STANDARDS-BASED SINGLE-POINT RUBRICS IN ADVANCED PLACEMENT ENVIRONMENTAL SCIENCE

by

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DEDICATION

This paper is dedicated to Eileen, the greatest educator I know. I have learned so much from you about teaching and so much with you about living. Your encouragement throughout this process kept me going when I was uncertain or anxious, and your love and support keep me going all the time. Thanks especially for your willingness to listen and for your patience when I needed it. I am so grateful that you are ‘my person’.

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ABSTRACT

Rubrics that link specific standards to assessment items offer educators a way to communicate with students about understandings and abilities and how to improve them. Single-point rubrics list a single, target performance expectation and leave open spaces for targeted feedback to encourage growth and creativity. The purpose of this study was to determine the effects of standards-based single-point rubric use on learning attitudes and student perception of meaning from grades among students in Advanced Placement Environmental Science classes. Before the intervention, surveys were administered to two sections of Advanced Placement Environmental Science classes to gather information about students' initial learning attitudes and perceptions of grades. For two units of study, standards-based single-point rubrics were implemented for feedback and assessment of student learning. During these units, rubric scores and student re-assessment attempts were recorded as evidence of student motivation. Traditional, percentage grades were calculated from standards-based single-point rubric scores for the units of study during intervention. After the two units of study, student learning attitudes and grades surveys were administered again, along with student interviews to determine if students' views about learning and grades had changed. Student learning attitudes and perceptions of grades generally agreed with 'expert' responses leading into the intervention. Quantitative and qualitative data suggested overall notable gains in students' problem-solving strategies learning attitudes and in students' perceptions of grade validity.

INTRODUCTION AND BACKGROUND

Grades are a foundational means of communication in education. Grades assigned to different types of assessments serve multiple purposes and may be interpreted in multiple ways by educational stakeholders. Students, parents, teachers, and academic institutions approach any conversation about grades from unique vantage points, which suggests consideration of whether what is intended to be communicated in grades is the meaning that ultimately is inferred about those grades. Using rubrics to link specific standards to assessment items provides the opportunity for greater clarity in communication to students about their understandings and abilities and how to improve them. This action research focuses on standards-based grading and use of single-point rubrics in Advanced Placement Environmental Science courses at Concordia International School Shanghai.

Context of the Study

Concordia International School Shanghai is in the residential Jinqiao District Shanghai, China, in the area known as Pudong (literally, “east of the [Huangpu] river” that splits Shanghai). Concordia is a Christian international school established in 1998 by the Lutheran Church Missouri Synod. Current enrollment for pre-kindergarten through grade 12 is 1150 students, with a total high school enrollment of 298 students (Hur, 2023).

Concordia high school is comprised of students from 19 nationalities. United States passports are held by 39% (N =298) of high school students, with 14% of high school students holding passports from South Korea and 13% of high school students holding Hong Kong passports (Hur, 2023). According to its website, “Concordia may only accept students with a valid non-PRC passport or an ‘Official Letter of Approval to Attend Concordia’ from the

Shanghai Education Commission" (Admissions Requirements, 2023, p. 2). Though all students but these few exceptions hold foreign passports, 37% of students have at least one parent with Mainland China passport, and 69% of students have at least one parent whose first language is Mandarin Chinese. Only 24% of students have at least one parent whose first language is English – the instructional language of the school (Hur, 2023).

Students at Concordia are academically driven, either intrinsically, through pressure from parents, or from a cultural desire to matriculate at top universities. Most Concordia graduates go on to study at schools in the United States, though some attend Canadian, European, or Korean universities. In addition to focusing on grades, many of our students also play instruments, are fluent in at least two languages, create socially conscious start-ups, and just like students the world over, enjoy social media and playing video games.

Concordia recently completed its Self-Study review with Western Association of Schools and Colleges. In that self-study, one area identified as a critical growth need was reorganization and articulation of assessment and reporting practices. Another critical growth need identified in the self-study was curriculum refinement via curriculum review cycle. Needs identified in the self-study resulted in implementation of Understanding by Design curriculum review and generated increasing interest in standards-based grading practices for possible implementation in the future.

I have been teaching at Concordia for the most recent eight years of my 23-year teaching career. My teaching practice has been shaped by professional learning and collaboration with colleagues. Two examples of this development are: 1) the incorporation of constructivist pedagogical practices resulting from graduate coursework in chemistry education, and 2) increasing curiosity about rubric and criteria development resulting from collaborative efforts with colleagues while working at Concordia. Last spring, I conducted student and faculty interviews about learning and grades, framing questions around the concepts of learning product, learning process, and learning progress proposed by Guskey (2006). Interview responses sparked my interest to learn more about the relationship between grading practices, learning attitudes, and student perception of meaning from grades. Specifically, interviewees agreed that measures of product, process, and progress are all valuable and that teachers were missing opportunities to communicate more fully with students about learning goals and grading criteria.

Focus Question

My focus question was, How will standards-based grading using single-point rubrics affect student learning attitudes and perceptions of the meaning of grades in science?

My sub-questions included the following:

1. How will single-point rubrics and standards-based grading affect student learning attitudes?
2. How will single-point rubrics and standards-based grading affect student perceptions of meaning of grades?

CONCEPTUAL FRAMEWORK

Grades and Grading

Challenges

For many years, student grades have been reported using percentage values. Despite their widespread use, percentage grades are difficult to defend from a procedural, practical, or ethical perspective (Guskey, 2013) . One issue with percentage grading arises from its magnitude; the size of the scale introduces greater variance in scores based upon it. As Guskey (2023) further asserted, “adding more gradations to the measurement scale offers only the illusion of precision” and “with more levels, more students are likely to be misclassified in terms of their performance on a particular assessment” (p. 70). In many schools, passing grades are subdivided among percent scores ranging from 60 to 100 percent. Grades below 60% are thus considered failing scores. These practices demonstrate a second problem with scale of percentage grades. A grading scale in which two-thirds of the designated levels describe failure also implies that degrees of failure can be more finely distinguished than degrees of success (Guskey, 2013).

Problems related to scale of percentage grades are further confounded by differences in beliefs and long-standing habits and experience, not only about grading but also about learning, effort, discipline, and classroom management (Brookhart, 2011). Wormeli (2006) identified two myths about learning that exacerbate issues in grading practice: 1) a belief that all students learn at the same pace, and 2) a belief that it benefits students and the school community for all students to demonstrate mastery on the same schedule without additional opportunities to show excellence in that task. These beliefs may contribute to the “plenty of teachers who firmly believe that grades should reflect what students ‘earn’ in the classroom by doing their work, following directions, and behaving” referenced by Brookhart (2011, p.13). Traditional grading practices often lead to "grade fog," in which content mastery is distorted by other criteria such as practice, neatness, organization, attendance, and behavior (Deddeh et al., 2010). For example, a grade of an A may mean that (a) the student knew what was intended before instruction began, (b) did not learn as well as expected but tried very hard, or (c) simply made significant improvement (Guskey, 2006). Current grading practices suffer from different beliefs and habits among educators, myths about learning that are simply unfounded, and lack of clarity in messaging and intent.

Purpose

Considering the challenges related to traditional grade reporting, several studies have investigated alternative grade reporting methods to communicate student learning (Deddeh et al., 2010; Erbes et al., 2021; Munoz & Guskey, 2015). Guskey (2006) suggested that educators must clarify our purpose in grading, for only then may we decide what evidence best serves that purpose and how best to communicate a summary of that evidence to parents and others. Meaning and purpose are shaped by beliefs and values, so educators working to define purpose of grades and grading must begin with careful consideration of those beliefs and values. Deddeh et al. (2010) identified three constructive beliefs about grades and learning:

> 1. Grades [should] clearly communicate to parents and students exactly what the student has learned.
>
> 2. Homework is essential for learning but should not be included in the grade.
>
> 3. It’s important to do whatever it takes to give students the opportunity to be successful while learning the material (p. 55).

Multiple studies refer to the importance of “keeping hope alive” among our students when making decisions about grades and learning (Cox, 2011; Roseboro, 2019; Wormeli, 2006).

Roseboro (2019) suggested that students who have time to learn and understand the standards and to give and receive feedback on performances are seldom so discouraged as to stop trying.

Feedback also informs teachers about students' needs and what is working in their instructional practices. Black and Wiliam (1998) articulated the idea of assessment *for* learning, stating

> teachers need to know about their pupils' progress and difficulties with learning so that they can adapt their own work to meet pupils' needs - needs that are often unpredictable and that vary from one pupil to another (p. 82).

Reeves (2011) reminded educators of the importance of grading as feedback for promoting student learning outcomes gains. Students learn course topics and personal responsibility best when frequent, specific, and timely feedback occurs during learning, not after learning (Wormeli, 2006). If we agree that grading is a form of feedback, then we should also agree on principles of effective feedback, such as specificity and timeliness, so students can use that feedback to improve academic performance (Reeves, 2011). Specific and timely feedback allows students and teachers to intervene within the learning process, adjusting instruction in real time.

Criteria

If educators agree that the purpose of grading is to provide feedback, the focus shifts next to the evidence from students for which feedback will be provided. Guskey (2006) suggested a solution to incorporating different learning criteria into student grades by reporting separate grades for each set of criteria. Guskey proposed three distinct sets of criteria to report as evidence of student learning: *Product*, *Process,* and *Progress*. *Product* criteria focus specifically students' academic achievement and performance for an "achievement" grade; *Process* criteria relate to homework, class participation, attitude, effort, responsibility, behavior, and other nonacademic factors; *Progress* criteria refer to indicators of students' learning gains (Guskey, 2006). In a study conducted by Cox (2011), a focus group (N=7) responded “absolute achievement” every time when responding to these questions in multiple ways: “1) absolute achievement or growth? 2) absolute achievement or effort? or 3) absolute achievement or achievement relative to ability?” (p. 76). This suggests that student grades should be based primarily on product criteria, with supplementary feedback provided for process and progress criteria. This "achievement" grade would, therefore, reflect the student's level of performance or accomplishment related directly to explicit learning goals established for the course (Guskey, 2006).

Standards Based Grading

Definition

Standards Based Grading (SBG) principles focus attention on student learning, assessment, and feedback to motivate future learning. When discussing SBG, Zimmerman (2017) shared four things about grading:

1. Mistakes are an important part of the learning process
2. The focus should be on learning (not earning)
3. Grades should reflect proficiency with skills and concepts
4. Reassessment opportunities should be given to students until reaching mastery.

Grading scales with three to five categories that clearly describe the discrete levels of student mastery or proficiency are suggested to offer students and parents more accurate information to guide improvements (Link & Guskey, 2022). Teachers should also plan for multiple assessments of each learning standard to accurately gauge student mastery (Guskey & Brookhart, 2019). Meaningful feedback and feed forward for multiple assessments of each learning standard can improve communication with students about learning and, ultimately, student learning resulting from improved communication.

SBG allows science teachers to communicate with students and their parents about the students' current understanding and skills, rather than using grades as a motivator (Brookhart, 2011; Mateas, 2016). As such, it is important to understand not only how teachers conceptualize SBG but also how students and parents interpret these reports (Guskey & Brookhart, 2019). SBG addresses several concerns associated with traditional (percentage) grading systems. Instead of moving on to new content and filling student records with "fluff" that may artificially inflate grades, SBG focuses student attention on learning – with the expectation that students work to develop knowledge and skills (Mateas, 2016). With mastery of standards as the primary learning goal, the focus shifts to what the student is learning rather than how much the student is doing (Miller, 2013). SBG systems have the potential to improve consistency of grades among teachers and across grades by explicitly separating academic achievement from other aspects of performance (Brookhart, 2011). Shifting conversations among educators, students, and parents toward learning and away from grades is another principle of standards-based grading.

Rationale

One specific component of SBG implementation reinforces a key point from NGSS Nature of Science statements, that scientific knowledge can be revised considering new evidence (NGSS Lead States 2013) (Appendix H). Within the Concordia high school science department, documentation of NGSS implementation has been a department goal in recent years. Implementation of SBG in science classes gives students experiences more like the "real world" where revision contributes to course rigor, and students gain enhanced understanding of their current levels of learning (Mateas, 2016).

Teacher buy-in is an important aspect of adopting changes to educational practice. Some of the reasons for adopting SBG include: (1) to focus instruction and assessment on a set of key standards, (2) to encourage teachers to operationally define what it looks like for a student to attain course and grade-level expectations, and (3) to improve communication with students and parents (Guskey & Brookhart, 2019). Current work in curriculum at Concordia is focused increasingly on standards and standards-based grading. Initiatives include curriculum review cycle, identification of power standards, and linking assessment to standards. Continuous training on curriculum, grading, and communication among administrators, teachers, parents, and students that focuses on assessment for each SBG competency, gradebook format, and rubrics is suggested for effective implementation of SBG (Frankin, Buckmiller, & Kruse, 2016; Guskey & Brookhart, 2019; Townsley, 2019). Continuous training accounts for staff turnover, for changes in the SBG system as people learn from and improve their processes, and for the fact that new families are constantly moving into school districts (Guskey & Brookhart, 2019). Each of these points is of particular concern in international schools like Concordia.

Implementation

In SBG, each standard typically includes 3 to 5 levels that describe students' progress toward mastery that more accurately communicates students' achievement and learning progress to parents, to students, and to others (Link & Guskey, 2022). With a focus on learning rather than modality of assessment, science teachers have the freedom to allow students' voice and choice in learning the NGSS (Mateas, 2016). Miller (2013) suggested that students "need to receive the clear message that evaluation is a partnership" (p. 113) and that teachers "alternate periods of collaborative classroom development of a work in progress with periods of dialogue between teacher and student" (p. 115). Spencer (2012) reported that translating jargon-filled standards into language that parents can better understand helps parents know what to do with the information provided by SBG. Regarding SBG, Guskey and Brookhart (2019) claimed that specific changes to grading practices improved consistency in educational settings (Table 1).

Table 1. Changes to grading practices and expected improvements in consistency within educational settings.

Changes to grading practice	Improvements in consistency
removing nonacademic factors from subject-specific grades	between the capabilities addressed on report cards and those expected by the standards
grading performance at of the end of the marking period	among teachers in their grading methods
sharing information about grading practices and expectations with parents and students	between grades and students' assessment results

Challenges

Efforts to implement educational changes are often met with resistance, so understanding how teachers conceptualize SBG and also how students and parents interpret these reports is a critical concern (Guskey & Brookhart, 2019). Miller (2013) reports that among students, "every group defined success primarily as getting the grades necessary for admission to college" and that "many experience high school as an ordeal that must be endured to get into college, get a good-paying job, and, finally, sometime in the hazy future, get the security and happiness that will make it all worthwhile" (p. 111). Student resistance to SBG has been identified around several themes: (a) the SBG implementation process, (b) grading issues, (c) preparation for university and future employment, (d) social issues, and (e) issues related to current teaching, learning, and motivation (Peters et al., 2017). Parents are most often concerned with college admissions effects and the potential for student motivation to decrease, as students may consider proficiency "good enough" – rather than striving for mastery (Percell & Meyer, 2021; Peters et al., 2017; Townsley, 2019). Teacher resistance to SBG is often a product of fatigue from previous educational reform initiatives, and teachers are often vocal about challenges expected in managing SBG gradebooks (Percell & Meyer, 2021). Though students, teachers, and parents approach adoption of SBG from differing perspectives, all stakeholders are likely to enter the process with some reservations.

Several recommendations are offered as strategies to mitigate the challenges of SBG implementation. Building school culture around SBG, offering frequent professional development, and providing teachers with opportunities to join decision-makers in selection of SBG gradebooks aids in teacher and student buy-in. Acknowledging parent concerns, providing answers to parent questions as best as possible, and providing students and parents with published reassurances of college admissions policies promotes parent and student acceptance of SBG (Percell & Meyer, 2021). Percell and Meyer (2021) also report that

> The New England Board of Higher Education (NEBHE), made up of 270 higher education institutions including Harvard, Brown, and MIT, crafted and signed letters of support for accepting students with competency-based report cards (p. 189).

Statements from competitive universities that support competency-based grade reporting could help secondary school communities minimize anxiety and garner support for SBG adoption, clearing the path for more efficient implementation of SBG.

Single Point Rubrics

Rubrics

The foundational paper that defines rubrics proposes that rubrics must have evaluative criteria, quality definitions for those criteria at specific levels, and a scoring strategy (Popham, 1997). Since that publication, rubrics have been further classified into three general categories: (a) holistic rubrics, (b) analytic Rubrics, and (c) single-point rubrics. Holistic Rubrics are considered the most general rubric design, listing three to five levels of performance with a broad (holistic) description of characteristics that define those levels (Balch et al., 2016). Analytic rubrics further break down the characteristics of an assignment into criteria and describe multiple performance levels for each criterion (Balch et al., 2016; Estell et al., 2016). While similar to an analytic rubric, the key distinguishing characteristic of the Single-Point Rubrics (SPR) is that, for each criterion, only the expected level of performance is provided with a qualitative definition or precise quantitative measure (Estell et al., 2016).

Design

Design elements are those choices about the dimensions included in rubric design that distinguish rubrics by type and purpose (Dawson, 2017). Rubric design elements summarized in Table 2 are suggested for consideration when designing rubrics for classroom use. Balch et al. (2016) suggested the use of a metarubric (rubric for a rubric) checklist (Table 3) proposed by Stevens and Levi (2004) to insure successful rubric design. Components of the metarubric checklist are organized into dimensions (evaluative criteria), descriptions (quality definitions), scale (quality levels), and overall rubric and fairness and sensibility (addressing all other design elements from above).

Table 2. Rubric design elements, from Dawson (2017).

Rubric Design Elements	
secrecy	who the rubric is shared with, and when it is shared
exemplars	work samples provided to illustrate quality
scoring strategy	procedures used to arrive at marks and grades
evaluative criteria	overall attributes required of the student
quality levels	the number and type of levels of quality
quality definitions	explanations of attributes of different levels of quality
judgement complexity	the evaluative expertise required of users of the rubric
users and uses	who makes use of the rubric, and to what end
creators	the designers of the rubric
quality processes	approaches to ensure the reliability and validity of the rubric
accompanying feedback information	comments, annotation or other notes on student performance
presentation	how the information in the rubric is displayed
explanation	instructions or other additional information provided to users

Table 3. Metarubric checklist, originally proposed by Stevens and Levi (2004), accessed via Balch et al., (2016).

Rubric part	Evaluation criteria	Yes	No
The dimensions	Does each dimension cover important parts of the final student performance?		
	Does the dimension capture some key themes in your teaching?		
	Are the dimensions clear?		
	Are the dimensions distinctly different from one another?		
	Do the dimensions represent skills that the student knows something about already (e.g., organization, analysis)?		
The descriptions	Do the descriptions match the dimensions?		
	Are the descriptions clear and different from each other?		
	If you used points, is there a clear basis for assigning points for each dimension?		
	If using a three-to-five level rubric, are the descriptions appropriately and equally weighted across the three-to-five levels?		
The scale	Do the descriptors under each level truly represent that level of performance?		
	Are the scale labels encouraging and still quite informative without being negative and discouraging?		
	Does the rubric have a reasonable number of levels for the age of the student and the complexity of the assignment?		
The overall rubric	Does the rubric clearly connect to the outcomes that it is designed to measure?		
	Can the rubric be understood by external audiences?		
	Does it reflect teachable skills?		
	Does the rubric reward or penalize students based on skills unrelated to the outcome being measured that you have not taught?		
	Have all students had an equal opportunity to learn the content and skills necessary to be successful on the assignment?		
	Is the rubric appropriate for the conditions under which the assignment was completed?		
	Does the rubric include the assignment description or title?		
	Does the rubric address the student's performance as a developmental task?		
	Does the rubric inform the student about the evaluation procedures when their work is scored?		
	Does the rubric emphasize the appraisal of individual or group performance and indicate ways to improve?		
Fairness and sensibility	Does it look like the rubric will be fair to all students and free of bias?		
	Does it look like it will be useful to students as performance feedback?		
	Is the rubric practical given the kind of assignment?		
	Does the rubric make sense to the reader?		

(Stevens & Levi, 2004).

Implementation

Deddeh and Fulkerson (2010) link rubric development to Understanding by Design, proposing that educators determine a logical flow of content, planning with the end in mind to ensure that achievement of all necessary standards. Within the context of this study, Advanced Placement Environmental Science (APES) Course and Exam Description (CED) Big Ideas, Enduring Understandings, Learning Objectives, and Essential Knowledge descriptors served as the "bank" of information from which SPRs were developed. APES CED statements were based loosely on Bloom's Taxonomy of learning objectives.

Structure of the CED includes units that include one or two Enduring Understandings that are based on four Big Ideas. Structure is similar to NGSS, with Big Ideas = Crosscutting Concepts, Enduring Understandings = Disciplinary Core Ideas, Learning Objectives = Performance Expectations, and Essential Knowledge statements analogous to NGSS Evidence Statements. Learning Objectives and their corresponding Essential Knowledge statements were used as standards within each unit of SBG study.

Benefits

Including and reviewing grading rubrics reduces anxiety for students and results in fewer grade "challenges," as students, families, and administration know how grades are determined (Roseboro, 2019). Elimination of extraneous measures of student performance, more opportunities for practice, opportunities for re-tests, and development of gradebooks to record data from all attempts to provide evidence for each standard are suggested for effective implementation of SBG / SPR (Deddeh & Fulkerson, 2010). Guskey (2013) encourages the use of integer grading to improve accuracy and honesty of student evaluation, thus improving reliability. Student reflections may also be used as some portion of the student grades, or as a "key" to unlock re-test opportunities (Roseboro, 2019).

The simple design of single point rubrics allows teachers to focus more energy toward meaningful feedback for students. Single point rubrics are described as tools for students to claim: a) I know where I'm going (quality definitions), b) I know where I am now (evidence/work), c) I know how to get there (quality feedback), and d) I know how to go beyond (creativity and ingenuity) (Fluckiger, 2010). Estell et al. (2016) associated these advantages with adoption of single-point rubrics:

1) less time to develop and construct rubrics

2) encouragement of creativity by purposely not specifying above-standard performance

3) clarity of performance expectations by listing single performance levels for each dimension

4) focus on proficiency by eliminating other descriptors

5) open spaces for writing targeted, specific feedback (p. 4).

Guskey (2013) asserts that "combining the grade with supplemental narrative descriptions or standards checklists describing the learning criteria used to determine the grade further enhances its communicative value" (p. 72), a practice that may be facilitated by SPR implementation. When also used in formative assessments, SPR may be equated to engineering design reviews, where descriptions of various modes of student failure are replaced with constructive messages describing areas for improvement in the assignments, which can then lead to increased student self-satisfaction through successful project completion (Estell et al., 2016).

METHODOLOGY

Demographics

The purpose of this study was to determine the effects of Standards-Based Grading (SBG) on learning attitudes and student perception of meaning from grades in Advanced Placement Environmental Science (APES) classes at Concordia International School Shanghai. High school student body at Concordia is comprised of 298 students of varied nationalities (Hur, 2023). APES classes at Concordia have been structured to follow the College Board Course and Exam Description for AP Environmental Science, which contains nine units of study that focus on four Big Ideas: energy transfer, interactions between Earth systems, interactions between different species and the environment, and sustainability. Recent work in curriculum development has included investigations of SBG for potential future implementation, so the opportunity to produce relevant evidence from action research focused on SBG at Concordia was timely and appropriate.

This action research was conducted in two sections of APES classes (N=18). Participants in the study had completed and were concurrently enrolled in a range of science coursework. Of the 18 participants from the classes, five students were in grade 11 and 13 students were in grade 12. Nine students identified as female, and nine students identified as male. All students in the classes had completed introductory biology and chemistry courses, including seven accelerated chemistry course completions. Two students completed AP Biology, two students completed AP Chemistry, five students completed AP Physics I, and one student completed Forensic Science. Concurrent enrollments include one student enrolled in AP Biology, two students enrolled in introductory physics, two students enrolled in AP Physics I, two students enrolled in AP Physics C, and one student enrolled in Applied Learning – Engineering course. Six of the 14 grade 12 students will be completing APES as their third and final science course to meet graduation requirements.

Treatment

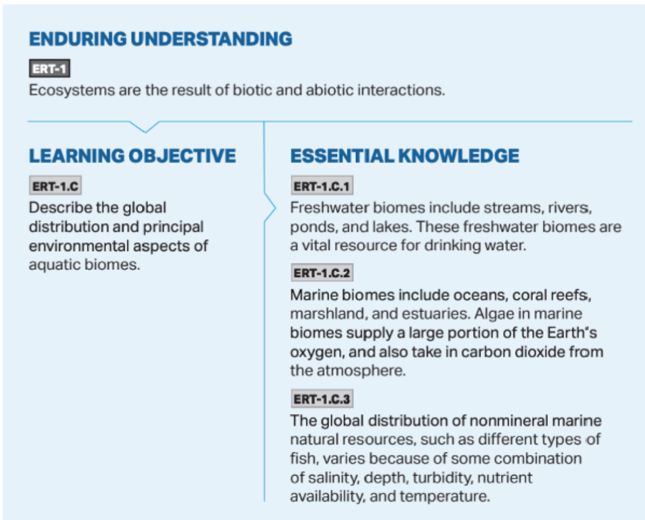
My focus question was, How will standards-based grading using single-point rubrics affect student learning attitudes and perceptions of the meaning of grades in science? My sub-questions were: (1) How will single-point rubrics and standards-based grading affect student learning attitudes? and, (2) How will single-point rubrics and standards-based grading affect student perceptions of meaning of grades? To examine these questions, I documented student learning attitudes and perceptions of meaning from grades using Pre- and Post-Intervention Likert Surveys, Post-Intervention Student Interviews, and records of student Re-Assessment Attempts during the intervention. Methodology for this action research project received exemption from Montana State University Institutional Review Board and compliance for work with human subjects was maintained throughout the study (Appendix A).

This study was conducted during second semester of APES classes. In the first semester of the course, students were introduced to foundational concepts of environmental science that included ecosystems, biodiversity, populations, Earth systems and resources, and land and water use. Two units that build on the prior learning in APES classes were scheduled to be included in this study: unit six about energy resources and consumption, and unit seven about atmospheric pollution. Interruptions to school schedules during first semester caused some rescheduling of events to semester two that reduced available class time. Considering that limitation, an ambitious pace was planned to complete the two units during fifteen 75-minute instructional periods spanning two months of the school calendar.

Leading up to the study, students became accustomed to predictable patterns in use of class time, pacing of assigned work, and traditional grading practices common to other courses at Concordia. Each unit of study normally included class time devoted to group work with relevant case studies, guided inquiry activities, and lab investigations or simulations. These learning experiences were supplemented with teacher-provided notes (some with videos) and formative assessments using College Board Topic Questions, Progress Checks, and Daily Videos from AP Classroom. Summative assessments followed introduction and development of learning objectives as described, with a single grade assigned to the full range of learning standards within that unit of study. Students had access to specific, timely feedback on individual learning standards only from their work with Topic Questions, Progress Checks, and intermittent formative feedback during learning activities in class. Establishing a more comprehensive system of feedback, assessment, and re-assessment opportunities for specific learning standards was the goal for changing the flow of instruction in APES classes during the study.

To initiate the study, student participants completed two pre-intervention Likert surveys, the Learning Attitudes Survey (Appendix B) and the Grades Survey (Appendix C). Groups of survey items related to specific learning attitudes (Appendix D) or specific grade perceptions (Appendix E) were identified as survey categories. Survey responses provided evidence to understand students' attitudes relevant to learning environmental science, students' beliefs and perceptions about grades, and connections to their experiences. Survey responses were compared to responses collected in post-treatment administration of the same surveys.

Following student completion of pre-intervention surveys, implementation of standards-based single-point rubrics to assess all student work began. The APES Course and Exam Description (CED) structure served as the source document for development of standards-based single-point rubrics to be used in the intervention. Each unit of study from the APES CED includes one or two Enduring Understanding statements followed by a collection of associated Learning Objectives (LOs). Each LO includes Essential Knowledge statements to clarify expectations for evidence that demonstrates proficiency for that standard (Figure 1).



ENDURING UNDERSTANDING

ERT-1

Ecosystems are the result of biotic and abiotic interactions.

LEARNING OBJECTIVE

ERT-1.C

Describe the global distribution and principal environmental aspects of aquatic biomes.

ESSENTIAL KNOWLEDGE

ERT-1.C.1

Freshwater biomes include streams, rivers, ponds, and lakes. These freshwater biomes are a vital resource for drinking water.

ERT-1.C.2

Marine biomes include oceans, coral reefs, marshland, and estuaries. Algae in marine biomes supply a large portion of the Earth's oxygen, and also take in carbon dioxide from the atmosphere.

ERT-1.C.3

The global distribution of nonmineral marine natural resources, such as different types of fish, varies because of some combination of salinity, depth, turbidity, nutrient availability, and temperature.

Figure 1. Sample Learning Objective from College Board AP Environmental Science Course and Exam Description (College Board, 2020).

Students were introduced to this structure early in semester one and regularly constructed unit review sheets based on this structure to prepare for unit assessments before the intervention. Additional continuity was provided to the transition to SBG by conserving other instructional practices that preceded the study. Students retained access to instructional notes and videos produced by the instructor and College Board (AP Classroom site), Topic Questions and Progress Checks (AP Classroom site), and other practice exercises consistently used in the course. The notable change to course structure was application of standards-based single-point rubrics to (1) provide feedback to students (formative assessment) about their abilities and understandings and (2) determine grades (summative assessment) based on specific standards associated with assigned work.

Each Single-Point Rubric (SPR) developed to assess student work corresponded to a specific standard (LO) from the College Board APES Course and Exam Description (CED). Common SPR structure was modified to include proficiency levels (Beginning, Developing, Succeeding, Integrating) and scores (0, 1, 2, 3) associated with the proficiency levels to track student progress and determine grades (Table 4). Spaces were also provided for specific feedback related to Areas for Growth, Notable Extensions, and notes on student evidence of learning Process and learning Progress. The hope was that improving quality of feedback would impact student motivation and performance by connecting learning process and learning progress to the learning products based on specific standards.

Table 4. Sample Standards-Based Single-Point Rubric developed from APES CED.

<table>
<tr><td colspan="4">Aquatic Biomes</td></tr>
<tr><td colspan="4">ENDURING UNDERSTANDING (ERT-1) Ecosystems are the result of biotic and abiotic interactions.</td></tr>
<tr><td rowspan="3">STUDENT ABILITY (ERT-1.C):
I CAN describe the global distribution and principal environmental aspects of aquatic biomes.</td><td colspan="3">CURRENT STATUS</td></tr>
<tr><td>DEVELOPING</td><td>SUCCEEDING</td><td>INTEGRATING</td></tr>
<tr><td></td><td></td><td></td></tr>
</table>

<table>
<tr><td>AREAS for GROWTH</td><td>INCLUDING THIS ESSENTIAL KNOWLEDGE:</td><td>NOTABLE EXTENSIONS</td></tr>
<tr><td rowspan="3"></td><td>ERT-1.C.1: Freshwater biomes include streams, rivers, ponds, and lakes. These freshwater biomes are a vital resource for drinking water.</td><td rowspan="3"></td></tr>
<tr><td>ERT-1.C.2: Marine biomes include oceans, coral reefs, marshland, and estuaries. Algae in marine biomes supply a large portion of the Earth’s oxygen, and also take in carbon dioxide from the atmosphere.</td></tr>
<tr><td>ERT-1.C.3: The global distribution of nonmineral marine natural resources, such as different types of fish, varies because of some combination of salinity, depth, turbidity, nutrient availability, and temperature.</td></tr>
</table>

<table>
<tr><td><u>PROCESS</u></td><td><u>PROGRESS</u></td></tr>
</table>

Proficiency level descriptors, corresponding rubric scores, and verbal interpretations of proficiency level descriptors were generated for use across all standards-based single-point rubrics (Table 5). In this study, a rubric score of zero indicated that a student had provided insufficient evidence for a standard. Rubric scores of one were associated with naïve or developing conceptual understanding. Rubric scores of two indicated that student work demonstrated proficiency for the standard, with scores of three reserved for extension of student proficiency that may include contextual integration of additional standards or Enduring Understandings from the CED or relationship to authentic experience(s) within student evidence of learning. Proficiency scores of three were expected to be generated most often from free response questions on summative assessments or via optional, alternate assessments that may include production of infographics, literary reviews, instructional videos, or class presentations.

Table 5. Proficiency Ratings for Single-Point Rubrics.

Mastery Level Description	**Rubric Score**	**Rubric Score Interpretation of Evidence**
Integrating	3	Evidence demonstrates complete knowledge / ability AND extension to include crosscutting concepts and/or authentic experiences
Succeeding	2*	Evidence demonstrates complete knowledge / ability
Developing	1	Evidence demonstrates partial knowledge / ability
Beginning	0	Insufficient evidence

Student grades were calculated from SBG rubric scores (Table 6). A rubric average score of two, indicating proficiency, was correlated to a traditional (percentage) grade of 89% (or B+). The rationale for this decision was that it required students to demonstrate integration of learning standards to earn an A grade for the grading term. A hallmark feature of SBG is the opportunity for re-assessment, so students were encouraged throughout the intervention to use rubric feedback to improve understandings and abilities and, subsequently, seek opportunities to provide evidence of improved proficiency by re-assessment. Qualification for re-assessment required students to submit a re-assessment ticket form that lists the learning standard to be re-assessed, current rubric score, description of errors and reflection on most recent assessment, and evidence of review work completed for re-assessment of that standard (Appendix F). All re-assessment requests and results were recorded as part of the grading record. Decisions about grading practices were guided by the principles of keeping hope alive and offering students opportunities to grow and to take ownership of learning.

Table 6. Standards-Based Grade Conversion for Traditional Grade Reports.

Course Grade	Single Point Rubric Average Score ($\bar{x}$)	Calculation Formula	Sample Calculation		
			Single Point Rubric Average Score	Calculation	Calculated Course Grade
A– ⟷ A+	**2.025 ⟷ 2.55**	$(\bar{x} + 2.45)(20)$	$\bar{x}$ **= 2.175**	$(2.175 + 2.45)(20)$	**93% (A)**
B– ⟷ B+	**1.525 ⟷ 2.024**		$\bar{x}$ **= 2.000**	$(2.000 + 2.45)(20)$	**89% (B+)**
C– ⟷ C+	**1.025 ⟷ 1.524**		$\bar{x}$ **= 1.524**	$(1.524 + 2.45)(20)$	**79% (C+)**
D– ⟷ D+	**0.525 ⟷ 1.024**		$\bar{x}$ **= 1.024**	$(1.024 + 2.45)(20)$	**69% (D+)**
F	**0.000 ⟷ 0.524**		$\bar{x}$ **= 0.524**	$(0.524 + 2.45)(20)$	**59% (F)**

Data Collection and Analysis Strategies

Data Collection

Each student's rubric scores and re-assessment records for each standard were recorded to assess frequency and success of re-assessment attempts. Students' pre-treatment and post-treatment grades will be analyzed for any statistical difference that may be correlated to the treatment. Data from pre-treatment and post-treatment surveys and pre-treatment and post-treatment interviews will be analyzed for any significant changes in student learning attitudes that may be correlated to treatment. Table 6 summarizes data collection methods that were utilized to gather evidence for analysis of each focus sub-question. Triangulation of data sets that include both quantitative and qualitative data improves credibility of claims made about the results of the investigation.

Table 7. Data Triangulation Matrix.

Research Questions	***Data Collection Method #1***	***Data Collection Method #2***	***Data Collection Method #3***
How will standards-based grading using single-point rubrics affect student learning attitudes in science?	Pre-/Post-Attitudes SURVEYS *Quantitative*	Post-treatment INTERVIEWS *Qualitative*	SBG Standard Re-assessment Tracking *Quantitative*
How will single point rubrics and standards-based grading affect student perceptions of meaning from grades?	Pre-/Post-Grades SURVEYS *Quantitative*	Post-treatment INTERVIEWS *Qualitative*	Pre-/Post-Attitudes SURVEYS *Quantitative*

<u>Pre- and Post-Intervention Learning Attitudes Survey.</u> Student Learning Attitudes Surveys were adapted from Colorado Learning Attitudes about Science Survey (CLASS), developed by Physics Education Research Group at Colorado (CLASS, n.d.). CLASS surveys have been generated for physics, chemistry, and biology students. CLASS surveys are Likert-structured surveys with responses varying from Strongly Disagree - Disagree - Neutral - Agree - Strongly Agree. Semsar et al. (2011) presented the CLASS-Bio survey as a rigorously validated means of measuring the effects of reformed pedagogy on students’ growth in scientific thinking expertise. The Learning Attitudes Survey was adapted for this study by exchanging the phrase "environmental science" for "biology" or "biological". Item 25 of the BioCLASS Survey was altered by substituting "benefit" for "health". Learning Attitudes surveys were administered before and after treatment.

Learning Attitudes Surveys contained groups of statements pertaining to categories of learning attitudes: Real World Connection; Problem-Solving Difficulty; Enjoyment; Problem-Solving Effort; Conceptual Connections / Memorization; Problem-Solving Strategies; and Reasoning. Learning Attitudes Survey structure enabled data collection for individual students and groups of students for individual items, item categories, and overall student responses. Administration of Learning Attitudes Surveys before and after treatment offered the ability to compare student learning attitude categories for potential changes.

Pre- and Post-Intervention Grades Survey. Grades Surveys were adopted from research completed by Daguplo (2017). Grades Surveys included Likert-scaled response options, like response options offered in Learning Attitudes Surveys. While Daguplo focused on potential differences between educators' and students' perceptions about grades and grading, this data collection instrument was included to collect evidence regarding students' perceptions about grades and grading within the context of this study.

Grades Surveys also contained groups of statements pertaining to categories of grade perceptions: Beliefs; Purpose; Impact; Process; and Validity. Similarly, Grades Survey statements were designed to collect data for individual students that could also be grouped to analyze individual items, item categories, and overall student responses. Pre- and post-treatment Grade Survey responses were intended to offer the ability to compare students' perceptions about grades and grading before and after treatment.

Standards and Re-assessment Tracking. Records of student requests for re-assessment were also maintained throughout the study. Tracking records of student re-assessments served as a quantitative checklist of observed behaviors, offering the researcher expedient, though less detailed, quantitative evidence of student motivation (Mertler, 2020). Student requests for re-assessment were initiated using a Re-Assessment Checklist form. The Re-Assessment Checklist required students to identify the standard for re-assessment, to reflect on initial misunderstanding of that standard, and propose an alternate form of assessment as evidence of improved understanding. Engaging students in thoughtful planning of learning Process and learning

Progress to improve learning Product (evidence) was the goal of the Re-Assessment Checklist requirement.

Student Interviews. Students were also interviewed to collect qualitative information related to student perception of grades and meaning from grades. Recorded student interviews offered a direct, flexible, and durable way to gather qualitative data (Mertler, 2020). Interview questions (Appendix G) were developed from the product, process, progress model of learning criteria proposed by Guskey (2006). Students were first asked to describe their own learning and to identify learning criteria from the Guskey model that held greatest personal importance. Further questioning was designed to determine students' perceptions of Standards-Based Grading practices and any connections linking SBG to Guskey learning criteria that students had developed from the intervention. Student interviews were conducted to collect qualitative evidence to triangulate with quantitative (survey, re-assessment) data for Learning Attitudes and Grades sub-questions.

Data Analysis

Surveys. Responses from each Likert survey were transposed to whole numbers, with values one through five corresponding to Strongly Disagree - Disagree - Neutral - Agree - Strongly Agree, respectively. Whole number values were normalized, using integers to represent agreement (Agree = Strongly Agree = +1), disagreement (Disagree = Strongly Disagree = –1), or neither (Neutral = 0). Normalization as described above was performed to allow interval interpretation of the data, because degrees of (dis-)agreement are most often interpreted as ordinal differences (Joshi et al., 2015). Normalized, integer student response values were compared to 'expert' teacher responses. Agreement with expert responses were considered favorable; contradiction with expert responses were considered unfavorable. Neutral responses were not considered favorable or unfavorable. Identification of favorable and unfavorable response types served as the foundation for analysis of data from Likert surveys (Table 8).

Table 8. Sample student responses and coding for Learning Attitudes Survey statement.

<table>
<tr><td colspan="5">Learning environmental science changes my ideas about how the natural world works.
STRONGLY DISAGREE | DISAGREE | NEUTRAL | AGREE | STRONGLY AGREE
EXPERT RESPONSE = +1 (AGREEMENT)</td></tr>
<tr><th>STUDENT ID</th><th>RESPONSE</th><th>1–5 CODED</th><th>NORMALIZED</th><th>FAVORABLE / UNFAVORABLE</th></tr>
<tr><td>1</td><td>AGREE</td><td>4</td><td>+1</td><td>FAVORABLE</td></tr>
<tr><td>2</td><td>DISAGREE</td><td>2</td><td>–1</td><td>UNFAVORABLE</td></tr>
<tr><td>3</td><td>STRONGLY AGREE</td><td>5</td><td>+1</td><td>FAVORABLE</td></tr>
<tr><td>4</td><td>NEUTRAL</td><td>3</td><td>0</td><td>NEUTRAL</td></tr>
</table>

For each survey item, mean, standard deviation, and standard error were calculated for normalized integer scores. Based on ‘expert’ agreement, favorable, neutral, and unfavorable response sums were determined for each survey item: for all participants, for gender groups, and for course sections. For each survey category, percent favorable and percent unfavorable scores were calculated: for each participant, for all participants, for gender groups, and for course sections. Mean, standard deviation, and standard error values were calculated for each percent favorable and percent unfavorable score grouping. Category scores for individual students were grouped into percentile bins for comparison of percent favorable and percent unfavorable score distributions.

Following calculations of means, standard deviations, standard errors, percentile scores, and initial graphical analysis, favorable and unfavorable score differences for each category were compared to standard error values to identify large changes in pre- and post-treatment responses.

Mean score differences of magnitude greater than two multiples of standard error for the category suggested statistically significant changes. For each category that met this initial criterion, individual student score differences from pre- and post-treatment administrations of surveys were calculated and examined graphically to determine whether score differences were distributed normally. Normal distribution of large score differences suggested application of paired student's t-test to analyze pre- and post-treatment category scores. Paired t-test analysis was performed for each category that met both criteria to determine whether changes in mean scores were statistically significant.

Re-assessment Tracking. Records of student mastery of standards and re-assessment attempts were collated by course section. Data groupings for standards mastery included: all standards mastered, only one standard below mastery, and multiple standards below mastery. Records of re-assessment types were also maintained to compare frequencies of each modality of student re-assessment.

Student Interviews. Transcripts were generated from all student interview recordings. Student responses from transcripts were organized into groups, based on relationship to either Learning Attitudes or Grades. Student responses data from each category were sorted into clusters of related responses to facilitate identification of salient themes from student interviews. Specific searches were performed within student interview responses for comments related to quantitative data categories that emerged from analysis of survey responses.

DATA AND ANALYSIS

Results

Impact of SBG on Learning Attitudes

Understanding how a change to standards-based grading affected students' learning attitudes was a primary goal of the study. Semsar et al. (2011) suggested that the CLASS-Bio Learning Attitudes Survey modified for this study was appropriate for measuring From the Learning Attitudes Survey data, I could see that my students already possessed learning attitudes that, generally, were favorable. Growth in one learning attitude category (Problem-Solving Strategies) was most evident from initial review of survey data. Students' comments from interviews supported the idea that Problem-Solving Strategies had improved. Re-assessment data also indicated that students were exercising opportunities to demonstrate Problem-Solving Strategies, making use of the growth in this learning attitude to positively affect learning outcomes.

Students participating in the study entered with favorable learning attitudes. Pre-and post-treatment Learning Attitudes Survey (*N*=18) responses are summarized in Figure 2. Among learning attitude categories, pre-treatment Enjoyment responses (41.9% favorable) were lowest and did not show growth in favorable responses from the post-treatment survey. All other learning attitude categories showed growth in favorable responses following SBG treatment. While Real World Connection responses (pre = 64.3% favorable, post = 66.1% favorable) were highest initially, Problem-solving Strategies (pre = 61.1% favorable, post = 84.7% favorable) showed the greatest increase in favorable responses from study participants.

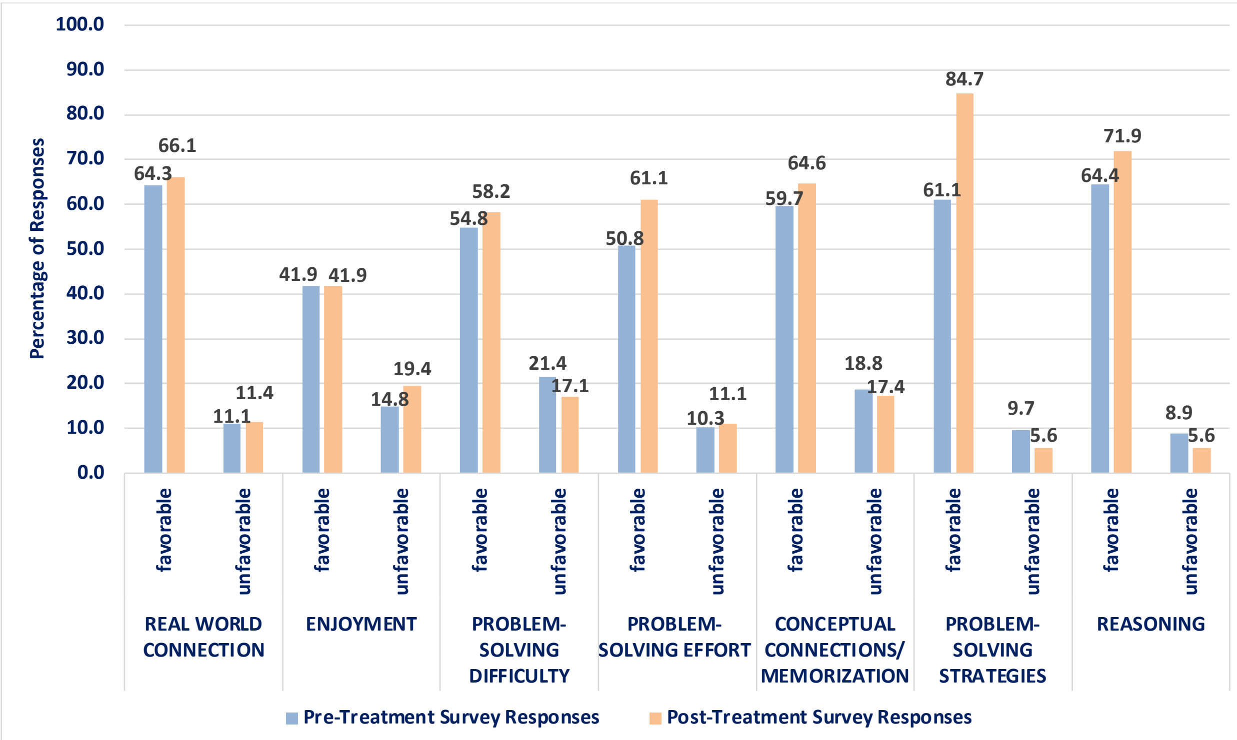


Figure 2. Summary of Learning Attitudes Survey Responses, (*N*=18).

Problem-solving Strategies category favorable mean score difference ($\Delta\bar{x} = 23.61$) was greater than twice the favorable mean score difference standard error ($\sigma_{\Delta\bar{x}} = 6.65, 2\sigma_{\Delta\bar{x}} = 13.7$) and seemed to meet the normal distribution criterion (Figure 3). Probabilities values ($p < 0.05$) indicate statistical significance of the difference of two means (Hutchinson, 1993). Paired t-test analysis for Problem-solving Strategies favorable responses resulted in $t(17) = -3.4490$ and $p = 0.00306$, confirming that the difference in means of participants' pre- and post-treatment percentile scores was statistically significant (Appendix H).

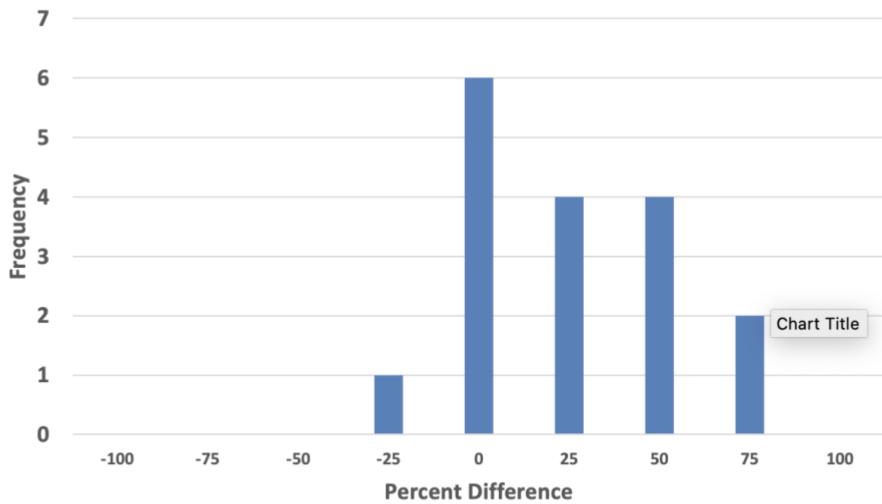


Figure 3. Problem-Solving Strategy Favorable Response Percent Difference, (*N*=18).

Student interview responses support the notion that problem-solving strategies and learning from mistakes had developed among study participants. One student described the development of his learning process, stating that "learning is about how people come to understanding the same answers differently…. I look at the work of someone else, either try to learn it that way or try to find another way that suits me and apply." Another student articulated the importance of learning from mistakes by commenting, "I learn a lot more from mistakes, building upon, creating a more fine [sic] understanding." Connections among knowledge and abilities from units of study had also become integral to student confidence when faced with new information. One student stated,

> The base material has a lot of connections across the units or concepts. When I'm learning a new concept and I recognize another part [concept] that I learned earlier, that's when I know it… being able to link what we're learning in class to other knowledge.

Non-verbal cues from other students during interviews indicated agreement with statements linking learning to recognizing patterns, overcoming mistakes, and applying a variety of strategies to problem-solving.

Study participants took advantage of re-assessment opportunities to achieve standards mastery (Succeeding proficiency level) and extension (Integrating proficiency level). Seventy-five percent of students with at least one Developing standard rating submitted re-assessments to achieve standard mastery (*n*=12). Re-assessment submissions for standard mastery included 62.5 percent unit review pages, 25 percent slide presentations, and 12.5 percent infographics (*n*=8). Among students who achieved mastery of all standards (*n*=14), 43 percent submitted re-assessment evidence of (Integrating) standard extension. Sixty-seven percent of mastery extension re-assessments were infographic format (*n*=6).

Table 9. Summary of Re-Assessment Data, (*N*=18).

***N*=18**	**INITIAL STATUS**	**RE-ASSESSMENT**	**FINAL STATUS**
> ONE STANDARD BELOW MASTERY	9	5	4
ONLY ONE STANDARD BELOW MASTERY	3	3	0
ALL STANDARDS MASTERY LEVEL	6	NA	14
STANDARDS EXTENDED BEYOND MASTERY LEVEL	0	6	6

Impact of SBG on Grade Perceptions

An additional goal of this study was to determine how a change to standards-based grading, using single-point rubrics, may affect students' perceptions of grades. Grades surveys indicated that students possessed and maintained favorable perceptions, except in the category Impact of grades, which was not surprising – considering the expectations for college admissions that many students and families hold throughout my school community. Though a trend toward unfavorable perceptions was demonstrated for Process of grade determination, students' perceptions of Grade Validity changed favorably. Students' interview comments suggested that each of these changes was related to administration of the study treatment. Results of the Learning Attitudes Survey supported students' improvement in Grade Validity perceptions, specifically when considered with re-assessment data.

For the Grades Survey, study participants demonstrated mixed agreement with teacher-favored responses in both pre-and post-treatment data sets. Figure 4 summarizes pre- and post-treatment Grades Survey responses (*N*=18). Grades Survey responses indicated that students' perceptions became more decisive during the treatment, as both favorable and unfavorable responses either remained constant or increased for nearly every category. Notably, survey items regarding Validity of grades demonstrated growth in favorable responses and a decline in unfavorable responses. Validity post-treatment favorable response mean score (62.7%) increased from pre-treatment favorable response mean score (51.6%), while post-treatment unfavorable response mean score (12.7%) decreased from its pre-treatment value (23.8%). Impact category from the Grades Survey was also unique; unfavorable responses (pre=38.9%, post=43.3%) were greater than and experienced greater growth than favorable responses (pre=26.7%, post=28.9%). In the Process category, the favorable response mean score decreased from its pre-treatment value of 42.36% to the post-treatment value of 36.11%, while unfavorable response mean score increased from pre-treatment value of 25.00% to post-treatment value of 36.11%. Beliefs and Purpose categories did not demonstrate remarkable shifts in this study.

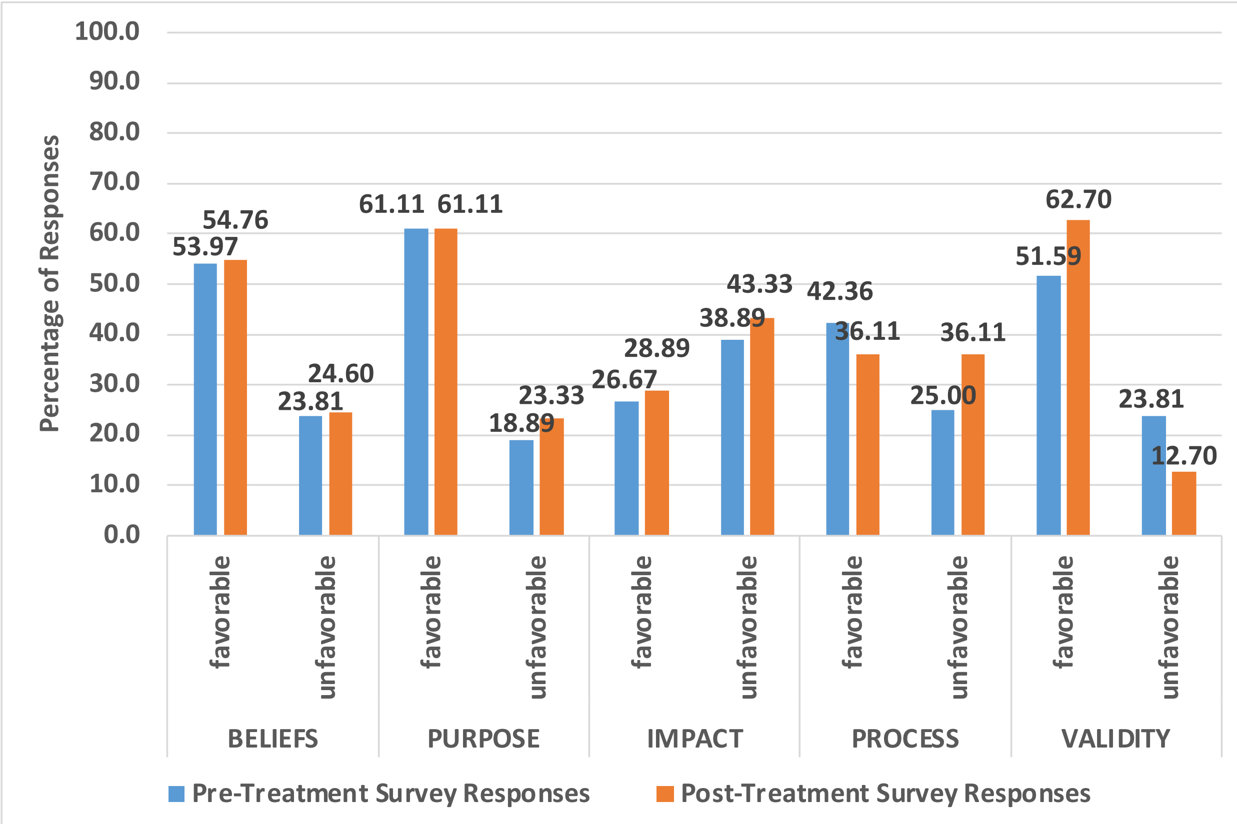


Figure 4. Summary of Grades Survey Responses, (N=18).

Three data sets were indicated for potentially significant changes: Process unfavorable response scores ($\Delta\bar{x} = 11.11, \sigma_{\Delta\bar{x}} = 4.39, 2\sigma_{\Delta\bar{x}} = 8.78$), Validity favorable response scores ($\Delta\bar{x} = 11.11, \sigma_{\Delta\bar{x}} = 4.25, 2\sigma_{\Delta\bar{x}} = 8.5$), and Validity unfavorable response scores ($\Delta\bar{x} = -11.11$, $\sigma_{\Delta\bar{x}} = 4.25, 2\sigma_{\Delta\bar{x}} = 8.5$). Distribution of student score differences for each of these response classes were examined graphically (Figure 5, Figure 6, Figure 7) to determine suitability of paired student's t-test application, based on the normal distribution criterion for such treatment. Each data set identified for application of paired t-test analysis sufficiently satisfied the normal distribution requirement.

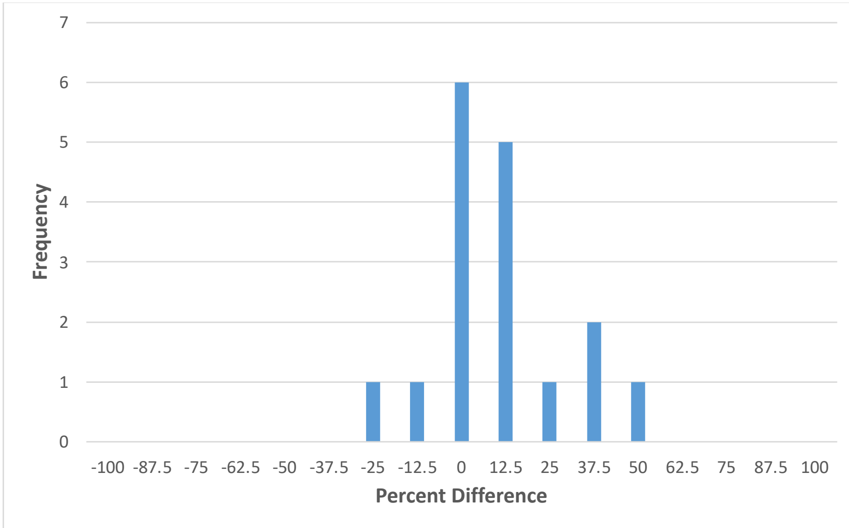


Figure 5. Grade Process Unfavorable Response Percent Difference, (*N*=18).

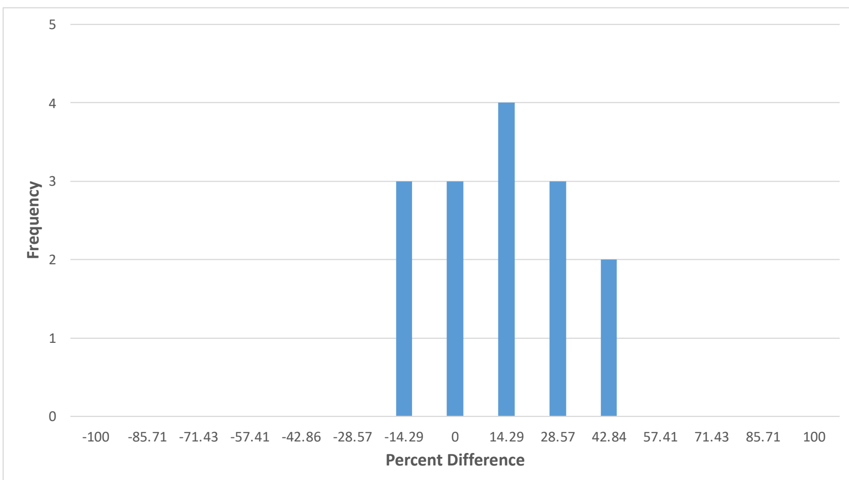


Figure 6. Grade Validity Favorable Response Percent Difference, (*N*=18).

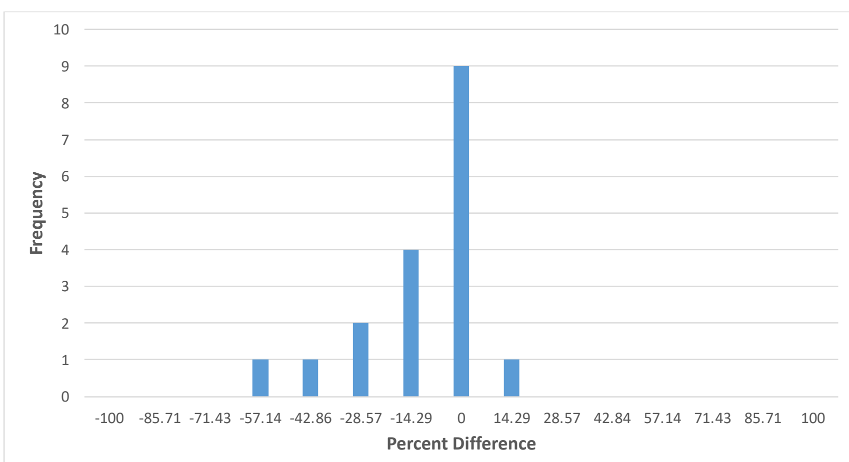


Figure 7. Grade Validity Unfavorable Response Percent Difference, (*N*=18).

Application of paired student's t-tests for each of these data sets yielded t statistics greater in magnitude than critical values for t, indicating that changes in student response mean scores from pre- and post-treatment administrations of the survey were statistically significant. For the unfavorable responses in Grade Process category, paired t-test application resulted in $t(17) = -2.5298$ and $p = 0.02159$ (Appendix I). Remarkably, paired t-test analysis for Grade Validity mean response scores resulted in $t(17) = -2.6130$ and $p = 0.01818$ (Appendix J), for both favorable and unfavorable response mean score changes. Probability values ($p < 0.05$) from each of these t-tests suggested statistical significance of mean differences (Hutchinson, 1993). Paired t-test analysis for Grade Validity resulted in $t(17) = -2.6130$, with $p = 0.01818$, confirming statistical significance of the difference in pre-treatment and post-treatment means for Grade Validity category.

In interviews, several students commented that the shift to standards-based grading marked a noticeable change in their perceptions of assessment and learning activities. One student stated, "I think the focus changes a lot, because before SBG, you just focused on the end of the unit, the exam at the end of the unit." She went on to comment that "with this system, [there's] things to worry about every day… and we still have the test, even though the stakes are lower." Another student added that "it's great to have more opportunities for students to show they understand some concepts, other than just the unit tests." And still another student stated, "The whole point of SBG is to shift [Learning] Progress up to first place in terms of importance; learning, overall, is supposed to be you learning from your mistakes and you becoming better." Additionally, one student declared, simply, "SBG is fair and useful for feedback."

Students also expressed concerns in interviews regarding multiple assessments and re-assessment opportunities with standards-based grading. One student commented that she was "struggling with new flexibility of SBG system," and that "fewer major assessments are preferred by me over more [numerous] smaller assignments that break up the learning." Another student added that "[the] pace of class also made it difficult to do re-assessment in addition to keeping pace." Students also identified that the implementation of SBG was lacking clarity about interpretation of proficiency levels and performance expectations associated with them. One student said, "Because [a rubric score of] two can mean average, or two can mean you know everything, there is some ambiguity." One of several comments related to Integrating proficiency level was that students "need more information about how to earn [Integrating] three scores."

In Learning Attitudes surveys, growth indicated in the Problem-Solving Strategies category supports the notion that students appreciated multiple opportunities to demonstrate mastery of learning standards and, specifically, opportunities for re-assessment. Other categories from the Learning Attitudes surveys did not demonstrate statistically significant changes; however, favorable learning attitudes reflected in data for Problem-Solving Difficulty, Problem-Solving Effort, and Reasoning categories also support students' statements regarding multiple opportunities for assessment of learning standards – an integral feature of standards-based grading. Re-assessment records indicated that students not only possessed favorable learning attitudes related to re-assessment, but also put these learning attitudes into action by taking advantage of re-assessment opportunities to demonstrate mastery and extension of learning standards.

CLAIM EVIDENCE AND REASONING

Claims From the Study

Three claims emerged from data and analysis of this action research, that include: (a) standards-based grading with single-point rubrics (SBG/SPR) can have a positive impact on students' learning attitudes, (b) SBG/SPR can improve students' perceptions of grade validity, and (c) implementation of SBG/SPR presents challenges. Below, data supporting each of these claims is summarized and shown to be consistent with findings by other researchers, followed by reflection on the value of insights to me as a researcher and implications for further research.

Learning Attitudes

Growth in favorable responses was observed across six of seven learning attitude categories in this study, with statistically significant growth confirmed for Problem-Solving Strategies. Student participation in re-assessment opportunities to achieve mastery of standards was observed at a rate of 75%, with re-assessment for proficiency beyond mastery occurring at a rate of 43%, demonstrating student determination to improve understanding of standards. Interview responses from students described an appreciation for finding new ways to solve problems, learning from mistakes, and making connections among crosscutting concepts.

One hope in carrying out this action research was that my students would experience positive outcomes like those described in previous research. Data from my research agrees with other publications describing decreased test anxiety (Lewis, 2022) and increased participation in remediation (Zimmerman, 2020). Zimmerman further describes a specific tendency for SBG to help lower-achieving students to close gaps in learning. In a study on effects of SBG implementation by Knight and Cooper (2019), environments were described as more conducive to learning, where students are afforded intellectual safety and a sense of belonging, with students shifting toward growth mindset as a result. Growth across learning attitudes categories, high participation in re-assessment, and student comments from interviews imply that such changes were occurring because of the treatment.

Value of the Study and Considerations for Future Research. While agreement with other published work was gratifying to note, data from the study provided me with invaluable insight regarding student learning experiences in my classes. Clarity of learning goals and performance expectations can help students focus more effort on learning and may contribute to favorable impacts on learning attitudes. Feedback that focuses on specific learning standards and student performance also contributes to gains in students' learning attitudes. Information about specific knowledge and skills can reduce anxiety by giving students a clearer vision of where they are, where they're going, and how to get there, as described by Fluckiger (2010).

I still have unanswered questions about results from my study and their dependence on the treatment. I wonder about the validity of my data because of the small sample size. Would I observe similar findings if this study were expanded to include more students? Would inclusion of participants from other courses and grade levels change outcomes? I also want to know more about how much the intervention specifically affected learning attitudes among participants and whether similar outcomes may also be produced in traditional grading settings over the same period of instruction. Further investigation may include collaboration with other science teachers to gather data on a larger scale and from both traditional and standards-based grading practices.

Grade Validity

Students’ perceptions of grade validity demonstrated significant growth from pre- to post-treatment surveys. Students made comments in interviews about fairness, usefulness of feedback, and appreciation for multiple assessment / re-assessment opportunities with standards-based grading practice. Increasing favorable responses for learning attitudes suggested that students were also developing growth mindset dispositions. Though not initially identified as a means of measuring students’ perceptions of grades, the rate of student participation in re-assessment opportunities further supports students’ claims from the interviews and survey results.

Student comments about standards-based grading are like those published by Zimmerman (2020), where students also mention appreciation for focused feedback and ownership of learning that comes from SBG implementation. Knight and Cooper (2019) mentioned SBG themes clearer communication and more purposeful planning, instruction, and assessment that contribute to students’ perceptions of grade validity resulting from standards-based grading. Related to the learning Product, Process, Progress model (Guskey, 2006) inspiration for my research, Erbes et al. (2020) noted that implementation of SBG shifted the focus of learning from product to process. Student interviews from my research suggested that the focus of learning shifted to Learning Progress, with one student stating that “the whole point of SBG is to shift Progress up to first place in terms of importance.” I firmly believe that shifting the focus of assessments was responsible for changes in students’ perceptions of learning and grading in my research.

Values of the Study and Considerations for Future Research. Insights about grades and grading from my research include: (1) standards-based grades are perceived to be more valid than traditional grades, and (2) specific feedback about performance related to standards offered by SBG motivates further learning. When students are informed of standards and performance expectations prior to learning experiences, fewer surprises occur in assessments and grading. Providing students with specific feedback, especially from formative assessments, helps steer student learning toward greater productivity and efficiency. More efficient and productive learning experiences help students achieve better learning outcomes.

I have stronger convictions about the relationship between standards-based grading treatment and changes in students' perceptions of grade validity than my belief about dependence of learning attitudes on implementation of SBG. However, the connection between SBG and grade validity perceptions could be strengthened with implementation and data collection on a greater scale. Other grades perceptions evidenced by student surveys and interviews may have less dependence on standards-based grading treatment and may be more related to cultural and social factors. I would like to investigate this notion further, perhaps by editing current prompts and generating additional prompts for surveys and interviews to gather data about cultural and social influence on grade perceptions within the context of SBG.

Challenges

Several challenges associated with implementation of standards-based grading and single-point rubrics became evident to the researcher while completing this action research. Determination of a method for converting standards-based single-point rubric scores to traditional grade reporting practices created uncertainty and anxiety for the researcher and, likely, student participants in this study. Another practical challenge for the researcher was production of narrative feedback to accompany rubric scores, especially because multiple assessment opportunities were offered for each learning standard. Though transition to standards-based grading record-keeping methods within the learning management system was facilitated through collaboration with the school's technology team, adjustment to SBG grading information required flexibility from the researcher and students alike.

Despite efforts to clearly communicate learning standards, proficiency levels, and re-assessment procedures, some students reported feelings of confusion resulting from changes to assessment practices. A negative trend for Enjoyment category from learning attitudes surveys may be related to students' confusion during standards-based grading treatment. Re-assessment was specifically identified as a source of anxiety for students, as evidenced by comments about misunderstanding re-assessment procedures and about feeling too overwhelmed to manage re-assessment while keeping pace with class work. Students also claimed that absence of exemplars for each proficiency level contributed to their confusion and anxiety during the study.

Challenges associated with SBG implementation have been documented by others, including a study by Erbes et al. (2020) that states, "its non-traditional terms can be ambiguous and challenging" (p. 65). Knight and Cooper (2019) discussed several challenges in standards-based grading implementation, including decreased enjoyment experienced by some students, especially among students described as "teacher pleasers" and "high fliers" (p. 81), a description fitting several study participants. Knight and Cooper also acknowledged difficulty in SBG implementation in isolated classes for students also enrolled in traditional-grading classes and that students' accountability often decreased initially, perhaps because student awareness of re-assessment opportunities. These findings emphasize the significance of the "fundamental tension" of re-assessment claimed by Beatty (2013) to be "the most difficult aspect of SBG to implement sustainably and to get right, but is also the most crucial" (p.15).

Value of the Study and Considerations for Future Research. Practical challenges in SBG implementation from this action research prompted significant reflection on my teaching practice, particularly around communication with students. Two areas for professional growth that emerged from the study are provision of exemplars and greater commitment to narrative feedback to guide student learning. I also became aware that even when I think I have communicated clearly with students, gaps in understanding may persist or develop later, depending on the expected duration of my messaging. This further highlights the importance of regular check-ins with students, whether formal or informal, as formative assessments or by some other means.

How to best implement SBG re-assessment remains a source of uncertainty for me, and one that I believe warrants further investigation. A future iteration of SBG may include variation in re-assessment procedures to gain insights about which methods are best suited for my classes. Any future exploration of standards-based grading that I endeavor demands more attention to decisions about re-assessment and its implementation, as re-assessment is integral to SBG.

Impact of Action Research on the Author

This research was motivated by a principle from the "assessment for learning" ideology described by Black et al. (2004):

> The criteria for evaluating any learning achievements must be made transparent to students to enable them to have a clear overview both of the aims of their work and what it means to complete it successfully (p. 6).

Though learning gains were the spirit of the work completed by Black et al., I wanted to improve alignment of learning and assessment practices in my classes to encourage growth in students' learning attitudes and students' valuation of grades and the grading process. I chose to design single-point rubrics for implementation of standards-based grading in my AP Environmental Science classes to investigate feasibility of these methods to achieve the desired goals. I also was driven by a professional desire to learn more about implementation of standards-based grading and single-point rubrics (SBG/SPR).

While moderate success in achieving my primary goals of improving learning attitudes and perceptions of grades was suggested by results of the study, valuable insights about my teaching practice and student experiences emerged from my implementation of SBG/SPR. Additional insights about communication with students, re-assessment, and integration of SBG/SPR within learning management system have inspired professional goals for continued development of my teaching practice (Table 10).

Table 10. Single-point rubric: Impact of action research on the author.

Concern *Evidence that Needs Work*	**Criteria** *Evidence for This Performance*	**Advanced** *Evidence of Exceeding Standards*
PROVIDE EXEMPLARS	**I CAN** communicate learning expectations clearly to my students.	SINGLE-POINT RUBRICS
NARRATIVE FEEDBACK RE-ASSESSMENT	**I CAN** implement SBG/SPR to assess student learning in my classes.	LEARNING MANAGEMENT SYSTEM
	I CAN promote SBG/SPR in my school community and beyond.	MENTORSHIP OPPORTUNITIES

From this implementation of SBG/SPR, I realized that my communication with students could be improved, both in the form of feed forward (exemplars) and feedback (narrative comments) accompanying single-point rubric scores. Exemplars for each proficiency level would serve as a rubric map to help students better understand the grading process. Student feedback from interviews indicated that exemplars would be especially helpful for students seeking to demonstrate proficiency beyond the mastery-level performance expectation provided on single-point rubrics. One concern that I have about exemplars is their potential to stifle creativity, so exemplars must be produced and introduced with care. Narrative feedback accompanying single-point rubric scores would likely be of greatest value to students still developing understanding of learning standards, providing guidance toward greater achievement. Whether using SBG/SPR or not, completion of this research has emphasized the importance of both exemplars and narrative feedback to encourage student learning gains.

Another area I want to further develop is refinement of re-assessment procedures. Within the context of this two-unit, four-week study, some students mentioned that the re-assessment process seemed daunting. Though I do not have evidence of students refraining from re-assessment because of those feelings, I wonder about possible effects on performance and timeliness of re-assessment attempts. Beatty (2013) mentioned several recommendations for improving efficiency of re-assessment, including planned re-assessment windows and designated catch-up time built into the course schedule. Though implementing such changes would reduce class instructional time, the potential pay-off of re-assessment efficiency may compensate for that reduction. Striking the right balance in time set aside for re-assessment within the class schedule is an item for further investigation.

One aspect of my professional expertise that experienced growth during this project was development of knowledge and skills related to our school's learning management system. Prior to this experience, I was unaware of standards-based grading features available in Canvas. After working with the technology team at our school to load single-point rubrics as learning outcomes, I learned how to produce rubrics from the learning outcomes to match assessments from class. Navigation of learning management system gradebook records was another new experience for me to learn and, subsequently, teach my students. Use of the learning management system features was convenient, though formatting of the single-point rubric structure that I preferred was compromised for that convenience. I expect that my new knowledge with learning management system structures will prove valuable for future implementations of standards-based assessments and single-point rubrics.

Completion of this action research provided opportunities for reflection on my teaching practices and professional identity. Improved communication with students, refinement of re-assessment procedures, and continued learning related to learning management systems are lessons from this work that have become commitments for my professional development. As an early adopter of standards-based grading in my school community, I hope to serve as a mentor for other teachers who are interested in implementing standards-based grading or single-point rubrics in their classrooms.

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APPENDICES

APPENDIX A

INSTITUTIONAL REVIEW BOARD APPROVAL

Received
Feb 21, 2023 8:29 AM

From
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To
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Subject
IRB Protocol #2023-491-EXEMPT APPROVED

Hello Beckman, Brad,
Your protocol was reviewed by the IRB and has been approved.
PI: Beckman, Brad
Approval Date: 2/21/2023
Title: Standards Based Grading in Advanced Placement Environmental Science
Protocol #: 2023-491-EXEMPT
Review Type: Exempt Review
Expiration Date: 2/21/2028

Work described under this protocol may now commence. The PI is responsible for ensuring that the protocol accurately describes research practices being conducted.
> Review Category designation determined by the IRB can be found in the final section of your protocol.
> IRB-stamped active Consent Forms are attached within your protocol where applicable.
> Any changes must be submitted via Amendment prior to implementation.
> Per the Common Rule, research only requires Interim (annual) Review by the IRB if 1) it was reviewed via Full Committee or 2) is regulated by the FDA.
> All research is subject to post approval monitoring.
> All protocol types must be renewed 5 years after approval.
> Inform the IRB once your research is complete so that the protocol may be inactivated.

Please contact your IRB Program Manager with any questions or if you are in need of assistance. Thank you for your diligence in the care of human subjects research participants.

Institutional Review Board for the Protection of Human Subjects | Office of Research Compliance | Montana State University

Access your protocol
anytimeat https://montanaprod.topazti.net//Elements?emailLink=11%2c102%2c9093.

APPENDIX B

LEARNING ATTITUDES SURVEY

Here are a number of statements that may or may not describe your beliefs about learning environmental science.

STRONGLY DISAGREE DISAGREE NEUTRAL AGREE STRONGLY AGREE

Choose one of the above five choices that best expresses your feeling about the statement.

If you don't understand a statement, leave it blank. If you have no strong opinion, choose NEUTRAL. Please express your own beliefs. Your answers will not affect your grade.

1. My curiosity about the living world led me to study environmental science.
STRONGLY DISAGREE DISAGREE NEUTRAL AGREE STRONGLY AGREE

2. I think about the environmental science I experience in everyday life.
STRONGLY DISAGREE DISAGREE NEUTRAL AGREE STRONGLY AGREE

3. After I study a topic in environmental science and feel that I understand it, I have difficulty applying that information to answer questions on the same topic.
STRONGLY DISAGREE DISAGREE NEUTRAL AGREE STRONGLY AGREE

4. Knowledge in environmental science consists of many disconnected topics.
STRONGLY DISAGREE DISAGREE NEUTRAL AGREE STRONGLY AGREE

5. When I am answering an environmental science question, I find it difficult to put what I know into my own words.
STRONGLY DISAGREE DISAGREE NEUTRAL AGREE STRONGLY AGREE

6. I do not expect the rules of environmental science principles to help my understanding of the ideas.
STRONGLY DISAGREE DISAGREE NEUTRAL AGREE STRONGLY AGREE

7. To understand environmental science, I sometimes think about my personal experiences and relate them to the topic being analyzed.
STRONGLY DISAGREE DISAGREE NEUTRAL AGREE STRONGLY AGREE

8. If I get stuck on answering an environmental science question on my first try, I usually try to figure out a different way that works.
STRONGLY DISAGREE DISAGREE NEUTRAL AGREE STRONGLY AGREE

9. I want to study environmental science because I want to make a contribution to society.
STRONGLY DISAGREE DISAGREE NEUTRAL AGREE STRONGLY AGREE

10. If I don’t remember a particular approach needed for a question on an exam, there’s nothing much I can do (legally!) to come up with it.
STRONGLY DISAGREE DISAGREE NEUTRAL AGREE STRONGLY AGREE

11. If I want to apply a method or idea used for understanding one environmental science problem to another problem, the problems must involve very similar situations.

STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE

12. I enjoy figuring out answers to environmental science questions.

STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE

13. It is important for the government to approve new scientific ideas before they can be widely accepted.

STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE

14. Learning environmental science changes my ideas about how the natural world works.

STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE

15. To learn environmental science, I only need to memorize facts and definitions.

STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE

16. Reasoning skills used to understand environmental science can be helpful to my everyday life.

STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE

17. It is a valuable use of my time to study the fundamental experiments behind environmental science ideas.

STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE

18. If I had plenty of time, I would take an environmental science class outside of my major requirements just for fun.

STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE

19. The subject of environmental science has little relation to what I experience in the real world.

STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE

20. There are times I think about or solve an environmental science question in more than one way to help my understanding.

STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE

21. If I get stuck on an environmental science question, there is no chance I'll figure it out on my own.

STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE

22. When studying environmental science, I relate the important information to what I already know rather than just memorizing it the way it is presented.

STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE

23. There is usually only one correct approach to solving an environmental science problem.

STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE

24. When I am not pressed for time, I will continue to work on an environmental science problem until I understand why something works the way it does.

STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE

25. Learning environmental science that is not directly relevant to or applicable to human benefits is not worth my time.

STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE

26. Mathematical skills are important for understanding environmental science.

STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE

27. I enjoy explaining environmental science ideas that I learn about to my friends.

STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE

28. We use this statement to discard the survey of people who are not reading the questions. Please select agree (not strongly agree) for this question to preserve your answers.

STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE

29. The general public misunderstands many environmental science ideas.

STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE

30. I do not spend more than a few minutes stuck on an environmental science question before giving up or seeking help from someone else.

STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE

31. .Environmental science principles are just to be memorized.

STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE

32. For me, environmental science is primarily about learning known facts as opposed to investigating the unknown.

STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE

33. Please enter your student ID #

APPENDIX C

GRADES SURVEY

Here are a number of statements that may or may not describe your beliefs about grades and grading.

STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE

Choose one of the above five choices that best expresses your feeling about the statement.

If you don't understand a statement, leave it blank. If you have no strong opinion, choose NEUTRAL. Please express your own beliefs. Your answers will not affect your grade.

1. I feel that grading at school is fair.
   STRONGLY DISAGREE — DISAGREE — NEUTRAL — AGREE — STRONGLY AGREE
2. I feel that my grades in my classes accurately reflects what I know.
   STRONGLY DISAGREE — DISAGREE — NEUTRAL — AGREE — STRONGLY AGREE
3. I feel that my grades are higher than my amount of understanding of the material.
   (Example: I have an A, but I really don't understand most of what is taught in class)
   STRONGLY DISAGREE — DISAGREE — NEUTRAL — AGREE — STRONGLY AGREE
4. I feel that my grades are lower than my amount of understanding of the material.
   (Example: I have a D, but understand everything or most of what is taught in class)
   STRONGLY DISAGREE — DISAGREE — NEUTRAL — AGREE — STRONGLY AGREE
5. Grades should be based on what I know and can do in a class.
   STRONGLY DISAGREE — DISAGREE — NEUTRAL — AGREE — STRONGLY AGREE
6. Grades should be based on what I know and can do in a class and how much work I complete.
   STRONGLY DISAGREE — DISAGREE — NEUTRAL — AGREE — STRONGLY AGREE
7. Grades should be based on how much work I complete.
   STRONGLY DISAGREE — DISAGREE — NEUTRAL — AGREE — STRONGLY AGREE
8. Grades me how well I am doing in a class.
   STRONGLY DISAGREE — DISAGREE — NEUTRAL — AGREE — STRONGLY AGREE
9. Grades tell me what I need to do to succeed in a class.
   STRONGLY DISAGREE — DISAGREE — NEUTRAL — AGREE — STRONGLY AGREE
10. Grades tell me how much I have grown in a class.
    STRONGLY DISAGREE — DISAGREE — NEUTRAL — AGREE — STRONGLY AGREE
11. Grades tell me where I am in comparison to other students.
    STRONGLY DISAGREE — DISAGREE — NEUTRAL — AGREE — STRONGLY AGREE

12. Grades tell me what kind of person I am.

STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE

13. Grades are rewards for good performance.

STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE

14. Grades are punishment for poor performance.

STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE

15. Grades control a student’s future options.

STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE

16. The primary purpose of grades is to ensure that high standards of education are maintained.

STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE

17. The primary purpose of grades is to benefit students.

STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE

18. Grades are based on teacher judgment.

STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE

19. Grades are based on objective measurement.

STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE

20. Students earn grades.

STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE

21. Teachers give grades.

STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE

22. Student performance determines the grade; teachers just record the grades.

STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE

23. Grades show how much work a student has completed.

STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE

24. Grades are based on fixed standards.

STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE

25. There is a close relationship between student effort in a class and the student’s grades.

STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE

26. Grades are arbitrary symbols assigned by teachers.

STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE

27. Grades are negotiable – they can be change by discussing the situation with the teacher.

STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE

28. Grades usually do not correspond with how much a student has learned.

STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE

29. Grades are certification that a student has mastered course content.

STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE

30. Grades are meaningless tokens that are just handed out.

STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE

31. Grades accurately reflect the quality of student performance.

STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE

32. Grades are merely an indication of student learning.

STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE

APPENDIX D

LEARNING ATTITUDE SURVEY CATEGORIES

Real World Connection

2. I think about the environmental science I experience in everyday life.
12. I enjoy figuring out answers to environmental science questions.
14. Learning environmental science changes my ideas about how the natural world works.
16. Reasoning skills used to understand environmental science can be helpful to my everyday life.
17. It is a valuable use of my time to study the fundamental experiments behind environmental science ideas.
19. The subject of environmental science has little relation to what I experience in the real world.
25. Learning environmental science that is not directly relevant to or applicable to human benefits is not worth my time.

Problem-solving Difficulty

3. After I study a topic in environmental science and feel that I understand it, I have difficulty applying that information to answer questions on the same topic.
5. When I am answering an environmental science question, I find it difficult to put what I know into my own words.
6. I do not expect the rules of environmental science principles to help my understanding of the ideas.
10. If I don't remember a particular approach needed for a question on an exam, there's nothing much I can do (legally!) to come up with it.
11. If I want to apply a method or idea used for understanding one environmental science problem to another problem, the problems must involve very similar situations.
21. If I get stuck on an environmental science question, there is no chance I'll figure it out on my own.
30. I do not spend more than a few minutes stuck on an environmental science question before giving up or seeking help from someone else.

Enjoyment

1. My curiosity about the living world led me to study environmental science.
2. I think about the environmental science I experience in everyday life.
9. I want to study environmental science because I want to make a contribution to society.
12. I enjoy figuring out answers to environmental science questions.
18. If I had plenty of time, I would take an environmental science class outside of my major requirements just for fun.
27. I enjoy explaining environmental science ideas that I learn about to my friends.

Problem-solving Effort

8. If I get stuck on answering an environmental science question on my first try, I usually try to figure out a different way that works.
12. I enjoy figuring out answers to environmental science questions.
20. There are times I think about or solve an environmental science question in more than one way to help my understanding.
22. When studying environmental science , I relate the important information to what I already know rather than just memorizing it the way it is presented.
24. When I am not pressed for time, I will continue to work on an environmental science problem until I understand why something works the way it does.
27. I enjoy explaining environmental science ideas that I learn about to my friends.
30. I do not spend more than a few minutes stuck on an environmental science question before giving up or seeking help from someone else.

Conceptual Connections / Memorization

6. I do not expect the rules of environmental science principles to help my understanding of the ideas.
8. If I get stuck on answering an environmental science question on my first try, I usually try to figure out a different way that works.
11. If I want to apply a method or idea used for understanding one environmental science problem to another problem, the problems must involve very similar situations.
15. To learn environmental science, I only need to memorize facts and definitions.
19. The subject of environmental science has little relation to what I experience in the real world.
23. There is usually only one correct approach to solving an environmental science problem.
31. Environmental science principles are just to be memorized.
32. For me, environmental science is primarily about learning known facts as opposed to investigating the unknown.

Problem-solving Strategies

7. To understand environmental science, I sometimes think about my personal experiences and relate them to the topic being analyzed.
8. If I get stuck on answering an environmental science question on my first try, I usually try to figure out a different way that works.
20. There are times I think about or solve an environmental science question in more than one way to help my understanding.
22. When studying environmental science, I relate the important information to what I already know rather than just memorizing it the way it is presented.

Reasoning

8. If I get stuck on answering an environmental science question on my first try, I usually try to figure out a different way that works.
14. Learning environmental science changes my ideas about how the natural world works.
16. Reasoning skills used to understand environmental science can be helpful to my everyday life.
17. It is a valuable use of my time to study the fundamental experiments behind environmental science ideas.
24. When I am not pressed for time, I will continue to work on an environmental science problem until I understand why something works the way it does.

Questions that don't fit but we'd like to keep.

4. Knowledge in environmental science consists of many disconnected topics.
13. It is important for the government to approve new scientific ideas before they can be widely accepted.
26. Mathematical skills are important for understanding environmental science.
29. The general public misunderstands many environmental science ideas.

APPENDIX E

GRADES SURVEY CATEGORIES

BELIEFS
I feel that grading at school is fair.
I feel that my grades in my classes accurately reflects what I know.
I feel that my grades are higher than my amount of understanding of the material.
(Example: I have an A, but I really don't understand most of what is taught in class)
I feel that my grades are lower than my amount of understanding of the material.
(Example: I have a D, but understand everything or most of what is taught in class)
Grades should be based on what I know and can do in a class.
Grades should be based on what I know and can do in a class and how much work I complete.
Grades should be based on how much work I complete.

PURPOSE
Grades me how well I am doing in a class.
Grades tell me what I need to do to succeed in a class.
Grades tell me how much I have grown in a class.
Grades tell me where I am in comparison to other students.
Grades tell me what kind of person I am.

IMPACT
Grades are rewards for good performance.
Grades are punishment for poor performance.
Grades control a student's future options.
The primary purpose of grades is to ensure that high standards of education are maintained.
The primary purpose of grades is to benefit students.

PROCESS
Grades are based on teacher judgment.
Grades are based on objective measurement.
Students earn grades.
Teachers give grades.
Student performance determines the grade; teachers just record the grades.
Grades show how much work a student has completed.
Grades are based on fixed standards.
There is a close relationship between student effort in a class and the student's grades.

VALIDITY
Grades are arbitrary symbols assigned by teachers.
Grades are negotiable – they can be change by discussing the situation with the teacher.
Grades usually do not correspond with how much a student has learned.
Grades are certification that a student has mastered course content.
Grades are meaningless tokens that are just handed out.
Grades accurately reflect the quality of student performance.
Grades are merely an indication of student learning.

APPENDIX F

RE-ASSESSMENT CHECKLIST

RE-ASSESSMENT CHECKLIST

NAME: ______________________________

DATE: ________________

LEARNING STANDARD : ____ ORIGINAL SCORE: _______

PROPOSED RE-ASSESSMENT DATE: _______________ TIME: ______________

What error(s) were made in your previous attempt(s) for this learning target?

Reflection statement that describes the work you completed to prepare for this re-assessment.
Identify resource(s), practice items, and locations of these items.
(ADDITIONAL RESOURCE ENTRY SPACES ON BACK OF FORM)

(back of form)

RESOURCE 1: _____________________________________ ITEM(s): ________________________________

LOCATION(s): ____

REFLECTION:

RESOURCE 2: _____________________________________ ITEM(s): ________________________________

LOCATION(s): ____

REFLECTION:

RESOURCE 3: _____________________________________ ITEM(s): ________________________________

LOCATION(s): ____

REFLECTION:

APPENDIX G

STUDENT INTERVIEW QUESTIONS

LEARNING QUESTIONS
Tell me about your science class this year. What do you like about the class? Why?

Tell me about how you normally learn new things.
What are some of the steps along the way to understanding something new?

Some people identify three ways to describe learning as:
(1) PRODUCT - to what extent students are able to correctly perform a task, and
(2) PROCESS - to what extent students are able to correctly show how to do, and
(3) PROGRESS - to what extent students have developed and/or refined their abilities within domains (1) and (2).
How important is each of these aspects to your learning? Why?

GRADING QUESTIONS
Tell me about standards-based grading in this class. What do you like about it? Why?

Has standards-based grading changed the way you approach learning? In what ways?

Some people identify three ways to describe learning as:
(1) PRODUCT - to what extent students are able to correctly perform a task, and
(2) PROCESS - to what extent students are able to correctly show how to do, and
(3) PROGRESS - to what extent students have developed and/or refined their abilities within domains (1) and (2).
How does standards-based grading address these components (or not address these components)?
How has your experience of standards-based grading changed your perception of these learning criteria?

APPENDIX H

PROBLEM-SOLVING STRATEGIES PAIRED t-TEST RESULT

PROBLEM-SOLVING STRATEGIES PAIRED t-TEST RESULT

PROBLEM-SOLVING STRATEGIES FAVORABLE RESPONSES: PAIRED t-TEST

PRE	**POST**
50	75
0	75
75	100
75	100
25	75
100	100
75	100
75	75
50	100
100	100
25	75
50	100
50	50
100	100
75	50
25	100
75	75
75	75

t-Test: Paired Two Sample for Means

	PRE	***POST***
Mean	61.1111111	84.7222222
Variance	825.163399	304.330065
Observations	18	18
Pearson Correlation	0.28530818	
Hypothesized Mean Difference	0	
df	17	
t Stat	-3.449041	
P(T<=t) one-tail	0.00153223	
t Critical one-tail	1.73960673	
P(T<=t) two-tail	0.00306446	
t Critical two-tail	2.10981558	

APPENDIX I

GRADE PROCESS PAIRED t-TEST RESULT

GRADE PROCESS PAIRED t-TEST RESULT

GRADE PROCESS UNFAVORABLE RESPONSES

PRE	POST
25.00	37.50
25.00	25.00
12.50	12.50
25.00	25.00
37.50	37.50
50.00	37.50
0.00	37.50
37.50	50.00
25.00	0.00
25.00	50.00
12.50	12.50
37.50	62.50
37.50	37.50
0.00	12.50
25.00	37.50
12.50	62.50
25.00	62.50
37.50	50.00

t-Test: Paired Two Sample for Means

	PRE	*POST*
Mean	25	36.1111111
Variance	183.823529	347.222222
Observations	18	18
Pearson Correlation	0.36380344	
Hypothesized Mean Difference	0	
df	17	
t Stat	-2.5298221	
P(T<=t) one-tail	0.01079344	
t Critical one-tail	1.73960673	
P(T<=t) two-tail	0.02158688	
t Critical two-tail	2.10981558	

APPENDIX J

GRADE VALIDITY PAIRED t-TEST RESULTS

GRADE VALIDITY PAIRED t-TEST RESULTS

VALIDITY UNFAVORABLE RESPONSES

PRE	POST
42.86	28.57
0.00	0.00
14.29	0.00
0.00	0.00
14.29	14.29
28.57	28.57
0.00	0.00
14.29	28.57
57.14	0.00
42.86	0.00
28.57	14.29
28.57	0.00
28.57	28.57
0.00	0.00
28.57	14.29
42.86	14.29
28.57	28.57
28.57	28.57

t-Test: Paired Two Sample for Means

	PRE	*POST*
Mean	23.8095238	12.6984127
Variance	288.115246	165.399493
Observations	18	18
Pearson Correlation	0.29329423	
Hypothesized Mean Difference	0	
df	17	
t Stat	2.61301911	
P(T<=t) one-tail	0.00909173	
t Critical one-tail	1.73960673	
P(T<=t) two-tail	0.01818347	
t Critical two-tail	2.10981558	

VALIDITY FAVORABLE RESPONSES

PRE	POST
14.29	42.86
71.43	100.00
85.71	100.00
42.86	42.86
71.43	85.71
57.14	57.14
85.71	85.71
57.14	71.43
14.29	42.86
42.86	42.86
14.29	57.14
14.29	57.14
57.14	57.14
100.00	85.71
57.14	42.86
42.86	57.14
28.57	42.86
71.43	57.14

t-Test: Paired Two Sample for Means

	PRE	*POST*
Mean	51.5873	62.69841
Variance	723.6228	411.4979
Observations	18	18
Pearson Correlation	0.741876	
Hypothesized Mean Difference	0	
df	17	
t Stat	-2.61302	
P(T<=t) one-tail	0.009092	
t Critical one-tail	1.739607	
P(T<=t) two-tail	0.018183	
t Critical two-tail	2.109816	