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Application of Single-Point Rubrics in Introductory Environmental Engineering Projects: A Case Study

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Abstract

Fair assessment of open-ended student work is often considered one of the most difficult aspects of teaching. If the assignment is over-constrained with specific criteria in a rubric, it may limit student creativity, but without guidelines, students may not include necessary items to produce accurate and professional work. Single point rubrics have been proposed as a compromise. The "single point" establishes the expectations of the assignment. Then, during grading, the instructor leaves feedback to document items that resulted in a loss of points in that category or evidence of work beyond expectations. This differs from a traditional rubric which pre-establishes thresholds for categories such as "Above Expectations" or "Meets Expectations." In the Introduction to Environmental Engineering course at The Citadel, a series of "mini projects" are used to expose students to topics in environmental engineering practice. Each project is also aimed to allow students to practice each of the three ABET models of communication (visual, written, and oral). These projects are each graded using single point rubrics. This paper details the assignment and rubric structure, grade distributions for the assignments when single-point rubric grading was used, and reflections from faculty and students on best practices for this rubric modality.

Introduction

Engineering programs are challenged, via the ABET criteria, to teach, improve, and assess the communication skills of students. [1] Unlike technical, quantitative, engineering content, communication does not have one correct answer and thus can be a challenge to assess for engineering educators. Faculty are trained that rubrics are one major tool to allow for fair assessment of almost any type of assignment, however overly defined rubrics can stymie creativity in communication assignments. [2]–[8] Single point rubrics are a rubric model used to provide more qualitative feedback from the grader while still clearly conveying the learning objectives assessed. Here we document the application of single point rubrics in a series of Environmental Engineering communication projects over a three-year period. Provided are information on the projects and rubrics, as well as student performance data and feedback on them.

Single Point Rubrics

Single point rubrics are a style of rubrics that focus on documenting student mastery of content at a specific standard while providing verbal feedback, particularly on aspects requiring improvement. One of the most common modes of introduction to single point rubrics appears to be through a 2015 post on the blog "Cult of Pedagogy." [9] It has since often been discussed online and in the research literature in the context of K-12 education where states have set specific standards for student learning and students must achieve a proficient level in each standard. [10]–[12] An example of a single point rubric utilizing some of the South Carolina Grade 2 Mathematics Standards is shown in Table 1. There have been other research

publications documenting the use of single point rubrics, or similar rubric models, in college or professional training settings. [13]–[17]

In its purest form, the rubrics are used for formative assessment, either by the instructor or a peer, rather than summative assessment, however some online discussions revolve around setting a "meets expectations" or "standards met" grade at a 3 of 4 allowing work that "exceeds standards" to earn a 4/4. In this way, a single point rubric can be adapted to a traditional grading schema (awarding A, B, C, etc.) without requiring the instructor to document each scoring division.

Table 1*: Example Single point rubric created with South Carolina Grade 2 Mathematics Standards – K-12 application of Single Point Rubrics are more common in literature. Note the space provided on each side to document verbal feedback.*

Areas for Improvement	Criteria: Standards for this performance	Evidence of Exceeding Standards
	Standard: 2.NSBT.1.a Demonstrate that 100 can be thought of as a bundle (group) of 10 tens called a "hundred"	
	Standard: 2.NSBT.1.b Demonstrate that the hundreds digit in a three-digit number represents the number of hundreds, the tens digit represents the number of tens, and the ones digit represents the number of ones	
	Standard: 2.NSBT.1.c Demonstrate that three-digit numbers can be decomposed in multiple ways (e.g., 524 can be decomposed as 5 hundreds, 2 tens and 4 ones or 4 hundreds, 12 tens, and 4 ones, etc.)	

ABET Outcomes

Among the many skills included in the ABET accreditation criteria for engineering programs, professional communication is included. [1] Communication is consistently recognized as an important skillset for practicing engineers after graduation. [18]–[20] There is a range of research on how professional communication can be taught and assessed in college programs. [2], [21]–[27] Here, we offer one more model to this body of literature, the use of single point rubrics. We applied single point rubrics as a format for summative grading, though single point rubrics can also be used for formative assessment.

Methodology – Assignment and Grading Description

Project Descriptions

Three projects are assigned to project teams (groups of two to three students) at a rate of approximately one per month during the "Introduction to Environmental Engineering" at The Citadel. Students are given one to two lecture periods per project to work with their teammate on the project, but instructors clearly state that this will not be enough to complete the entire project. Each project provides students with exposure to several aspects of Environmental Engineering and has them exercise different communication methods for their deliverable.

Project 1 Description: This project focuses on Environmental Impact Analysis, particularly on the contents of Environmental Impact Statements (EIS). This documentation, or a waiver application, is required for federally funded projects and thus is of importance to all civil engineering students, not just those with future careers as environmental or water resources engineers. Students are provided with four different published EIS and select the topic most interesting to their group. Topics are listed below as an example, though as campus partners provide more documents to The Citadel, the list can change. As only four options are provided, multiple groups may select the same topic.

1. Stream restoration project
2. Shrimping industry policy amendment
3. Telecom Network installation
4. Water treatment residual management plan

Project 1 Deliverable: As an EIS is a written document; students are instructed that they will practice their written communication skills. The groups must collaboratively write a 500-100-word professional style memorandum to summarize the key aspects of their selected EIS for an imaginary company supervisor. This requires them to review the EIS- which is 250 pages or more- then create a summary of no more than three pages.

Project 2 Description: This project introduces groups to Life Cycle Analysis (LCA). Student teams must select one of the 19 LCA articles provided. Topics range from food/personal care products to building materials to human/animal life. Each group must have a unique topic. Publications were sourced from OpenLCA, EcoInvent, and the International Journal of Life Cycle Analysis.

Project 2 Deliverable: Students are instructed that they will practice visual communication. When provided with a journal article, they must create a poster to communicate the key points. Some topics may be addressed via poster text, such as the product description and database tools, but most must be addressed graphically through various flowcharts or tables. Students are shown examples of scholarly posters but are limited to an 11" by 17" format and thus must employ their judgement on formatting expectations. The posters are printed by the instructor and shared with the department at-large enabling popular voting for "most visually appealing," "most informative," and related categories for bonus points on the project.

Project 3 Description: Project 3 takes place between the last unit test of the semester and the final exam. The goal is to (a) expose students to important historical case studies in environmental engineering and (b) stimulate critical thinking through application of numerical course content to "real world" scenarios. Teams are provided with a list of 15 environmental "disasters" in US history. These include cases such as Love Canal, Times Beach, and the Exxon Valdez oil spill. Teams may petition the instructor to use a case study not on the list. US cases are used to have students make connections between history and the US laws/policies created in response. All groups must have a unique topic.

Project 3 Deliverable: Student groups must create a short oral presentation, with slides, to be delivered to the class. Students are limited to no more than 6 slides and are given recommendations about professional presentation techniques. The project deliverable includes the team's presentation and peer evaluation of other groups' presentations, including the presentation skill and technical content. Depending on course scheduling constraints and class enrollment, some semesters may have live presentations or pre-recorded videos. If delivered in-person, this requires multiple class sessions to accommodate not only the presentations themselves but live "question and answer" sessions after each. If video recorded, one class session is used where students watch peer presentations on their own laptops and use online discussion boards to have "question and answer" interactions.

Project Rubrics

While a traditional single-point rubric employs a single (one) point for each category when evaluated as "meets expectations", this equal weighting of all topics was judged to be inadequate for these projects. Instead, these rubrics employ different weights for grading categories. As the categories vary in weight, the rubric must show both the maximum number of points possible in the category and the points for "meets expectations" with and understood minimum in the category of zero points. Lastly, not all categories can earn points for being beyond the "meets expectations" category. "Meets expectations" is employed as the maximum in categories where the list of requirements fully encompasses all that could be done and therefore students should not spend extra time on that category.

The "meets expectations" requirements are explicitly noted in the project rubric provided to the students. This allows students to work through the list of requirements while creating their deliverable. Requirements are intended to be specific and numerical so that each item can be evaluated as "Yes" or "No" when grading. For example, Project 2 requires the students' LCA poster includes "General name of products analyzed given and any specific (i.e. brand/location) information to the product included." A subset of the requirements can be more subjective such as "Memo clearly states the purpose of the project proposed" as seen in the Project 1 rubric-shown in Table 1 in an abridged format.

The total points for the "meets expectation" rating vary by project. Project 1 is set at 85/100 points, Project 2 at 80/100 points, and Project 3 at 72/100 points. This decrease was set to (a) accommodate students as they adjust to use of this rubric style for grading projects and (b) to provide additional explicit requirements for deliverable styles that students in the program historically have less experience with. By the time that students take "Introduction to Environmental Engineering" they, on average, show high competence in oral presentations due to prior course content while professional memorandums are newer. Thus, student teams on Project 3 are more likely to employ "best practices" without explicit instruction and therefore earn more than the "minimum expectation" points.

Table 1: *Rubric used for Project 1 (EIS Summary in Professional Memo). Table is abridged to fit in article – space for instructor written feedback has been removed.*

Category	**Minimum Expectations Requirements:**	**Points for Meeting Min. Expectations**	**Max Possible Points When Work Beyond Min. Demonstrated**

Memo Formatting	• Memo has a header block which includes:
	  o To: Recipient Name
	  o From: Your Name
	  o Date
	  o Subject:
	• Memo body should not include a salutation.
	• Memo conclusion includes "next steps" and a courteous close.
	• Memo is uniform in font style/size and utilizes bold/italics appropriately
		5	5

EIS Purpose	• Memo clearly states the purpose of the project proposed • Purpose stated is accurate based on the information provided in the original document	8	10
EIS Alternatives	• Memo includes *all* alternatives from the original EIS • Enough content is included that the alternative action can be understood without needing to read the original document	15	15
EIS Affected Environment	• Memo includes two effects on each: physical, biotic, and socioeconomic environments • Items listed are reasonable and accurately classified	12	15
EIS Effects (Not Selected Alternative)	• One alternative from the EIS that was not selected for implementation is included • Two positive and two negative expected effects are clearly included in the memo • Expected effects are reasonable and reflect the content in the complete EIS	15	20
EIS Effects (Selected Alternative)	• The alternative selected for implementation is correctly stated in the memo • At least three reasonable and accurate justifications for its selection are summarized in the memo	15	20
Writing Quality	• Writing in memo achieves all the following: 1. Minimal typographical errors 2. Minimal grammatical errors 3. Utilizes effective paragraph structure- with one major topic per paragraph 4. Body of memo is within word limits (500-1000 words) 5. If bullet lists are included, appropriate sentences or paragraph to introduce the list comes first. 6. Active voice used over passive voice 7. Written in a professional manner (does not use conjunctions and/or slang) 8. Any abbreviations/acronyms defined upon first use	15	15

Assessment of Knowledge Retention

Applications of Environmental Impact Assessment via EIS-type discussions has been a course learning outcome in Introduction to Environmental Engineering at The Citadel for many years and is annually assessed on the Final Exam. While the specific engineering project scenario in question on the final exam changes, the general discussion questions do not, thus providing a point of comparison to assess the impact of the project implementation across years. The projects were first implemented in Spring 2022. Student performance on the EIS final exam question from Spring 2020 to Spring 2023 has been averaged at the class section level to preserve student anonymity. Further, in Spring 2023, two instructors taught sections of the course, one who used the projects and one who did not, enabling another point of comparison.

LCA and historic case study knowledge are not historically explicit course learning objectives. These were introduced more recently through continuous improvement efforts in the course to enhance critical thinking. Thus, there is no historical reference for knowledge retention.

Results - Student Outcomes

Project Grade Distributions

The series of projects was first implemented in Spring 2022 and was repeated in Spring 2023 and 2024. Average project grades are presented in Table 2. The data presented is for the course sections with the most highly aligned student populations (traditional college aged students). An additional course section with non-traditional aged students (largely over 22 years old as first-year college students) has been excluded.

Student grades for Project 1 (writing an EIS summary) were largely unchanged between 2022 and 2023 but saw an increase in 2024. In 2022 and 2023, the class average was below the score for “Meets Minimum” requirements. Anecdotally, this was due to a combination of students vocally disliking writing assignments and their attempt to sub-optimize their deliverable to achieve a passing grade. In 2024, a separate course order change was implemented in the curriculum requiring more lab report writing classes in junior year. Thus, it is hypothesized students had additional prior experience with technical writing resulting in higher scores.

Project 2 (creating an LCA poster) scores were different each year but were all greater than the “Meets Minimums” score. The change in modality from written to visual communication between Project 1 and 2 was welcomed by most students in 2022 and 2023. Average scores in those years may have also been increased for Project 2 due to the presence of voting by faculty and peers. Teams selected in categories such as “most visually appealing” and “most informative” were able to earn bonus points. The bonus ranged from 0 to 3 points depending on how many categories a group won.

Project 3 shows the largest differences in student grades; however, this was likely due to a change in the presentation modality and thus the point assignment in the rubric rather than a true decrease in performance. In 2022, presentations were all held in person and students were awarded individual credit for asking and answering questions during Q&A sessions after each presentation. In 2023, to accommodate a class site visit, the in-class time that could be devoted to presentations was reduced to one lecture day. Thus, all groups pre-recorded their presentations. The class period was used for students to view the recordings on their personal laptops and conduct Q&A via online discussion boards. Expected minimums for the discussion boards were

set at asking questions of three other groups and responding to at least three questions posed to your group. For up to an additional 10 points beyond minimums, the students could (a) ask questions to more than 3 groups, (b) respond to more than 3 questions posed to their group, or (c) follow up on the answers to questions they posed. The aim of lowering the grade to "meet minimums" was to inspire students to have continued discussions via the online boards like what happened in person the previous year, however this was not observed. Yet in 2024, using the same grading rubric as 2023, students took part at much higher rates in the discussion board, resulting in higher class averages.

The relatively large variations between the years appear to be a function of the student cohort's prior training in different communication mediums rather than a reaction to rubric style. After two years of project implementation, the 2024 cohort may have heard more about the grading method from the prior students and approached the projects differently to earn higher scores on two of the three projects.

Table 2: *Average project grades are for two implementation years are shown with the rubric score for "Meets Minimum Requirements." Median shown in parentheses. Project 3 scoring for "Meets Minimums" changed from 2022 to 2023 due to change in student deliverable presentation modality.*

	"Meets Minimums" Score	**Spring 2022**	**Spring 2023**	**Spring 2024**
Project 1	85%	82.6% (83.5%)	81.6% (81.0%)	91.0% (95%)
Project 2	80%	89.2% (92.0%)	83.6% (85.0%)	80.9% (83%)
Project 3	80% - 72%	85.6% (88.5%)	78.9% (79.0%)	89.9% (94%)

Before Spring 2022, when the move to formal projects with single point rubrics was implemented, more traditionally graded versions of Project 1 and Project 2 were implemented. Before 2022, EIS documents were assigned for review as part of a homework assignment completed by individual students. Homework for this class was largely graded on completion rather than accuracy and thus cannot be directly compared to the student grades in Project 1.

In Spring 2021, Project 3 (historic case study presentations) were conducted utilizing a traditional rubric. The rubric assigned a total of 40 points into 6 criteria such as "necessary depth of research demonstrated" and "accuracy of research presented." Each criterion had 6-point divisions ranging from "no marks" to "outstanding." The average grade was 92%. This grade would have been earned by a team earning full points for technical items (having the correct number of slides and competent verbal presentation skills) with the second highest point division for categories related to the presentation's content. Further, that year, the presentations did not have a required peer involvement aspect, which as seen in 2023, greatly affected student Project 3 grades. When the points for peer involvement were removed from the single point rubric scores in 2022 to 2024, the Project grades increase and are comparable to the scores from a traditional rubric in 2021. However, peer interaction was a desired outcome to enhance the critical thinking and communication goal outcomes of the projects.

Student Project Feedback

Feedback on the student projects and the grading method were collected from the end of semester course evaluations. The course evaluations were general for the entire course and thus specific mentions of projects were student initiated during open-ended questions about what was most or least liked about the course and suggestions for future changes.

In 2023, 3 of the 16 students who wrote about their favorite aspects of the course mentioned the projects. Of 16 who wrote about their least favorite aspects of the class 7 mentioned the grading system (single point rubrics) used on the projects. Feedback included comments such as “make it more obtainable to get above an 85 on projects” and the opinion that “the grading scale- ‘going above and beyond’ should be bonus points.” However, numerical Likert scores from students evaluating the course were at or above that of the average of all School of Engineering courses.

In 2022, where the project grades were slightly higher than 2023, the impact on the course evaluation feedback was minimal. One student out of 12 who wrote comments on their least favorite aspect of the class mentioned the project. Again, only one student commented that they would suggest a course change related to the project, but it was not about content or grading, rather the timing. They wished all projects were done at the end of the semester rather than throughout.

In 2024, the class that performed higher on Project 1 than the other years, only one comment was given about the projects. It said that “some of the projects could have just been discussion posts.” This comment may reflect the cohort’s preference for written submission and the growing use of discussion boards on campus.

The change in course-level verbal feedback about the projects between the years, particularly 2022 to 2023, may have been influenced by the change in presentation modality in Project 3 which was completed right before the course evaluation surveys were conducted. The lowered minimum expectations for student engagement in online discussion boards via the virtual presentations was intended to foster more online discussion among students aiming for above “meets minimum” points. However, students sub-optimized their discussion board post quantity and content to just the “meets minimum” level without realizing that the score for “meets minimums” was lower than it had been on earlier projects thus leading to some confusion when project grades were posted.

Knowledge Retention Impacts

As a part of the department’s ABET annual data collection plan, student scores on a Final Exam question on Environmental Impact Assessment, and the EIS contents, is stored. The test question remains largely the same, though the exact engineering project posed changes annually to limit opportunities for cheating. This poses an additional comparison to evaluate the effectiveness of the project series. Data presented in Table 3 includes Spring 2021 to Spring 2024. Spring 2020, a potential second “pre-project” year, was excluded due to the impact of COVID mandated emergency online education methods. Instead, a “historic average” from 2014-2019 is included.

Table 3: *Average score on the EIS question on the Final Exam. "Historic Average" is the average from the 4-years prior to Spring 2020 when the course was disrupted by COVID-19.*

	Historic Average	Spring 2021	Spring 2022	Spring 2023	Spring 2024
EIS Final Exam Question Score	83.8%	92%	84%	87%	93%

The performance in the EIS Final Exam question has varied overtime. Immediately before and after COVID, scores on the EIS Final Exam varied by nearly 10%. Immediately following the new project implementation, the scores returned to their pre-COVID level, however scores have been increasing ever since. While an indicator of student knowledge retention on the project topic before and after project implementation, it is not definitively conclusive due to coincident changes in course instructors, course modality, and other curricular changes in the department. No similar type of data exists for LCA or historic case studies to assess the possible impacts of Projects 2 and 3 on student knowledge retention

Conclusion

The adoption of single-point rubric for the new series of projects in the Introduction to Environmental Engineering course did not occur without challenges. Students had increased frustration upon their first interaction with the rubrics, but performance on the projects and indicators of knowledge retention were not negatively impacted. Overall, the projects achieved the intended goal of allowing students exposure to wider topics in Environmental Engineering and practice on the three ABET models of communication (written, visual, verbal). Authors recommend other faculty consider use of single-point rubrics for projects in their program as it allows for less restricted creativity by students.

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