ASEE 2022 ANNUAL CONFERENCE
Excellence Through Diversity
MINNEAPOLIS, MINNESOTA, JUNE 26TH-29TH, 2022 ASEE

Paper ID #36819

Impact of Two Reflective Practices in an Engineering Laboratory Course using Standards-based Grading

Casey Jane Ankeny (Associate Professor of Instruction)

Casey J. Ankeny, PhD is an Associate Professor of Instruction at Northwestern University. Casey received her bachelor's degree in Biomedical Engineering from the University of Virginia and her doctorate degree in Biomedical Engineering from Georgia Institute of Technology and Emory University where she studied the role of shear stress in aortic valve disease. Currently, she is investigating cyber-based student engagement strategies in flipped and traditional biomedical engineering courses. She aspires to understand and improve student attitude, achievement, and persistence in student-centered courses.

Amy Adkins (Assistant Teaching Professor)

Amy N. Adkins is an Assistant Teaching Professor in the Joint Department of Biomedical Engineering at University of North Carolina (UNC) and North Carolina State University (NCSU). She received her Ph.D. and M.S. in Biomedical Engineering from Northwestern University and her B.S. in Engineering Science from St. Mary's University in San Antonio. Her technical research which relates to her PhD Dissertation is focused on utilizing novel imaging techniques to quantifying adaptation of muscle structure in humans. She also desires to implement innovative teaching, mentoring, and hands-on problem solving to develop students' deep understanding of engineering principles and to inspire them to tackle real-world problems which can aid human health.

David P O'neill

David O'Neill is an Associate Professor of Instruction and the Michael Jaharis Director of Experiential Learning for the Biomedical Engineering Department at Northwestern University. He read Engineering Science at University College, Oxford, receiving his M.Eng. and D.Phil. degrees. During his doctoral studies in the engineering department and post-doctoral work in the department of physiology, anatomy and genetics, he taught undergraduate tutorials for Keble, New, University, and Harris Manchester Colleges, was College Lecturer for New College and a Senior College Lecturer in Engineering Science for Keble College. Current projects and interests include implementing mastery-based grading schemes, and how cognitive load can be affected by vertical curricula and the level of synopticism throughout the biomedical engineering degree path .

Impact of Two Reflective Practices in an Engineering Laboratory Course using Standards-based Grading

Introduction:

Typically, traditional summative-based grading simply shows students point deductions, often failing to provide a link between what instructors want students to know (course goals or objectives) and their understanding. As a result, an alternative method of assessing student work, standards-based grading (SBG), is becoming more popular in the engineering education field to provide students with rich feedback on how well they are meeting course standards [1] . Though SBG more explicitly links student proficiency and course goals, its effectiveness still relies on student initiative to read and internalize the SBG feedback. This is a not a trivial task. Both anecdotal educational wisdom and a handful of studies suggest that students do not incorporate feedback [2] , especially when paired with a grade [3]. Additionally, there can be student hesitance in accepting SBG scheme after years of schooling with traditional summative grading.

To maximize SBG's potential for improving student mastery, students must view it as valuable and incorporate it into their learning. Reflective practices have been used with evidence-based strategies, including standards-based grading [1], to tailor student learning and efforts. More specifically, it has been demonstrated that student access to SBG feedback increased when paired with structured reflection [4]. In addition, reflection is known to increase student awareness about their own learning [5]. These findings motivate us to utilize reflection as a means to gain student acceptance of SBG feedback in addition to developing student metacognitive abilities.

Despite the engineering education field's recognized enthusiasm for developing self-directed learners [6] and knowledge that reflective techniques can foster this skill [5], little work has been done to optimize reflective techniques in the classroom. Even fewer have implemented such techniques in a laboratory-based courses. Thus, this study investigated the implementation of two reflective practices in a laboratory course that uses standards-based grading: 1) reflective surveys after work completion and 2) engineering notebooks to be completed during course sessions ("reflect-while-doing"). We hypothesized that reflecting while completing deliverables in addition to post-submission reflection would enhance student receptiveness to standards-based grading as well as learning as measured by a standards-based grading system when compared to only reflecting post-submission.

Methods:

Course Description and Consenting Process

This study was conducted over two terms in an experimental design laboratory course for second-year and advanced first-year Biomedical Engineering majors. Both quarters were team-taught with a single pair of instructors. There were different teaching assistants (TAs) for each quarter; see below (Grader Calibration) for efforts to mitigate the effect of different TAs. During both quarters student participants (Winter; n=18 and Spring; n=24) completed the course in a hyflex format where some students took the course entirely virtually and synchronously, whereas others took the course entirely in-person. Groups were formed by course modality. The course consisted of two modules [M1: sensor characterization and M2: modeling with confounding factors to find statistical differences in human data] [7]. Both instructors used a similar structure for their module with regards to the balance of content-delivery, instructor-led review, active learning, and experimental work. Deliverables for each module included both a draft and full report (team assignments). All graded work, except the final exam, was assessed using standards-based grading. The course standards were used to measure progress towards the mastery of problem-solving skills and included the following standards [8]: 1) Problem Identification, 2) Knowledge Processing, 3) Approach and Experimental Design, 4) Analysis, 5) Interpretation, 6) Communication, and 7) Teamwork.

The study investigator, who was not a course instructor, explained the study and performed the consenting process at the start of the course. Students had the choice regarding whether their work was included in the study, however all students were required to participate in the reflection exercises and all submissions were given course credit, rather than being linked to the quality scores used in the study. There was no incentivization presented to the students with regards to remuneration, compensation, or course credit.

Reflective Surveys

During both quarters, students completed short post-submission reflective surveys based on work by Diefes-Dux, *et al*., [8]–[10] before as well as after receiving instructional feedback on the submitted assignment. During the consent process, the student investigator provided examples of strong and poor reflections as models. Specifically, the survey [7] was comprised of four reflective questions:

1. What do you believe you have and have not learned and achieved in this assignment?
2. How well do you think the evaluation of your work represents what you have and have not learned and achieved?
3. What learning objectives/standards are high priority for you to focus on developing going forward?
4. What specific actions do you plan to take based on our evaluation of your work?

For each module, there were three reflective surveys: immediately following submission of the laboratory report draft (Question 1 only), at the time of final report submission (all questions), and after receiving the final report feedback (all questions). The quality of reflection was assessed by grading the post-submission surveys using a points-based method like previous work [7], [9], [11]. The assessments of reflection quality were not shared with the students and were performed after all data had been collection.

Engineering Notebooks

In the second quarter, student teams were additionally asked to "reflect-while-doing" in the form of engineering notebooks. The instructional team provided rationale for completing notebooks, logistical information in composition and submission, as well as how the notebooks will be evaluated and used to reflect on team progress. Notebook grades contributed to the draft lab report grade and were evaluated based on the following specifications which were influenced by course standards:

1. Daily objective and rationale
2. Visual Communication (use of graphs, diagrams, etc.)
3. Evaluative and Creative Processes (including interpretation of findings, reflection on failures, brainstorm of next steps, and prediction of outcomes)
4. Organization and Completeness

Each specification was evaluated independently and aligned with one or more standard. More specifically, students earned one point if the specification was fully met, one-half point if it was partially met, and zero points if it did not meet specification. Along with their point grade, students were provided detailed written feedback from the instructional team about what they did, and did not, do well in terms of meeting course standards.

Grader Calibration

To account for potential different interpretations of standards-based grading mastery levels between different TAs in each course offering, a grader calibration activity was overseen by the instructors. A subset of lab reports from Quarter 1 were selected by the first quarter TAs and given, without mark-up, to the TAs for the second quarter. The subset of lab reports were selected to be representative of the range of grades given (mastery levels achieved). The second quarter TAs graded the subset of lab reports and a discussion was had with all TAs and instructors to achieve 'calibration'. Anecdotally, only minor calibration was required with TAs from both quarters being in general agreement on assessment of mastery level achieved for the sample lab reports.

Attitudinal Surveys

Students also participated in a post-course attitudinal survey consisting of questions regarding the value of reflections with standards-based grading as well as questions about their engagement with the reflective practices [8]. The student value survey was designed to capture student attitude regarding the value, utility, and interested of reflection with standards-based grading on a 4-point agreement scale from "1- strongly disagree" to "4- strongly agree". Results are presented in tabular form as percentages combining rankings of "1-strongly disagree" with "2-disagree" and "3-agree" with "4-strongly agree".

The engagement with standards-based grading survey measured the degree of agreement with statements, using the same scale as the value survey, related to: 1) the referencing of standards while completing the work, 2) metacognition, and 3) the practice of reflection in the context of assessments using standards-based grading. Similarly, results are presented in tabular form as percentages combining rankings of "1-strongly disagree" with "2-disagree" and "3-agree" with "4-strongly agree".

Survey results between the Winter quarter with reflective surveys only were compared the Spring quarter which had both reflective surveys and engineering notebooks. Comparisons of agreement scores were made using the non-parametric statistical test for two independent samples, the Mann-Whitney U test, as the data were based on an ordinal scale.

Assessment

Achievement was assessed using both final report scores and final exam scores. When investigating increased achievement within a quarter, Module 1 and Module 2 final report scores were compared using the parametric statistical test for independent samples, the student *t*-test, as the scores were continuous.

Descriptive statistics between reflection survey scores and report scores or final exam scores, as well as subsequent inferential statistical tests, were conducted using parametric statistics appropriate for continuous scores. More specifically, Pearson's correlation coefficients were calculated to describe a potential linear relationship between these variables. Further, *t*-scores were calculated and corresponding *p*-values found to determine significance. A post-hoc power analysis was conducted to determine the achieved power. G*Power settings included a two-tailed test, large effect size of 0.3, alpha of 0.05, and power of 0.8. Further, a *t*-score was calculated, and a corresponding *p*-value found to determine if correlations were significant.

Results:

Achievement Improvement over Time

When analyzing report scores (Winter – n=12 and Spring – n=16), we saw a modest but statistically significant improvement for report scores from M1 to M2 (difference in averages = 7%; $p<0.001$) in the first quarter; however, we did not see a significant difference in the second quarter (difference in averages = 0.2%; $p=0.83$) as shown in Figure 1 below.

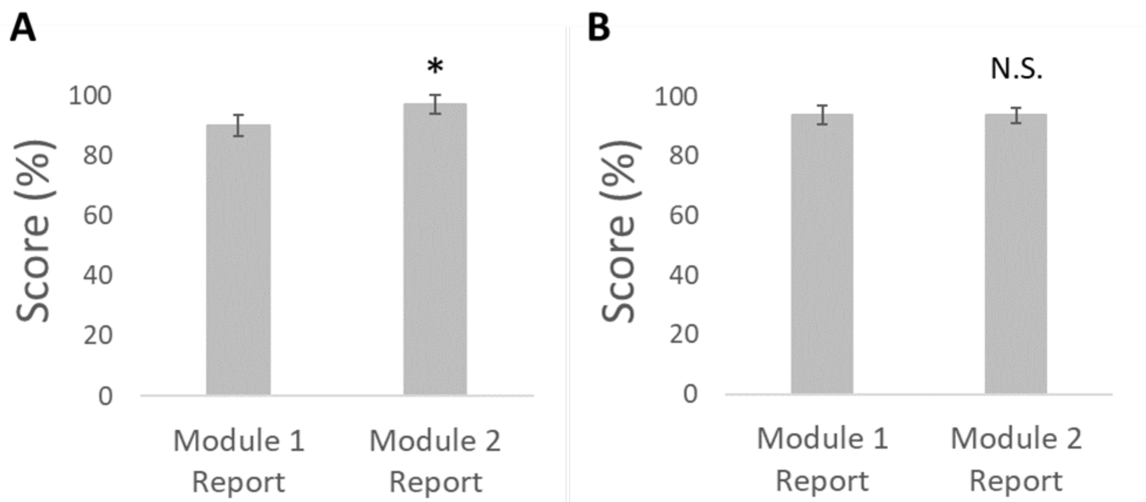

Fig. 1 Achievement Improvement Over Quarter There was a small but statistically significant increase in report scores between Module 1 and Module 2 ($p<0.001$, n=18) during the first quarter as shown in panel A. During the second quarter, there was no difference between average report scores between Module 1 and Module 2 as shown in panel B (n=24).

Correlation between Reflection Scores and Achievement

For the first quarter using only reflective surveys, we saw a statistically significant positive correlation between individual reflection survey scores and individual final exam scores where the Pearson's correlation coefficient was 0.64 ($p=0.02$, n=12) as shown in the dotted trendline of Fig. 2A. To address the potential outlier (z-score = –2.8) related to the lowest reflection score, we re-conducted the analysis without that participant, yielding a correlation coefficient of 0.22 (solid trendline, $p=0.67$, n=11). During the second quarter which included both reflective surveys and engineering notebooks, there was a positive correlative trend between reflective survey scores and final exam scores (0.42, $p=0.1$, n=16) as shown in Fig. 2B.

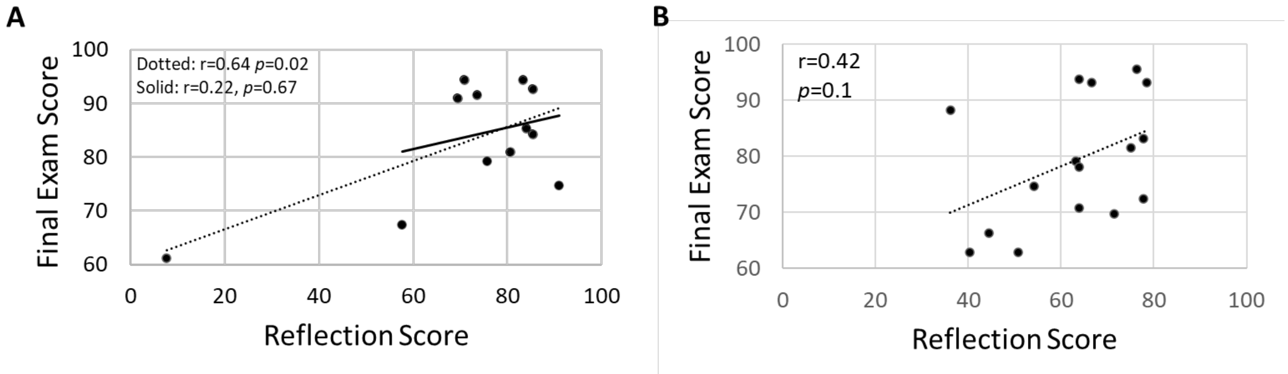

Fig. 2 Correlation between Reflection Survey Scores and Final Exam Scores (A) During the first quarter, there was a statistically significant positive correlation between reflection survey scores and the final exam scores (dotted trendline, r=0.64, *p*=0.02, n=12). The solid trendline shows the correlation without the suspected outlier (r=0.22, *p*=0.67). (B) During the second quarter, there was a trend showing a positive correlation between reflective survey scores and final exam scores (r=0.42, *p*=0.1, n=16).

To probe the relationship between the reflection survey scores and lab report assignments, we calculated the Pearson's correlation coefficient for each quarter. As shown in Fig. 3A., we found a mildly positive correlative trend between reflection survey scores and lab report assignments for the first quarter (dotted trendline, 0.24; *p*=0.46; n=12) and, as shown in Fig. 3B, a mildly negative correlative trend for the second quarter (–0.37; *p*=0.16; n=16) though neither were statistically significant. Analysis without the suspected outlier in Winter quarter (Fig. 3A) yielded similar results with a correlation coefficient of 0.19 (solid trendline, *p*=0.57, n=11).

A post-hoc power analysis showed that there is not significant power to detect a large effect size in these correlations. More specifically, the achieved power for the Winter (n=11–12) and Spring (n=16) correlations were 0.15–0.17 and 0.22 respectively, instead of the desired power of 0.8.

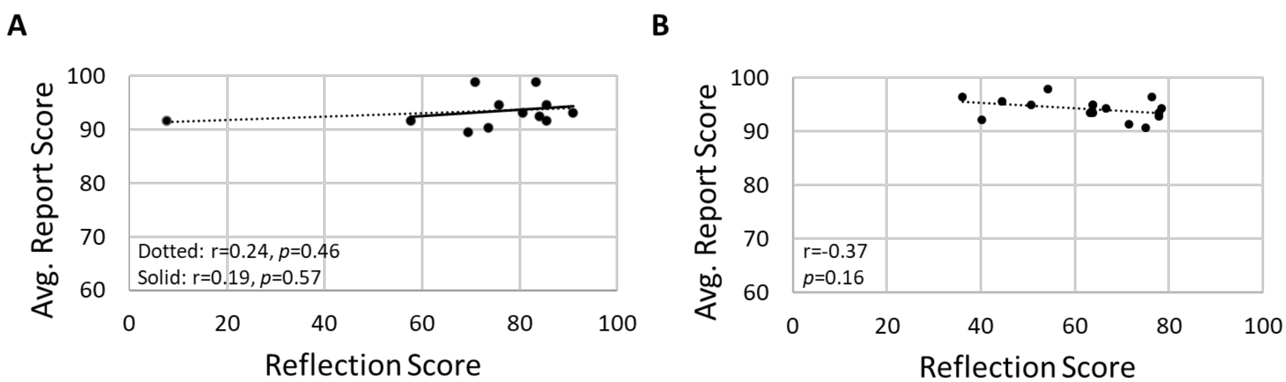

Fig. 3 Correlation between Reflection Survey Scores and Average Report Scores There was a mildly positive correlative trend between reflection survey scores and average report scores during the first quarter (A). Trendlines are shown with and without the suspected outlier [dotted (r-0.24, p=0.46, n=12) and solid lines (r=0.19, p=0.57, n=11), respectively]. During the second quarter, the Pearson's correlation coefficient was a mildly negative correlative trend between reflection survey and average report scores (r=-0.37, p=0.16, n=16). Neither correlation was statistically significant.

Student Value of Reflection with Standards-based Grading

The Student Value of Reflection with Standards-based Grading survey had a Winter (surveys only) response rate of 6 out of 18 study participants; whereas, the response rate for Spring (surveys and notebooks) was 8 out of 24 study participants. The number of online students versus in-person students were similar (Winter: 3 online and 3 in-person; Spring: 3 online and 5 in-person).

Table 1. Student Value of Reflections with Standards-based Grading

	Winter 21 (Surveys Only)	**Spring 21 (Surveys + Notebooks)**
COST	***Agree/Strongly Agree***	***Agree/Strongly Agree***
Not too much effort	67%	63%
Did not make feel frustrated or anxious	83%	50%
Not too much time	83%	88%
INTEREST	***Agree/Strongly Agree***	***Agree/Strongly Agree***
Motivating	50%	88%
Engaging	17%	50%
Help understand learning	50%	88%
Responsibility for own learning	17%	100%
UTILITY VALUE	***Agree/Strongly Agree***	***Agree/Strongly Agree***
Course Value	100%	75%
Course Useful	100%	88%
Course Relevance	100%	100%
More reflections	17%	63%

In part due to a small sample size, we did not detect any significant improvements in terms of student value of the reflections used to support standards-based grading. However, it is interesting to note a trend (p=0.15) in the question regarding how reflection promotes students to take responsibility for their own learning. Only one student from Winter quarter when only reflective surveys were used "agreed" or "strongly agreed" with the statement that reflections used in the course in conjunction with standards-based grading encouraged them to take responsibility for their own learning; whereas 100% of the respondents "agreed" or "strongly agreed" with the statement in Spring quarter where there were both summative reflective surveys as well as reflective engineering notebooks.

Reflection Engagement Survey

Viewing both quarters together, the reflection engagement survey (n=14) showed students do reflect on standards-based grading and incorporate their reflections into the next iteration of the assignment. More specifically, 11 were aware of the course learning objectives based on course standards. Most students reviewed the standards-based grading rubric while completing the deliverables for both Module 1 (12) and Module 2 (13). Twelve students reviewed the standards after receiving instructional team feedback and grade and twelve students used their performance on Module 1's deliverables to guide Module 2's submission.

We uncovered a disconnect between SBG reflections and students' perceived utility with exam preparation. Fifty-seven percent used the standards to study for the final and 54% said that the standards rubric guided their study habits. Moreover, 64% used performance on the reports (which were graded according to the standards) to guide their preparation for the final. Lastly, approximately half of the participants (54%) felt that the standards tracked what they had and had not learned.

When comparing results from those that only completed reflective surveys in Winter as compared to those who completed both reflective surveys and reflective engineering notebooks, we did not find statistically significant improvements. However, there may be a trend that the reflective practices helped guide their study habits (p=0.16) and that the students used the standards to prepare for the final (p=0.21) more so in the Spring with the addition of the reflective engineering notebooks. The small sample size may be inhibiting the ability to find significant improvements.

Table 2. Results from Engagement Survey with Reflective Practices

	Winter 21 (Surveys Only)	**Spring 21 (Surveys + Notebooks)**
	Agree/Strongly Agree	***Agree/Strongly Agree***
Used Standards when completing assignment - M1	67%	100%
Used Standards when completing assignment - M2	83%	100%
Reviewed standards after receiving grade	83%	88%
Used performance on M1 to guide M2 submission	67%	100%
	Agree/Strongly Agree	***Agree/Strongly Agree***
Awareness of Learning Objectives	50%	100%
	Agree/Strongly Agree	***Agree/Strongly Agree***
Recommends that SBG be used for all courses	17%	50%
Agree standards track what have learned/have not learned	33%	86%
	Agree/Strongly Agree	***Agree/Strongly Agree***
Agreed that standards guided study habits	33%	75%
Reviewed standards for final	17%	75%
Used performance on report to guide prepare for final	50%	75%

Discussion:

Achievement with Different Reflective Practices

We saw a statistically significant increase in report scores from Module 1 to Module 2 in the first quarter of the study (Fig. 1). This was not surprising as the students have additional opportunities to practice. Interestingly, there was no statistically significant difference between Module 1 and Module 2 report scores when engineering notebooks were included in the second quarter. This could be due to notebooks in M1 accelerating student learning towards mastery before report submission as noted by slightly higher report scores in the second quarter compared to the first. It is important to note that report scores were high in both quarters.
There may be a positive correlative trend between reflection survey scores and final exam scores as supported by Fig. 2. This comparison is of interest because both the reflection surveys and the final exams are completed individually, whereas reports are submitted as a team. These results could indicate: 1) strong students typically score highly on all assignments or 2) reflecting deeply aids individual performance in final exams. If the data point related to the lowest reflection score were to be removed for the first quarter (Fig. 2A), the correlation would no longer be significant as shown in the results section. In the future, we will increase our sample size as indicated by the *post-hoc* power analysis to better investigate this relationship.

As shown in Fig. 3, there is not a statistically significant correlation between reflection scores and average report scores. There are several potential reasons for this. One potential explanation is that the sample size being too low (n=12–16 instead of 29). Further, we originally predicted that engineering notebooks would improve students' ability to reflect on the reflection surveys; however, we found no statistical difference in reflection survey scores between the two quarters (p=0.18). Additionally, the grades for the reports were universally high so it may be hard to show a statistically significant improvement in achievement with this metric. Lastly, the reflection surveys were completed individually, and the report scores were team-based. In future work, we will increase the sample size to investigate whether those students who reflect deeply through notebooks and reflection surveys increase their mastery of course standards (as measured by the deliverable scores). Further, we will make the reports or final deliverables individual assignments. This not only benefits the study analysis but, more importantly, tracks the individual student's progress towards mastery.

Student Attitude about Reflection with Standards-based Grading

Student attitude about standards-based grading was mixed. Students felt that the standards-based grading rubric and feedback guided preparation of future report submissions. It is important to note that the laboratory nature of the course with reports as deliverables facilitated the implementation of standards-based grading with reflection. The students were able to directly relate the course standards to their written assignments.

Though there were no statistically significant differences between quarters in terms of student value of reflections and engagement with standards-based grading as shown in Tables 1 and 2, there may be some interesting trends to further investigate. Interestingly, respondents that participated in both reflective surveys and reflective engineering notebooks may show a tendency to have increased responsibility of their own learning versus the respondents who only participated in reflective surveys (p=0.15). More investigation is required to determine if this is a significant finding. If so, this could be because students simply had more time to reflect on their progress towards standards and it is known that reflection boosts students' responsibility for their own learning [5]. An alternate explanation is that the students more deeply and productively reflected while doing the assignment rather than after the work was completed.

In terms of student engagement, there may be a trend for respondents who completed reflective engineering notebooks to be more likely to use the course standards and the feedback to prepare for the final exam than those who only participated in reflective surveys. More specifically, those in agreement of the following statement in Winter quarter was 33% as compared to 75%: "I believe having my work assessed based on standards guides my study habits." Similarly, agreement from Winter to Spring for the following statement was 17% to 75%: "I reviewed my performance on the standards associated with the final exam after feedback was released." These could be because the reflective activities closely aligned with the standards and with increased exposure during the Spring quarter, students more easily identified the standards as important areas to demonstrate on the exam. More work is necessary to better understand this trend, especially given the small sample size. Additionally, there may be some ambiguity in the survey items as the Winter respondents did not answer an item that tests the same latent variable in a similar fashion. More specifically, 50% of respondents in the Winter "agreed" or "strongly agreed" with the following statement as opposed to 75% in the Spring: "I used the assessment of my performance on the standards to guide my preparations for the final exam."

Study Limitations and Future Work

Limitations of the study include small class sizes in both course offerings, less than full participation in the study, and with two modules, students had a limited number of attempts to demonstrate mastery. Assessing intervention effectiveness was complicated by a mix of individual reflective practices and team-based lab reports. It is important to note that while Modules 1 and 2 were taught by different instructors the instructors were consistent for both quarters. Further, there were different teaching assistants over the two quarters. To provide continuity, the instructional team from both quarters met to undergo grader calibration as described above. Briefly, both quarters graded the same sample of reports and worked together to reach consensus on the standards grading. It is important to note that although Module 1 and Module 2 had different scenarios, sensor characterization in Module 1 and human experimentation in Module 2, the problem-solving standards for both were the same and the deliverables were graded according to the same rubric. Further, both modules lasted five weeks.

For future offerings, the instructional team intends to alter the use of reflective surveys by providing feedback on the quality of their reflections like the feedback mechanism in place for the engineering notebooks. It is worth noting that because the reflective engineering notebooks were graded as part of the formative feedback that students were extrinsically motivated to reflect deeply unlike the reflective surveys which were rewarded by participation only. Further, the instructional team will alter course deliverables to include more individual assignments. This removes the "divide and conquer" strategy whereby students split the report into discrete sections and only work on their parts, as well as increases sample size for the study. The instructors will increase the number of opportunities for students to progress towards mastery of course standards. We will then investigate to see if individual reflection with increased instructional team feedback will improve individual student mastery of course standards.

Ease of Adoption

In general, it is important to note that standards-based grading can be translated to exam-based courses where each problem is tagged with a corresponding standard or standards [4]. Further, reflection has been successfully introduced into courses without standards-based grading [2]; however, we feel that reflection about student learning is facilitated using standards-based grading rubrics which are intimately tied to course learning objectives. Direct implementation of these practices would be possible in laboratory- and design-based courses. Adaptation to the "reflection-while-doing" practice would be required for courses such as lecture courses where engineering notebooks are not suitable.

In conclusion, our initial results suggest that an increase in reflective practices, namely the addition of reflective engineering notebooks, may improve student perception of standards-based grading as well as may increase their engagement with mastery of course standards. Further, reflection may aid student mastery but future work with larger sample sizes is required. These results will direct the design of a future study to rigorously answer how individual reflective techniques translate to individual mastery of course standards.

References:

[1] A. Carberry, M. Siniawski, S. Atwood, and H. Diefes-Dux, “Best Practices for Using Standards-based Grading in Engineering Courses Best Practices for Using Standards-based Grading in Engineering,” *ASEE Conference Proceedings*, 2016.

[2] H. K. Sinclair and J. A. Cleland, “Undergraduate medical students: who seeks formative feedback?,” *Medical Education*, vol. 41, no. 6, pp. 580–582, Jun. 2007, doi: 10.1111/J.1365-2923.2007.02768.X.

[3] R. Butler and M. Nisan, “Effects of No Feedback, Task-Related Comments, and Grades on Intrinsic Motivation and Performance,” *Journal of Educational Psychology*, vol. 78, no. 3, pp. 210–216, Jun. 1986, doi: 10.1037/0022-0663.78.3.210.

[4] H. A. Diefes-Dux and L. M. C. Castro, “Student Reflection to Improve Access to Standards-Based Grading Feedback,” in *2018 IEEE Frontiers in Education Conference (FIE)*, 2018, pp. 1–9. doi: 10.1109/FIE.2018.8659325.

[5] S. Ambrose, “Undergraduate Engineering Curriculum: The Ultimate Design Challenge,” *The Bridge: Linking Engineering and Society, National Academy of Sciences*, pp. 16–23, Jan. 2013.

[6] P. ’Bednar, R. ’Eglin, and C. ’Welch, “Contextual Inquiry: A Systemic Support for Student Engagement through Reflection,” *Interdisciplinary Journal of Knowledge and Learning Objects*, vol. 3, 2007.

[7] A. Adkins, D. O’Neill, and C. Ankeny, “WIP: Effectiveness of Different Reflection Approaches for Improving Mastery in an Engineering Laboratory Course,” *ASEE Conferences*, 2021.

[8] C. J. Ankeny and M. C. Tresch, “Creation and Deployment of a Virtual, Inquiry-Guided Biomedical Engineering Laboratory Course,” *Biomedical Engineering Education*, vol. 1, no. 1, pp. 67–71, 2021, doi: 10.1007/s43683-020-00017-w.

[9] H. Diefes-Dux, “Student reflections on standards-based graded assignments,” Jan. 2016, pp. 1–5. doi: 10.1109/FIE.2016.7757445.

[10] H. A. Diefes-Dux and A. R. Carberry, “Cases of Student Reflection within a Course Using Standards-Based Grading,” in *2019 IEEE Frontiers in Education Conference (FIE)*, 2019, pp. 1–9. doi: 10.1109/FIE43999.2019.9028501.

[11] M. Menekse, G. Stump, S. Krause, and M. Chi, “The Effectiveness of Students’ Daily Reflections on Learning in an Engineering Context,” Jan. 2011, pp. 22.1451.1-22.1451.10. doi: 10.18260/1-2–19002.