Post: 2.78 ↑	t(37)= -1.71,p = .04824	0.28
Growth mindset	Pre: 4.19 Post: 4.11	t(37)= 0.55, p = .2944	-	Pre: 4.33 Post: 4.64 ↑	t(34)= -1.76, p = .04408	0.30
Fixed Mindset	Pre: 2.12 Post: 2.49 ↑	t(37)= -2.63, p = .006	0.43	Pre: 1.69 Post: 1.93 ↑	t(36)= -2.09, p = .02208	0.34
Fear of Failure	-	Not collected this semester	-	Pre: 4.74 Post: 4.34 ↓	t(37)= 1.84, p = .03685	0.30
Engineering Recognition	Pre: 3.48 Post: 3.87 ↑	t(37) = -2.48, p = .009	0.40	Pre: 3.50 Post: 3.74 ↑	t(37)= -1.77, p = .04275	0.29
Engineering Performance/Comp. Beliefs	Pre: 4.43 Post: 4.67 ↑	t(37) =-2.02, p = .025	0.33	Pre: 4.43 Post: 4.36	t(37) = 0.75, p = .2288	-

Note. Survey were collected at the beginning of the semester (Pre) and at the end of the semester (Post). Arrows are intended to signal directional changes in mean values. Green arrows signal desirable changes. Red arrows signal undesirable changes.

References

[1] J. Feldman, *Grading for equity: What it is, why it matters, and how it can transform schools and classrooms*. Corwin Press, 2018.

[2] L. B. Nilson, *Specifications grading: Restoring rigor, motivating students, and saving faculty time*. Stylus Publishing, LLC, 2015.

[3] G. A. Garcia, *Becoming Hispanic-serving institutions: Opportunities for colleges and universities*. Johns Hopkins University Press, 2019.

[4] J. Ives and M. Castillo-Montoya, "First-Generation College Students as Academic Learners: A Systematic Review," *Rev. Educ. Res.*, vol. 90, no. 2, pp. 139–178, 2020, doi: 10.3102/0034654319899707.

[5] D. E. Blackwell, D. Patrice, and J. Pinder, "What Are the Motivational Factors of First-Generation Minority College Students Who Overcome Their Family Histories To Pursue Higher Education?," *Coll. Stud. J.*, vol. 48, no. 1, pp. 45–56, 2014.

[6] M. Próspero and S. Vohra-Gupta, "First generation college students: Motivation, integration, and academic achievement," *Community Coll. J. Res. Pract.*, vol. 31, no. 12, pp. 963–975, 2007, doi: 10.1080/10668920600902051.

[7] E. Irlbeck, S. Adams, C. Akers, S. Burris, and S. Jones, "First Generation College Students: Motivations and Support Systems," *J. Agric. Educ.*, vol. 55, no. 2, pp. 154–166, 2014, doi: 10.5032/jae.2014.02154.

[8] T. Petty, "Motivating first-generation students to academic success and college completion.," *Coll. Stud. J.*, vol. 48, no. 1, pp. 133–140, 2014, [Online]. Available: https://login.ezproxy.net.ucf.edu/login?auth=shibb&url=http://search.ebscohost.com/login.aspx?direct=true&db=aph&AN=96336720&site=ehost-live.

[9] C. R. Wibrowski, W. K. Matthews, and A. Kitsantas, "The Role of a Skills Learning Support Program on First-Generation College Students' Self-Regulation, Motivation, and Academic Achievement: A Longitudinal Study," *J. Coll. Student Retent. Res. Theory Pract.*, vol. 19, no. 3, pp. 317–332, 2017, doi: 10.1177/1521025116629152.

[10] Y. Tibbetts, J. M. Harackiewicz, E. A. Canning, J. S. Boston, S. J. Priniski, and J. S. Hyde, "Affirming Independence: Exploring Mechanisms Underlying a Values Affirmation Intervention for First-Generation Students," *J. Pers. Soc. Psychol.*, vol. 110, no. 5, pp. 635–659, 2016, doi: 10.1037/pspa0000049.Affirming.

[11] K. K. Inkelas, Z. E. Daver, K. E. Vogt, and J. B. Leonard, "Living-learning programs and first-generation college students' academic and social transition to college," *Res. High. Educ.*, vol. 48, no. 4, pp. 403–434, 2007, doi: 10.1007/s11162-006-9031-6.

[12] J. Ranalli and J. P. Moore, "New faculty experiences with mastery grading," *ASEE Annu. Conf. Expo. Conf. Proc.*, vol. 122nd ASEE, no. 122nd ASEE Annual Conference and Exposition: Making Value for Society, 2015, doi: 10.18260/p.24524.

[13] K. D. Hjelmstad and A. Baisley, "A novel approach to mastery-based assessment in sophomore-level mechanics courses," *ASEE Annu. Conf. Expo. Conf. Proc.*, vol. 2020-June, 2020, doi: 10.18260/1-2--34028.

[14] H. Ritz, K. Dimiduk, and A. van Paridon, "Effect of mastery-graded exams on student outcomes in statics and mechanics of solids course," *ASEE Annu. Conf. Expo. Conf. Proc.*, vol. 2020-June, 2020, doi: 10.18260/1-2--34496.

[15] L. E. Craugh, "Adapted mastery grading for Statics," *ASEE Annu. Conf. Expo. Conf. Proc.*, vol. 2017-June, 2017, doi: 10.18260/1-2--27536.

[16] A. Harsy, C. Carlson, and L. Klamerus, "An Analysis of the Impact of Mastery-Based

Testing in Mathematics Courses," *Primus*, vol. 0, no. 0, pp. 1–18, 2020, doi: 10.1080/10511970.2020.1809041.
[17] A. Halperin, "Mastery-based testing in calculus with a final exam component," *PRIMUS*, pp. 1–23, 2020.
[18] O. E. Fernandez, "Second Chance Grading: An Equitable, Meaningful, and Easy-to-Implement Grading System that Synergizes the Research on Testing for Learning, Mastery Grading, and Growth Mindsets," *Primus*, 2020, doi: 10.1080/10511970.2020.1772915.
[19] C. Midgley *et al.*, "Manual for the Patterns of Adaptive Learning Scales." pp. 734–763, 2000.
[20] C. S. Dweck, *Mindset: The New Psychology of Success*. Penguin Random House, 2006.
[21] C. S. Dweck, *Mindset: Changing the way you think to fulfil your potential*. Robinson, 2017.
[22] D. E. Conroy, J. P. Willow, and J. N. Metzler, "Multidimensional fear of failure measurement: The performance failure appraisal inventory," *J. Appl. Sport Psychol.*, vol. 14, no. 2, pp. 76–90, 2002, doi: 10.1080/10413200252907752.
[23] A. Godwin, "The development of a measure of engineering identity," *ASEE Annu. Conf. Expo. Conf. Proc.*, vol. 2016-June, 2016, doi: 10.18260/p.26122.
[24] D. S. Yeager and C. S. Dweck, "What Can Be Learned From Growth Mindset Controversies ?," *Am. Psychol.*, no. December, 2020, doi: 10.1037/amp0000794.
[25] C. Senko, C. S. Hulleman, and J. M. Harackiewicz, "Achievement goal theory at the crossroads: Old controversies, current challenges, and new directions," *Educ. Psychol.*, vol. 46, no. 1, pp. 26–47, 2011, doi: 10.1080/00461520.2011.538646.
[26] C. Senko, "Comparing Three Models of Achievement Goals : Goal Orientations , Goal Standards , and Goal Complexes," no. September, 2016, doi: 10.1037/edu0000114.
[27] C. Senko *et al.*, "Achievement Goal Theory at the Crossroads : Old Controversies , Current Challenges , and New Directions Achievement Goal Theory at the Crossroads : Old Controversies , Current Challenges , and New Directions," vol. 1520, 2011, doi: 10.1080/00461520.2011.538646.