



## Assessing Student Writing Competencies in Environmental Engineering Courses

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## Introduction

Students enrolled in the environmental engineering program at the University of Wisconsin-Platteville are required to complete a large number of diverse writing assignments. They complete ten laboratory courses, many of which require weekly lab reports. Senior-level courses are focused on design, and students prepare many technical design reports in these courses; a large design paper is the final deliverable for the capstone Senior Design course. Moreover, given the undergraduate-only nature of the university, all student writing is assessed by faculty members. The traditional model for grading student writing is to mark up the writing with corrections and suggestions for improvements and assign a grade between 0 and 100%.

Despite the extensive practice students carry out and despite the frequent, thorough, and well-intentioned critical feedback they obtain on their writing, student writing effectiveness as measured using the rubric for Senior Design reports is often very poor. As a result, some faculty members have questioned the current assessment method to evaluate student writing. The current method is very time consuming, provides insufficient motivation to students to continuously improve, and has not improved student writing to a level required for entry into professional practice. Consequently, the objective of this study is to answer the question: “how can more valuable input that improves student writing be provided in a manner that is time-efficient for faculty?” One potential solution is writing competency-based grading (WCBG).

The theory behind WCBG is that rather than assigning grades on individual writing assignments, a grade is assigned at the end of the semester based on the number of writing competencies a student has achieved. In the WCBG model, three levels of writing competencies are outlined. Examples of low-level competencies include “no inexcusable spelling errors” and “no more than one sentence fragment.” Upper level competencies include “Appropriate (technical) tone used throughout entire document” and “All claims supported with quantitative evidence.”

In this paper, the experience of three faculty members using WCBG in two environmental engineering courses will be shared. The courses in which WCBG was used were two sections of Hydrology and two sections of Fluid Mechanics. Hydrology is a 3-credit senior-level course and consists of two hours of lecture and two hours of lab each week. The Hydrology results presented in this paper comes from one section of Hydrology in Spring 2013 and one section in Fall 2013; both sections were taught by the first author of this paper. Fluid Mechanics is a 4-credit junior-level course that consists of three hours of lecture and two hours of lab each week. The Fluid Mechanics results in this paper come from two sections taught in the Fall 2013 semester; these sections were taught by the other two authors of this paper.

To assess the question “How can more valuable input that improves student writing be provided in a manner that is time-efficient for faculty?”, multiple measures were used, including instructor reflections, student performance in the course, and student responses to an end-of-semester survey.

## **Background**

Competencies are used in areas of engineering education other than in engineering writing. Design-based courses such as capstone courses provide an example of outcome based assessment that have been implemented successfully at a variety of engineering institutions and across multiple engineering disciplines. In addition, ABET evaluates programs based on specific outcomes and student competency in those outcomes.

Writing based competencies are used as a form of assessment in ESL (English as a Second Language) type programs but minimal literature exists using competency based writing frameworks for evaluating technical writing. Troy et al (2004) used a competency based framework for evaluating group writing of junior level biomedical students. They used two team based writing assignments in a junior level biomedical class to enhance instruction and assess competency in written communication and team based collaboration. Over a five-year period, an iterative process was used to: develop the assignments and skills to teach, develop design criteria and assessment, design class activities and student feedback, and finally grade papers, assess students and refine the process. They divided assessment into two categories: lower and higher level thinking.

## **Implementation of Writing Competency-Based Grading**

At the beginning of the semester, class time (two hours in Hydrology; one hour in Fluid Mechanics) was devoted to writing instruction. In Hydrology for example, students were given a sample Senior Design report to evaluate as a take-home assignment. They were provided with a list of writing competencies and asked to identify places within the report where the various competencies were met (or were not met). An in-class discussion was held to review this assignment, which then segued into a discussion of WCBG.

The “backbone” of WCBG is the grading rubric. The grading rubric used at University of Wisconsin-Platteville contains three levels: Low, Medium, and High. Papers that do not meet all competencies corresponding to the Low level are deemed “Unacceptable.” The competencies listed in each outcome level varied slightly for each course and varied as the semester progressed (as will be noted in the “Reflection” section of this paper). The competencies used at the end of the Fall 2013 semester for the 4000-level Hydrology course are listed in Table 1. A similar list of competencies was used in the 3000-level Fluid Mechanics course, with adjustments to fit the instructors’ preferences. These adjustments were relatively minor; for example, in the 4000-level courses, two or more comma errors are considered a Low level error, while for the 3000-level courses they were considered a Medium level error.

Competency-based grading in engineering education has incorporated Bloom’s Taxonomy (Bloom, 1956) to assess student achievement (Froyd, 1997), and in some sense the competency levels described herein can be correlated to different Bloom’s levels. For example, WCBG competencies needed to achieve a “Low” rating included correct spelling (i.e., memorization). Level 2 competencies focused more on application (e.g. “Tables and graphs are interpreted correctly and thoroughly”), and Level 3 include competencies that involved evaluation and analysis, such as “Results presented in graphics and tables are integrated into the Discussion section.”

**Table 1: Writing Competencies**

<b>Level 1 (Low)</b>	<b>Level 2 (Medium)</b>	<b>Level 3 (High)</b>
• No inexcusable spelling errors	• No spelling errors	• All paragraphs have an effective topic sentence
• No sentence fragments	• All paragraphs are focused on a single topic/idea	• Appropriate (technical) tone used throughout entire document
• No run-on sentences	• Essential information is conveyed	• All claims supported with quantitative evidence
• Proper format	• Data is presented in a form that is readily understood	• Thoroughness and conciseness are properly balanced
• Proper capitalization in every instance	• Tables and graphs are interpreted correctly and thoroughly	• Uncertainty of hydrologic calculations is reflected
• No other grammar mistakes	• Work is technically correct	• Care taken to choose the "best" word
• Assignment requirements are satisfied/sufficient content	• Audience is always kept in mind	• Graphics added to make reader’s job easy.
• Correct use of numbers/numerals in every instance	• No ambiguous statements	• Appendices are appropriately compiled for brevity and ease of use
• No more than two comma errors	• All sentences are logical	• Bulleted/numbered lists are used when appropriate
• No “crazy,” confusing sentences	• Engineering conventions of tables/graphics are followed	
• No “crazy” significant figures		
• Quantitative adjectives used as appropriate		

Each written report (six in Hydrology; ten in Fluid Mechanics, four of which were group assignments) was assessed using the WCBG rubric. A numeric score was assigned (1 point for Low, 2 points for Medium, 3 points for High, and 0 points for Unacceptable). If students failed to attain a single Low Level competency, they obtained a score of 0; likewise, success at

attaining all Low Level competencies yet failing to attain a single Medium Level competency resulted in a score of 1. To attain a score of 3, all High Level competencies must be met.

The lab score counted as 25% of the overall course grade in Hydrology and 20% in Fluid Mechanics. For the WCBG implementation, 40% of the lab points were assigned to technical correctness and 60% points of the lab points were assigned to writing effectiveness. A 15-point scale was used to assign the writing effectiveness points as shown in the following list:

- 15/15 – 3 assignments that achieve High Level competency
- 14/15 – 2 assignments that achieve High Level competency
- 13/15 – 4 assignments that achieve Medium Level competency
- 12/15 – 3 assignments that achieve Medium Level competency
- 11/15 – 4 assignments that achieve Low Level competency
- 10/15 – 3 assignments that achieve Low Level competency
- 9/15 – 2 assignments that achieve Low Level competency
- 8/15 – 1 assignment that achieve Low Level competency
- 0/15 – 0 assignments that achieve Low Level competency

## **Results**

The average scores for student writing increased as the semester progressed (Figure 1). This was seen in the increasing average score and even more notably in the decreasing number of Unacceptable papers in the two sections of Fluid Mechanics. (“Average Score” is obtained by assigning a value of 0 to “Unacceptable,” 1 to “Low,” 2 to “Medium,” and 3 to “High.”) In two sections (Fluids 1 and Hydrology), a decrease in average score was noted near the end of the semester. This may be attributable to student “burn-out”.

In addition to the scores improving, students also reported more confidence in their technical writing ability (Figure 2 and Figure 3). As reported in the end-of-semester survey, more than half of all students perceived that their writing effectiveness had improved. Also notable is that students in one of the sections of Fluid Mechanics (“Fluids 1”) were much more confident in their writing ability as compared to students in other sections. This may be due to the fact that the Fluids 1 instructor told the students often (nearly every time that graded labs were returned) that their writing was improving.

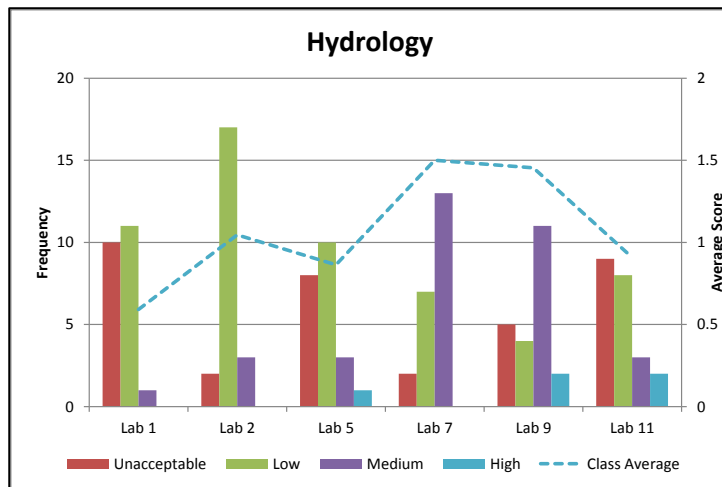
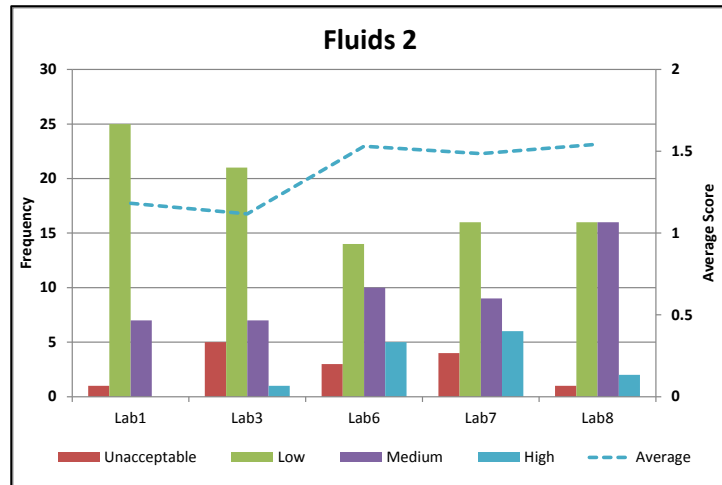
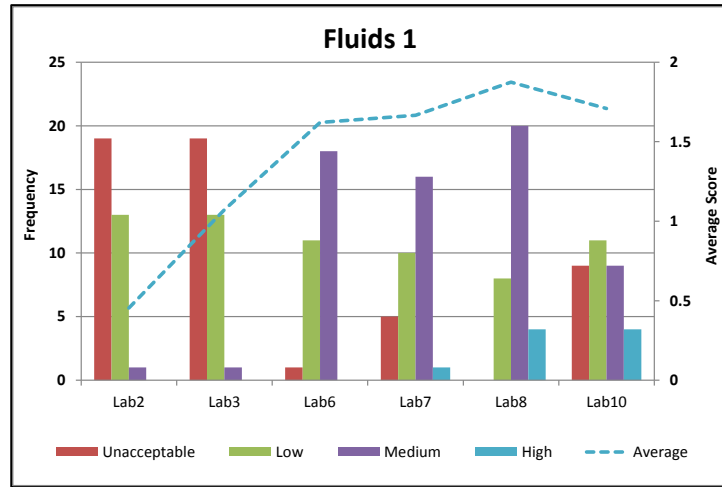
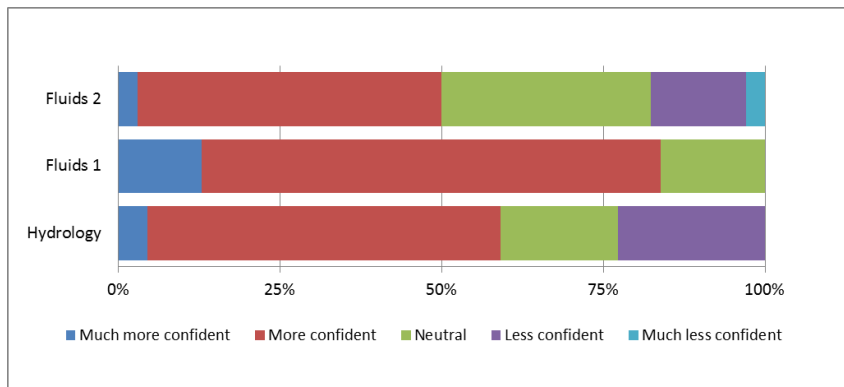
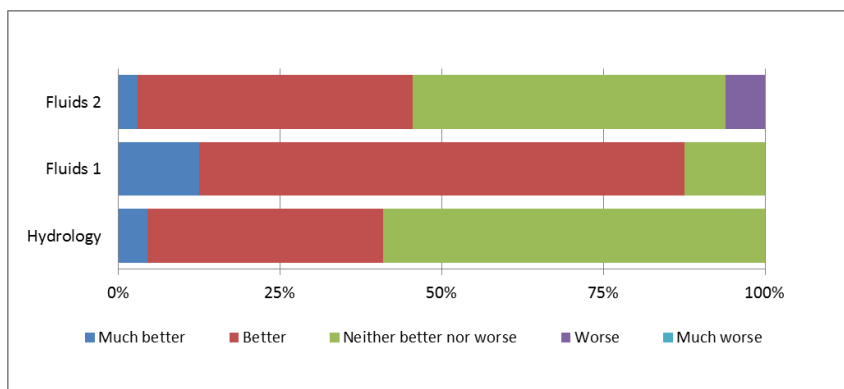


Figure 1: Student Performance

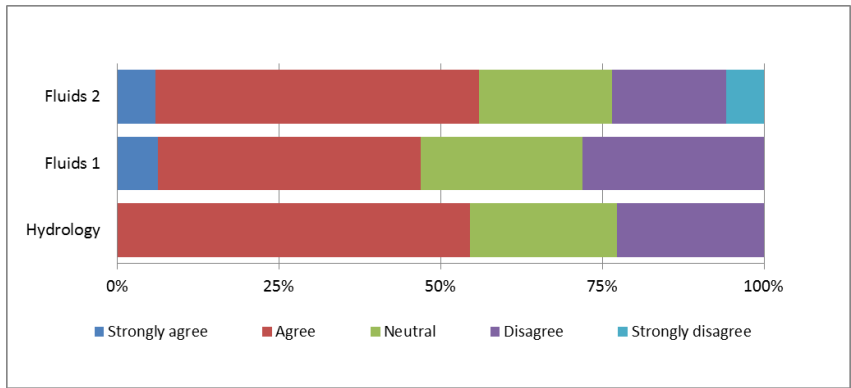


**Figure 2: Student results when prompted by the following: “As a result of WCBG used this semester, I am \_\_\_\_\_ in my technical writing ability.”**

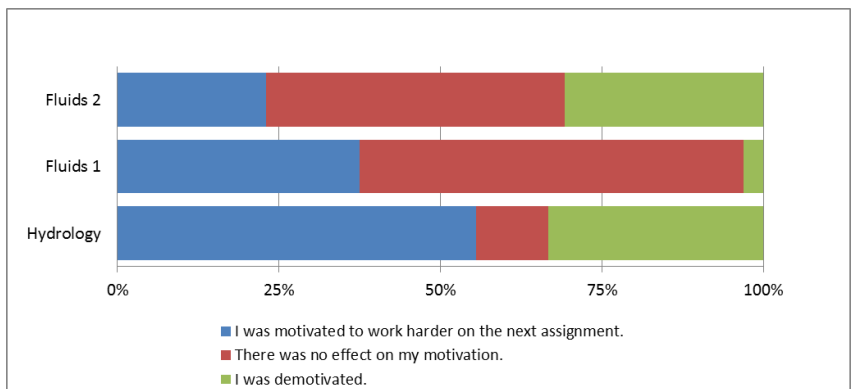


**Figure 3: Student results when prompted by the following: “I am a \_\_\_\_\_ writer now than I was at the start of the semester.”**

To many students, the WCBG is a radical departure from the manner in which their writing has been graded in previous courses. Additionally, a large number of students repeatedly turned in writing that was categorized as “Unacceptable.” Some of the survey questions were written to address potential negative attitudes among the students toward this out-of-the-ordinary and rigorous writing assessment. Approximately half of all students agreed that the instructor’s expectations were reasonable (Figure 4). When asked whether or not earning a score of “Unacceptable” impacted motivation, the students responded as shown in Figure 5. Although a minority of students reported being demotivated, the fractions are troublingly high and will be addressed in future implementations of WCBG.

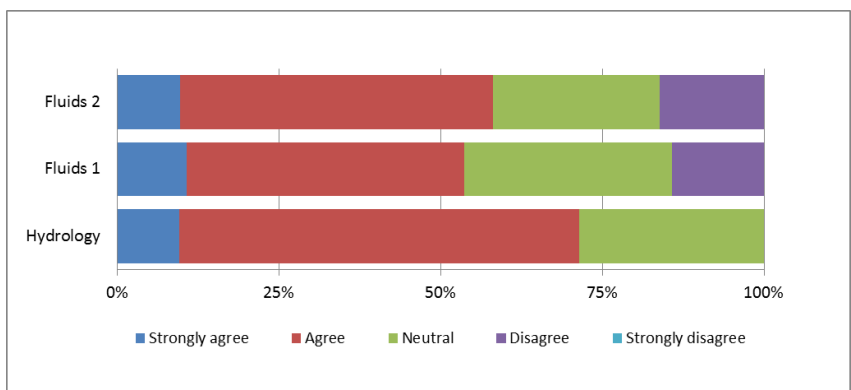


**Figure 4: Student results when prompted by the following: "I thought the expectations of my instructor were reasonable."**



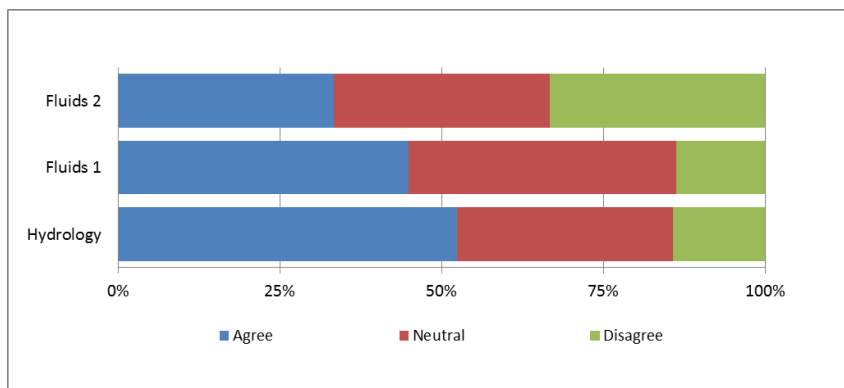
**Figure 5: Student results when asked the following: "How was your motivation affected after receiving a grade of 0?"**

Two questions on the end-of-semester survey addressed concerns students had expressed in conversations (some directly to faculty members and some between students that were overheard by the instructor). Some students were concerned that the grading rubric was too subjective and did not properly assess the quality of their writing. The results in Figure 6 and Figure 7 show that, although students felt that the WCBG method was fair, they had concerns about the objectivity of the rubric.



**Figure 6: Student results when asked the following: "I feel that WCBG was applied fairly"**





**Figure 7: Student results when asked the following : “The rubric is designed such that two instructors grading the report independently would arrive at the same score.”**

## Discussion

The results presented in the previous section along with the instructor reflections inform the following lists of advantages and disadvantages of WCBG.

Advantages of WCBG include:

- Student writing improves (i.e. a decrease in the number of unacceptable writing assignments, which is especially noticeable as the semester progresses).
- The bar is raised on student writing in a fair, transparent, and defensible way.
- Students are provided with focused feedback on ways to improve their writing. One student wrote on his survey at the end of the semester: “I liked that it encouraged you to improve your writing flaws. It also made you slow down and read what you are writing, to make sure that it made sense.”
- Results can be directly used for ABET assessment. For the present study, if two labs earned a score of 2 or 3, this was deemed a satisfactory achievement of the ABET Outcome “ability to communicate effectively”.
- Faculty workload is *potentially* reduced due to improved student writing by mid-semester (i.e., well-written papers are easier to grade than are poorly-written papers).
- The rubric allows some flexibility – for example, faculty members can adjust the level assigned to various competencies in response to course level (e.g., 4000- or 3000-level) or course content (for example, a Level 3 competency for Hydrology is “Uncertainty of hydrologic calculations is reflected”). The rubric was also altered as the semester progressed; for example, the Fluid Mechanics instructors allowed students to make up to four comma errors and still obtain a Level 1 competency following the first lab.

Disadvantages include

- Although some criteria are objective (e.g., grammar and punctuation), many upper level criteria are subjective (e.g., tone and accounting for audience), leading to variations in grading between faculty.
- First-time users of the rubric may assess work more slowly than if they used a familiar rubric.
- Instructor writing skill, and thus the ability to evaluate student writing effectiveness, varies from instructor to instructor.
- Some students are discouraged upon receiving a grade of 0 (i.e. they did not even satisfy the Level 1 competencies) even after investing many hours in preparing the document. One student commented “We put a lot of work into [labs] and a 1/3 [i.e. attaining a Level 1 Competency] is almost a slap in the face.”

The faculty reflections, along with written student feedback have helped identify the following “tips for success” in implementing WCBG.

- Graded reports must be returned promptly to students to allow them to implement changes before the next writing assignment is due.
- Instructors must continuously “sell” the WCBG method to the students. For example, at the beginning of the semester, the instructor can show the distribution of grades from the previous semester so that students see that most students obtained more than 75% of the 10 points devoted to writing effectiveness. As another example, the instructor should praise the class as the semester progresses and should note how the number of “Unacceptable” papers has (hopefully) decreased. A third example relates to a student written comment on the survey: “I do not think comma errors make or break whether a supervisor thinks you are a good worker or not.” This type of mindset that appeared to be shared by several students could have been offset midway through the semester by the instructor emphasizing the need for careful attention to detail needed by engineers in their writing, as attention to detail instills (or removes) confidence in clients of an engineer’s technical competence.
- Instructors should be somewhat unyielding when grading the first WCBG reports, but should consider “forgiving” certain errors as the semester progresses. All instructors were troubled when they had to assign a rating of Unacceptable to a report that, absent for example a sentence fragment, was otherwise well-written and would have received a Medium or High rating. Following the first two laboratory reports, one instructor had the policy of forgiving a Level 1 error if it was the only error in that competency level.
- The campus writing center should be integrated into WCBG usage. A writing center can be more effective when students bring their draft report and a copy of the rubric, and can identify to the writing center tutor exactly which competencies he or she needs help with. Additionally, one of the authors allowed forgiveness of certain low level errors if the student brought the paper to the Writing Center and then rewrote the paper in response to the Writing Center input. For this present study, student usage of the University of

Wisconsin-Platteville Writing Center was minimal in Fluid Mechanics; about 1/3 of Hydrology students used it.

- An “optimum” number of assignments exists in terms of affecting student motivation. Six assignments were used in Hydrology, which appears to be satisfactory. In Fluid Mechanics, ten WCBG assignments were administered; one Fluid Mechanics student noted, “Early on in the course, I learned that it took very little effort to earn a 1, and I could earn a decent grade, so I just did that, rather than spend a ton of time for a few points.”

Like any rubric, the WCBG rubric has a degree of subjectivity. A greater level of subjectivity is inherent in the Level 3 competencies as compared to Level 1 competencies and most likely cannot be eliminated. For example, two instructors may disagree about whether or not a phrase meets the competency that “Data are presented in a form that is readily understood.” Even in the lower levels, subjectivity does exist, often based on the preferences of the instructor. For example, the second author does not tolerate personifying a graph or figure (e.g. he does not allow a student to write “the table *shows*”) while this error does not seem bothersome to the first author.

Whether or not the WCBG method saves instructor grading time is not currently agreed upon by the authors. However, all authors agree that the method is no more time consuming than the traditional grading methods. The method has the potential to save time given that student writing improves as the semester progresses, which would reduce grading time. Moreover, the use of a well-defined rubric saves time in deciding and systematizing how to assess writing. All authors plan on using WCBG in the Spring 2014 semester.

## **Conclusion**

Writing competency based grading (WCBG) was implemented by three instructors in four sections of two different courses. Over 50% of all students surveyed at the end of the semester claimed they had more confidence in their technical writing abilities and were better writers. About two-thirds of all students answered that WCBG was a fair method, with that number at approximately 90% when “neutral” responses were included. Even though students found the grading scheme to be more demanding than they were accustomed to, many still saw its value; one student wrote “Labs were graded harshly, but grading system has potential.” (student underline). Results were similar for the junior- and senior-level. WCBG has the potential to save time as student work improves throughout the semester and by allowing the faculty member to perform ABET assessment of writing competency concurrently with grading the lab. All authors plan to incorporate the aforementioned improvements and use WCBG in the upcoming semester in courses that have a lab component.

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