

THE IMPACTS OF STUDENT-CENTERED TEST REVISION IN AN
ADVANCED PLACEMENT PHYSICS CLASSROOM

by

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ABSTRACT

This action research study investigated the effects of implementing active, student-centered test corrections on long-term content knowledge and student confidence in an Advanced Placement Physics 1 classroom. The treatment process of active test corrections was compared to the previous post-test process utilizing lecture-based test feedback provided by the teacher. Data collection methods involved pre- and post-test revision content assessments, Likert surveys, open-ended student surveys, and teacher observations. Results showed significant growth in both long-term content knowledge retention as well as student confidence. This study suggests that test corrections effectively supported students in error correction and growth towards content mastery, leading to greater feelings of success and competence among students in advanced science courses.

CHAPTER ONE

INTRODUCTION AND BACKGROUND

Context of the Study

I have taught Advanced Placement physics classes throughout my 13 years as a high school teacher, including Advanced Placement Physics 1 for as long as the course has been offered. I teach at Hanover Park High School, a public school serving students in East Hanover and Florham Park, New Jersey. These communities are affluent, and the district has high levels of parental involvement, student motivation, and pressure to succeed. The AP Physics 1 course that I teach is a first-year physics course targeted to the highest-achieving juniors in the high school. These students often have course loads filled with Honors and AP-level courses, participate in several extra-curricular activities, and expect to continue their academic success in AP Physics. One of the challenges I have always struggled with in teaching this course is in assessment scoring. The scoring of the year-end AP exam has used very low cutoff scores when assigning passing grades of 3, 4, or 5 to students (College Board, 2024). This means that expectations on AP-level assessment are drastically different than typical classroom assessments. A raw score of roughly 38% yields a passing grade of three on an AP Physics 1 exam when it would be a shocking failure in a typical education setting. The highest AP score of 5 is earned with any raw score over approximately 72%, which is a score lower than most of the high-achieving population enrolled in the course may have ever scored on a science assessment in previous courses (College Board, 2024).

It was suggested in my AP training that exposing students to AP-style questions and expectations throughout course assessments is incredibly beneficial in producing high scores on

the end-of-year exam. I have found this to be a successful method overall when it comes to my students' preparation and results for the AP exam. However, aligning the two drastically different grading expectations between raw test scores and curved traditional assessment scores that are entered into a gradebook has been a challenge. Typically, AP teachers curve assessments designed with AP-style questions to address this difference in score alignment. However, the shock of seeing a low raw score is demoralizing and demotivating to students. These emotional responses can undermine confidence and long-term engagement with physics content, which is why I began considering a more student-centered approach to reviewing assessments. A grade of 50% on a classroom test means that the student knew only half the material on the assessment, and if a student repeatedly receives scores in that range, they begin thinking that they are not capable of learning or succeeding in science even though those scores would comfortably pass the AP exam with a successful score of 3. Reassurances to students that a low raw score is a successful one on a future AP exam rarely holds meaning for students who have put significant effort into studying for a challenging classroom test. Fostering a mindset of growth and improvement instead of having these assessments be a roadblock to student progress is a major factor in implementing this study.

I am also concerned about the potential lack of reflection and improvement that happens when reviewing an assessment after it is returned to students, and the potential effects this has on long-term content knowledge retention. I typically return assessments to students and review the questions and how to solve them in an almost entirely teacher-driven method. I encourage student questions but often notice low participation levels. I am concerned that students do not benefit from this type of review in correcting errors in content or problem-solving process from

the test, especially in a course with a cumulative end-of-year exam. Compounding observed issues in my assessment process is that AP style assessments often have time pressure where students look back at their work during test review and realize that they knew the answer to a question, or the science behind it, but did not correctly communicate their understanding on the test. This leads me to believe that there is an opportunity to address test-taking and problem-solving skills that I may not be taking advantage of with my current post-assessment process. I have always wished I had a better solution to help students focus on the large amount of physics that they do know, reinforce positive views of their science ability, and better identify growth opportunities for future assessments, all without sacrificing the benefits of the AP-style exams. The purpose of this study was to investigate the effects of implementing a student-centered, active assessment revision process on long term content knowledge and student confidence in my AP Physics 1 classes at Hanover Park High School.

I completed my action research project during the third marking period (second semester) of my AP Physics course. By this point in the year, students have taken four to five large AP-style unit tests. Students have a good sense of their typical performance on AP-style assessments and have developed a self-assessment of their competence in the subject. The tests students have taken in the first semester was followed with my typical teacher-led test review process where I reviewed the correct answers to the assessment, common themes I noticed in student errors, and offered an opportunity for questions. The tests have been curved to better align the AP expectations with typical classroom expectations. During the action research project, data was collected using a variety of methods to assess this teacher-driven review process as it was implemented for tests in semester two. A student-centered revision process was then

implemented for subsequent exams, and data was collected again to assess this process. By this point in the year, students have formed habits and self-perceptions that can make this shift to student-centered review especially impactful.

Focus Question

My focus question was, How does implementation of a student-centered test revision process impact learning outcomes in an AP Physics classroom?

My sub-questions include the following:

1. How does a student-centered test revision process impact students' long-term content knowledge retention?
2. Does participation in a test revision process affect student confidence in physics?

CHAPTER TWO

CONCEPTUAL FRAMEWORK

Introduction

The importance of reflection, revision, and continuous formative assessment in physics classrooms is a central theme in published educational research on the topic. Several educators have documented attempts to apply the benefits and growth opportunities offered by formative assessment to typical summative examinations with positive observational results. However, few studies have methodically collected data to measure long-term growth in learning outcomes or effects on student confidence or attitudes towards science.

Assessment in Physics

An effective physics classroom should be one where students not only learn fundamental laws and content of the discipline but also grow and practice their analytical and problem-solving skills. A well-designed curriculum should feature assessment that measures and provides feedback on both goals. The Next Generation Science Standards exemplify this approach to science education through promotion of a three-part model encouraging curriculum design that covers not just *Disciplinary Core Ideas*, but also skills-based *Science and Engineering Practices* and thematic *Cross-Cutting Concepts* (NGSS Lead States, 2013). The NGSS standards have been widely adopted as baseline science standards in states across the country, including in New Jersey where this study was implemented (New Jersey Department of Education, 2020). Advanced Placement courses build on NGSS ideas with additional standards that continue the approach of stressing both specific content and thematic, skill-based *Science Practices* (College

Board, 2024). Assessment in courses should measure student progress and proficiency in achieving these standards. Valid and effective science assessments should also provide evidence that students have successfully addressed any misconceptions that they held at the beginning of the learning period (Resbiantoro, 2022). The wide variety of skills, content, and growth that must be assessed to demonstrate mastery of a topic in alignment with course standards can therefore make summative science assessments challenging for students (Kibble, 2017). Keeping the desired outcome of assessment in mind while designing learning experiences is a central tenet of the Understanding by Design model (Wiggins & McTighe, 1998). The student-centered test revision implemented in this study directly supports this framework by using summative assessments as intentional learning opportunities that return students to the key conceptual and skill-based goals of the unit. Strengthening alignment between assessment, feedback, and the intended learning outcomes should be a central and frequent goal for an educator in lesson design throughout a course.

There are two main types of assessment that should be implemented in effective course design. Formative assessment is critical for building long-term student understanding and is a key part of a constructivist learning approach which benefits both teacher and student. These formative assessments should be implemented frequently and centered on providing feedback designed to enable student improvement. Eventually, students take summative assessments that measure their proficiency in both science skills and content knowledge mastery across a unit or course, and these summative assessments can carry high stakes and cause significant student anxiety (Angelo & Zakrajsek, 2024). Malespina and Singh (2022) agree, specifically citing the effects of these assessments on student self-efficacy and motivation, especially with female

students. Henderson and Harper (2009) also add a discussion of the increased frequency of these summative assessments in advanced high school courses and the frequent lack of feedback offered to students after completing these summative assessments. This lack of feedback can further exacerbate student motivational concerns if students achieve low scores (Henderson & Harper, 2009). Guskey (2010) addresses these concerns by describing how these summative assessments can still be part of the learning process through implementation of mastery learning, which applies the same feedback and frequent reassessment characteristics of formative assessments to typical summative assessments. Guskey and Henderson and Harper both stress the negative impacts of moving forward in curriculum without addressing skill and content issues that arose on mid-course assessments. Reflection and growth opportunities are therefore a critical, and often overlooked, aspect of effective assessment design.

Value of Reflection in Learning & Assessment

Student reflection and self-evaluation of their work is a critical component of effective learning and should be applied throughout the learning process to foster growth. This emphasis on reflection and improvement has gained a more mainstream view among teachers and students, but older beliefs that discouraged errors and reflection are still prevalent among some teachers and in many student perspectives (Metcalf, 2017). Black and Wiliam (1998) also stress the importance of rejecting an expectation of error-free student work in describing the importance of formative assessment for student growth, including the critical role of feedback on all aspects of learning. This feedback should be designed to turn student errors, misconceptions, or incomplete mastery into growth opportunities. The lack of this type of feedback has especially harmful effects on lower-achieving students who can view low scores as evidence of an inability to learn

or improve (Black & Wiliam, 1998). Metcalfe (2017) agrees with Black and Wiliam as she describes modern research demonstrating that student errors in course ideas are a critical part of the learning process, provided that these errors are addressed with corrective feedback. Students' ability to self-assess and reflect on error in their thought process is a particularly critical skill for success in higher level courses (Stanton et al., 2021). Making and correcting errors "enhances later memory for and generation of the correct response" (Metcalfe, 2017, p. 484), which is consistent with Stanton's (2021) advocacy for instructor aid in helping students develop metacognitive strategies to build processes for self-correcting errors. Halmo et al. (2024) also provide evidence that students with effective metacognitive and reflective strategies achieve higher success in science courses and agree with Stanton that development of these strategies should be an intentional goal in science courses. Halmo et al. demonstrate that these metacognitive abilities help students persist through challenging problems when errors are made or roadblocks are reached in problem solving, consistent with Metcalfe's discussion of the value of student error commission and correction. Metcalfe also identifies the value of a lower-stakes error and correction process in increasing performance in later higher-stakes assessments. Taken together, modern literature is clear on the benefits of allowing students to take risks and commit errors in fostering development of higher-level analysis and problem-solving skills. It is therefore incumbent for teachers to find a way to encourage student errors, and their correction, in a safe way that leads to deeper understanding.

Physics teachers can use student errors and preconceived notions as a valuable part of the learning process. Resbiantoro et al. (2022) identify both a challenge and opportunity for course design in physics classrooms when tackling these student misconceptions. Students enter physics

courses with preconceived ideas about how to explain natural phenomena they have observed throughout their life, and these ideas are often in conflict with correct application of the laws of physics (Brookes et al., 2020). Students must break their misconceptions and rebuild a new understanding of the content consistent with correct physics to achieve mastery (Resbiantoro et al., 2022). Both Resbiantoro et al. (2022) and Brookes et al. (2020) promote remediation of misconceptions and erroneous thought process through student construction of correct ideas through discussion, experimentation, and feedback, the pillars of formative assessment. Once this process of formative error revision has been completed across a learning period, summative assessment occurs and should measure student proficiency and mastery (Angelo & Zakrajsek, 2024). A concrete application of summative assessment treats it as the end of the learning process, but for summative assessments given throughout a course there is still time to implement further error revision opportunities and achieve continued student learning and growth.

Using the Summative Assessment as a Learning Tool

Unit summative exams can be a valuable learning tool if teachers and students view them as continued learning opportunities. Henderson and Harper (2009) share a view of student work on an exam as a record of the students thought process and problem-solving ability, and exam scoring as an identification of gaps or flaws in that thinking. Benson and Zhu (2015) describe summative assessments in a similar way, portraying these assessments as tools to measure mastery, not just specific aspects of a lesson in the way that formative assessment is often used. Guskey (2010) cites the importance of offering feedback and revision opportunities on summative assessments as a critical component of mastery learning. This process of revision can

increase student motivation and lead to higher student success in course outcomes (Guskey, 2010). Henderson and Harper note that most students initially are only concerned with their overall grade when a summative exam is returned and do not meaningfully reflect on the exam content or instructor-delivered feedback. This mindset is addressed by Henderson and Harper through offering student-driven grade improvements for meaningful reflection and error correction on exams, which they observed lead to conceptual growth and success on standardized tests. Weiman et al. (2014) find similar results using a two-stage exam process where students first complete their exams individually and then discuss questions in collaborative groups. A major finding in this study was the positive observations of depth of student discussion on exam topics that helped lead to student reflection and metacognition on their problem-solving approaches (Weinman et al., 2014). Benson and Zhu also found similar results when asking students to correct exams in an introductory-college level course, stressing the importance of identification of gaps in knowledge when assessed via a traditional summative assessment. Libertini et al. (2016) adds a discussion of the specific growth opportunities afforded to lower-achieving students when correcting an exam, as well as improvement of effective study and exam preparation habits for all students. Taken as a group, the studies cited above make clear the benefits of encouraging reflection and correction on exam results as a valuable learning tool. While carried out in different ways, all the authors provided evidence for successful implementation of a reassessment strategy in science classes. This study implemented similar revision and reassessment opportunities in hopes of achieving the same successful outcomes.

Reassessment protocol in the classroom can be implemented in several formats, each designed to achieve specific goals and address certain challenges with the process. Henderson

and Harper (2009) assigned exam corrections as a take-home assignment, requiring a statement explaining the error to ensure students were actively reflecting on their thought process instead of simply copying correct answers. Significant increases in conceptual understanding were noted through this process, although challenges were sometimes identified with student approaches that did not generalize the error analysis sufficiently to be meaningful (Henderson & Harper, 2009). McManus (2011) implements a similar retake method in which students complete their exam in class and are given a copy of the test to complete collaboratively outside of class. This method asks students to reflect on their work without a graded copy or feedback from the instructor, and McManus reports that students held meaningful discussion about all parts of the test, not just errors. McManus identifies a downside of this method in that both his method and Henderson and Harper (2009) sacrifice test security to encourage out-of-class student reflection, as well as allowing student copying without metacognition. Ruggerio (2022) addresses the security and copying concerns with both methods by requiring students to collaboratively reflect and evaluate on marked copies of returned tests in class and then re-take the test during the next class period. Since student reflection is happening in the classroom, instructors can monitor students and measure effort. Ruggerio reports high levels of engagement and quality discussions similar to Weiman et al. (2014), who offered a two-stage exam without instructor feedback.

Several educators have noted specific improvements in lower-achieving students when implementing reassessment strategies. Kemp (2021) implemented an optional correction opportunity that took place outside of the classroom and found significant improvement in lower-achieving students and only weak correlation between test correction and improvement in higher achieving students. This study suggested that the increase in learning outcomes in lower

achieving students is due to improvement in metacognitive strategies effected by the corrections exercise while higher achieving students may benefit less as they are more likely to already practice these metacognitive habits (Kemp, 2021). While all correction methods encourage student reflection aiming towards mastery, McManus (2011) and Ruggerio (2022) make this an explicit requirement by requiring students to earn scores of over 95% on retake scores to receive a grade improvement and find that almost all students reach this requirement. While there are some concerns noted in the areas of test security and ensuring universal effort, the common reflection in these sources is that the student collaboration, discussion, and conceptual improvement towards mastery is clear and beneficial for long-term learning.

Conclusion

Modern educational research makes clear the myriad benefits of formative assessment in student growth and achievement of learning outcomes and reaching high educational standards. The most critical aspect of implementing effective formative assessment is ensuring that students receive feedback and can effectively reflect and implement the recommendations in the feedback. While summative assessment traditionally does not take advantage of the learning opportunities offered by formative assessment, many educators have begun implementing test revision and correction opportunities that enable students to use in-course summative assessments as beneficial learning tools. Teachers who have implemented these opportunities report positive outcomes for both students and educators, evidence of conceptual growth toward mastery, and initial data suggesting improved long-term learning. More rigorous data collection is still needed to confirm these outcomes.

CHAPTER THREE

METHODOLOGY

The purpose of this study was to investigate the effects of implementing a student-centered, active assessment revision process on long term content knowledge and student confidence in my AP Physics 1 classes at Hanover Park High School. Hanover Park High School is a public high school serving the towns of East Hanover and Florham Park, New Jersey. These are generally wealthy towns in a high cost of living area. Parental involvement, student motivation, and pressure to succeed is high. There are 697 students enrolled in Hanover Park High School. Historically the student body has had high participation and success rates in AP courses, with 192 students taking 476 exams in the 25-26 academic year and 93.75% ($N=192$) of AP test takers earning at least one score of three or above. The high school has a 96.5% ($N=697$) four-year graduation rate and a typical two- or four-year college attendance rate of approximately 90% ($N=697$) (Hanover Park High School, 2025).

I teach two sections of AP Physics 1 with 24 total students. These 24 students are the highest-achieving juniors in the school in science and are very motivated and invested in their academic success. Most of the students in my AP Physics class take several Honors and AP level courses and have extensive extra-curricular schedules in addition to rigorous academic schedules. The diversity of the class roughly reflects the diversity of the school, which has 28% ($N=697$) minority enrollment (U.S. News and World Report, 2024). There are no students with IEPs or 504s in either of the two sections of this class.

Treatment

My action research project was intended to investigate the effects of student-centered assessment revision in my AP physics classes. Prior to this action research project, I used a teacher-led assessment review process paired with grade curves derived from AP exam scoring, and I was concerned that this may not be an effective way to score and review summative assessments. This teacher-led post-assessment review consisted of returning graded and curved exams to students. This was followed by a lecture-style overview of commonly missed test questions and demonstrations of how to solve the problems on the tests. Student questions were encouraged, but generally infrequent, and overall student engagement was low. My action research project investigated if replacing this teacher-centered plan with student-centered active test correction was a more effective process.

The student-driven revision process implemented as the treatment in this study began with returning graded tests to students, but without any markup revealing correct answers. Students were instructed that instead of a curve, they would receive half-credit back for successful correction of their test (defined as reaching at least a 90% when the test was re-graded). Students were required to give a written explanation for corrected questions and to show all work and completely re-solve corrected open-ended questions. Corrections occurred in-class during a full 42-minute period where they were encouraged to work in groups and have discussions with peers to make their corrections and revisions. I was interested in investigating the effectiveness of this change as it related to both long-term content knowledge and student confidence. I consider these two very important areas for success on the AP exam, and I hoped to improve my pedagogy through this action research investigation. The research methodology for

this project received an exemption by Montana State University's Institutional Review Board and compliance for work with human subjects was maintained (Appendix A).

Data Collection and Analysis Strategies

Data Collection Methods

I selected a variety of data collection methods as part of a mixed-methods approach to my action research. The main source of quantitative data were content assessments given before and after each of the post-assessment processes. These assessments measured growth in content knowledge after a short delay following the test review or revision. Student experiences with the two different types of post-test procedure were investigated through a variety of data collection methods, including Likert surveys (pre and post treatment), open-ended survey questions, and teacher observation. Together, these differentiated methods were designed to give a complete picture of the effectiveness of the different post-test strategies as they related to my research questions (Table 1).

Table 1. Data Triangulation Matrix.

Data Collection Instruments	Research Questions		
	Focus Question: How does implementation of a student-centered test revision process impact learning outcomes in an AP Physics classroom?	Sub-Question 1: How does a student-centered test revision process impact students' long-term content knowledge retention?	Sub Question 2: Does participation in a test revision process affect student confidence in physics?
Pre and Post Treatment Content Knowledge Assessment	X	X	
Pre and Post Treatment Likert Survey	X		X
Open-Ended Survey Questions	X	X	X
Teacher Observations	X	X	X

Instrument Justification

Pre and Post Treatment Content Knowledge Assessment.

The main instrument used to assess long term content knowledge gains was a Pre and Post Treatment Content Knowledge Assessment (Appendix B). Hake (1998) provides a foundational study showing the effectiveness of pre/post treatment content assessments in measuring gains attributable to a specific intervention. Further studies in physics education research have established matched pre and post testing as a core strategy for measuring and quantifying gains in learning (Bao & Redish, 2006; McKagan et al., 2022). The Pre and Post Treatment Content Knowledge Assessment implemented in this study consists of four free-response questions from summative unit assessments selected or modified to measure growth in content knowledge after test review. A pre and post assessment were given for each unit test (Figure 1).

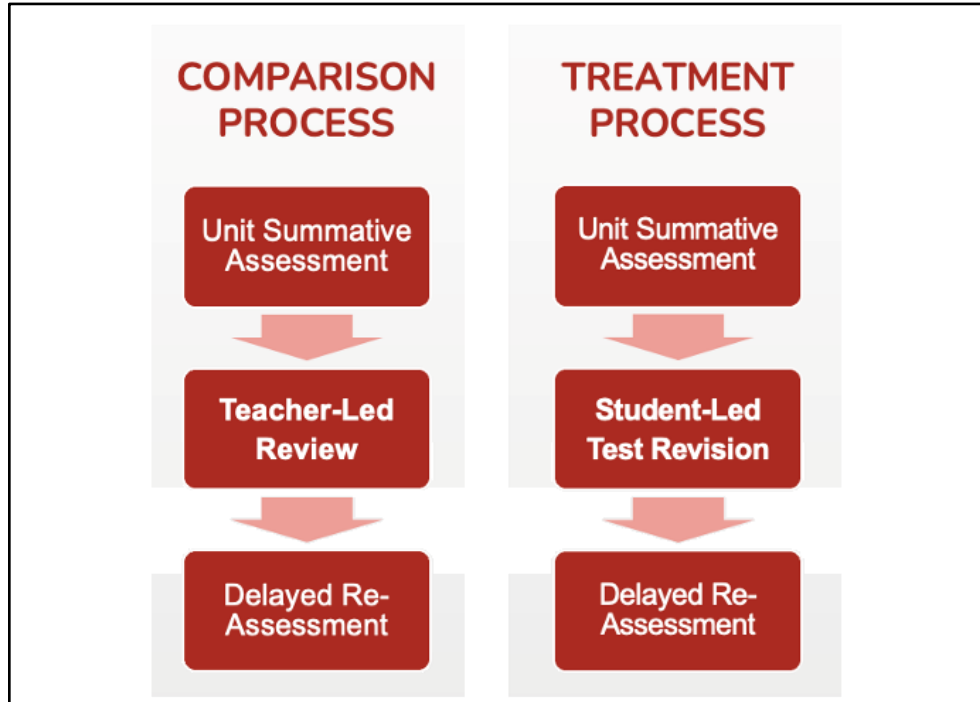


Figure 1. Pre and post assessment implementation.

The first data source was a selected free response question from a larger unit assessment that students took in class at the culmination of the rotational motion unit. After the first assessment was graded and returned to students, a teacher-led post-test review was conducted. Approximately one to two weeks after this teacher-led review, the second assessment was given to students to measure any potential gains in content knowledge proficiency from the teacher-led review. This second assessment was designed to be similar in style to the free response question selected from the unit test. Small modifications were implemented to assess growth in understanding rather than recall, aligning with Hake's (1998) emphasis on measuring conceptual learning and problem-solving ability. This process was repeated in the next unit (Energy) with a selected test free response question and delayed re-assessment. However, in this second unit an active, student-led review and revision process was used instead. This intentional instructional

intervention and matched pre & post intervention assessments allows for direct measurement and quantification of students' conceptual content mastery, directly supporting my first sub-question.

Pre and Post Treatment Likert Survey.

A Pre & Post Treatment Likert Survey (Appendix C) was used to collect data relevant to both of my sub-questions. The survey was designed to be given immediately after both types of post-test review sessions to capture student self-assessment while the review process was fresh in their minds. Care was taken in designing this survey to avoid bias in wording that may have prejudiced respondents towards a certain answer, and the neutral option was removed from the survey to force students to select either an agree or disagree-based answer (Giroux, 2017). Survey questions assessed two primary areas: student self-confidence and the perceived effectiveness of the feedback and corrections processes.

The survey also included an open-ended question at the end, providing me with an opportunity to collect qualitative data from students. This question ("Is there anything else you would like me to know about our post-test process?") was worded as openly as possible to enable collection of data on any aspect of the review process. I value this question as it allowed collection of this qualitative data immediately after both post-test procedures, and asked all participants to provide open-ended responses that may yield valuable information beyond the more structured Likert survey.

Teacher Observations.

Observations of student discussion and behavior provided supplemental data. This was designed to yield as much evidence as possible to support the conclusions in my study.

Observations were recorded using a Student Engagement & Metacognition Observation Protocol

(Appendix E) during both types of review processes that reflected my observations on student learning and metacognition (Mertler, 2025). This was challenging when conducting a teacher-led review, but observations were recorded immediately after the class. Observations were easier to collect during the student-led revision process where I was intentionally not an active participant. I felt it was important to have a plan for what I planned to observe to ensure rigorous observation collection that is consistent across different classes (Mertler, 2025). I designed my Student Engagement & Metacognition Observation Protocol to make observations on levels of student participation, reflection, engagement, and metacognition. When students were correcting their work in the student-driven process I also made observations on how many students were getting to correct answers and the quality of content-based discussion that describes the process to reach those answers, not just the correct answers themselves. This data collection method provided some challenges due to the constraints of my study and the requirement for me to lead the first review process, but it did provide additional qualitative data that adds a teacher and content expert view on the review process.

Analysis Strategies

Both quantitative and qualitative analysis strategies were used to provide a complete mixed-methods analysis of the data collected.

Quantitative Data Analysis Strategies

Quantitative data analysis was used to analyze the result of the pre- and post-treatment content assessments. Normalized gains were calculated for each unit's pre and post review assessments to measure any improvement in scores between the two tests (Hake, 1998; McKagan

et al., 2022). The gains from the two different review methods were then compared using a Wilcoxon Signed-Rank test to determine if there was a significant difference. This test was selected based on the small sample size and non-normal distribution (Zimmerman, 1997; Corder & Foreman, 2014). This provided direct evidence to help answer my sub-question investigating effects of student-centered review on long-term content knowledge.

Frequency analysis was conducted on the individual Likert question results to visualize differences in the responses after each type of review (Bartley & Bowen, 2014). This frequency analysis provided quantitative data for both research sub-questions. The data for the confidence questions in the survey (Items 1, 2, 3, and 7) provided the main quantitative data source for that sub-question, while the process utility questions (Items 4, 5, 6, and 8) were the source of supplemental data to be combined with the results of the pre- and post- treatment content knowledge assessment. Data for each of the two groups of Likert results were aggregated for both pre- and post-test surveys. A Mann-Whitney U-Test was performed for each subset to measure potential differences in the results (Boone & Boone, 2012).

Qualitative Data Analysis Strategies

Qualitative data analysis strategies were used to supplement the quantitative results from the content assessment and Likert surveys. Thematic coding and analysis were used on the open-ended survey questions (Jensen & Laurie, 2017), and frequency analysis was then conducted on the themes revealed by the thematic coding (Kirk, 2017). My hope was for this qualitative data to be useful in revealing reasons and themes that help explain the quantitative statistical results measured from other data collection instruments. These methods and analysis strategies were designed to create a comprehensive picture of student experience and learning that is supported

by as much evidence as is possible to collect in a limited classroom study. Having both quantitative and qualitative sources of data allowed for richer and more robust conclusions to be drawn from the study despite limits inherent in the research setting from low sample sizes (Mertler, 2025).

CHAPTER FOUR

DATA ANALYSIS: CLAIMS AND EVIDENCE

Results

Data analysis conducted following the treatment period demonstrated significant improvement in both long-term content knowledge retention as well as student confidence. Analysis was conducted using both quantitative and qualitative methods to triangulate conclusions of the study. Statistical results from pre- and post-tests strongly aligned with qualitative data from surveys and teacher observations.

Content Knowledge Retention

Implementation of an active test correction process increased students' long-term content knowledge retention. Student assessment scores increased in both the comparison process (re-assessment after passive lecture-style feedback) as well as the treatment process (re-assessment following active test revision and corrections). However, the amount of improvement was much larger following the test correction process (Figure 2). The distribution of re-assessment scores was also much narrower following the treatment process, demonstrating that the intervention was much more effective in score improvement for all students. Seventeen out of 18 students (94%) participating in this study demonstrated higher gains for the treatment process vs. the comparison process.

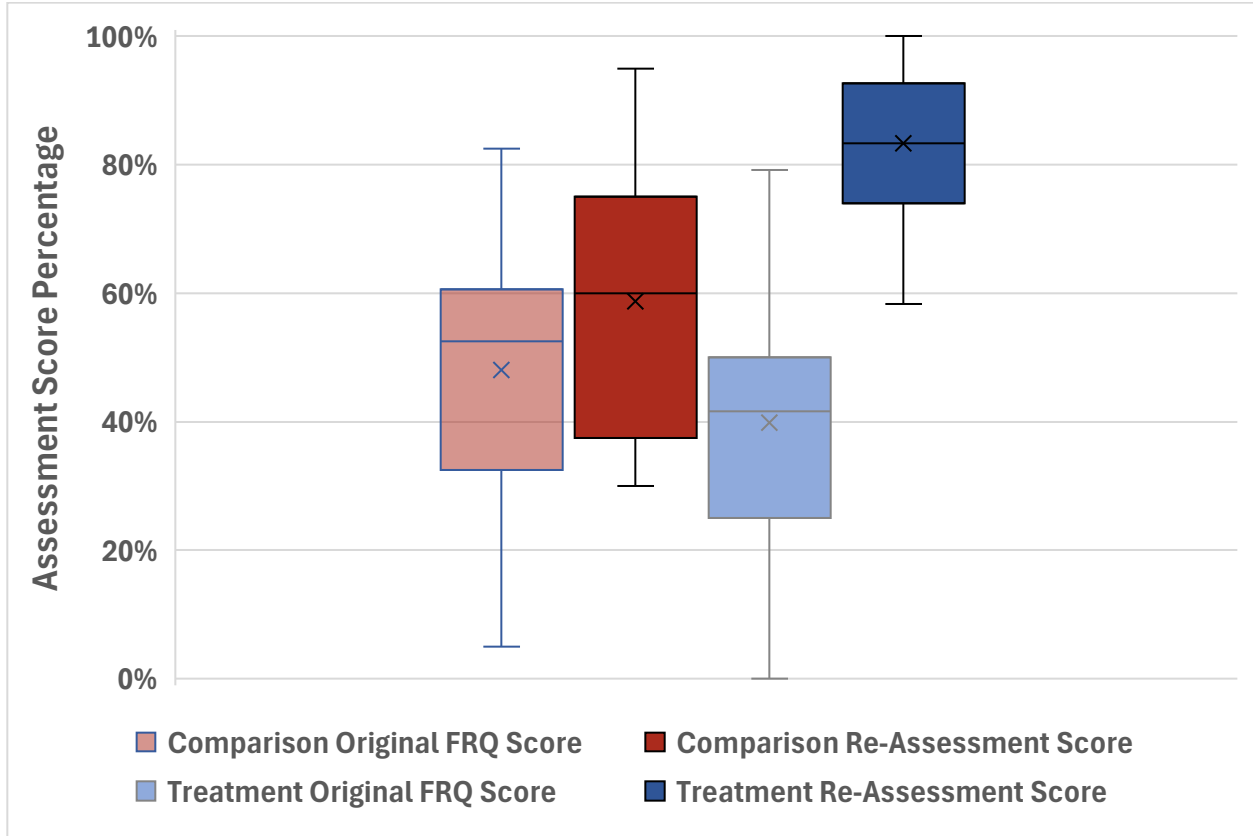


Figure 2. Student assessment results for original FRQ and delayed re-assessment, ($N=18$).

Normalized gains calculated on the comparison and treatment processes also showed significant improvement for the treatment process (Figure 3). During the comparison process, 33% of students ($N=18$) demonstrated either negative gains or no gain on the delayed re-assessment, while all students achieved positive gains following the treatment process. The median gain percentage improved from 14% for the comparison process to 76% for the treatment process. The significant improvement in normalized gains is particularly evident at the lower end of the score distributions. The minimum gain for the treatment group was 41%, compared to -22.7% for the comparison group. Notably, this 41% minimum would have ranked in the upper quartile of the comparison distribution.

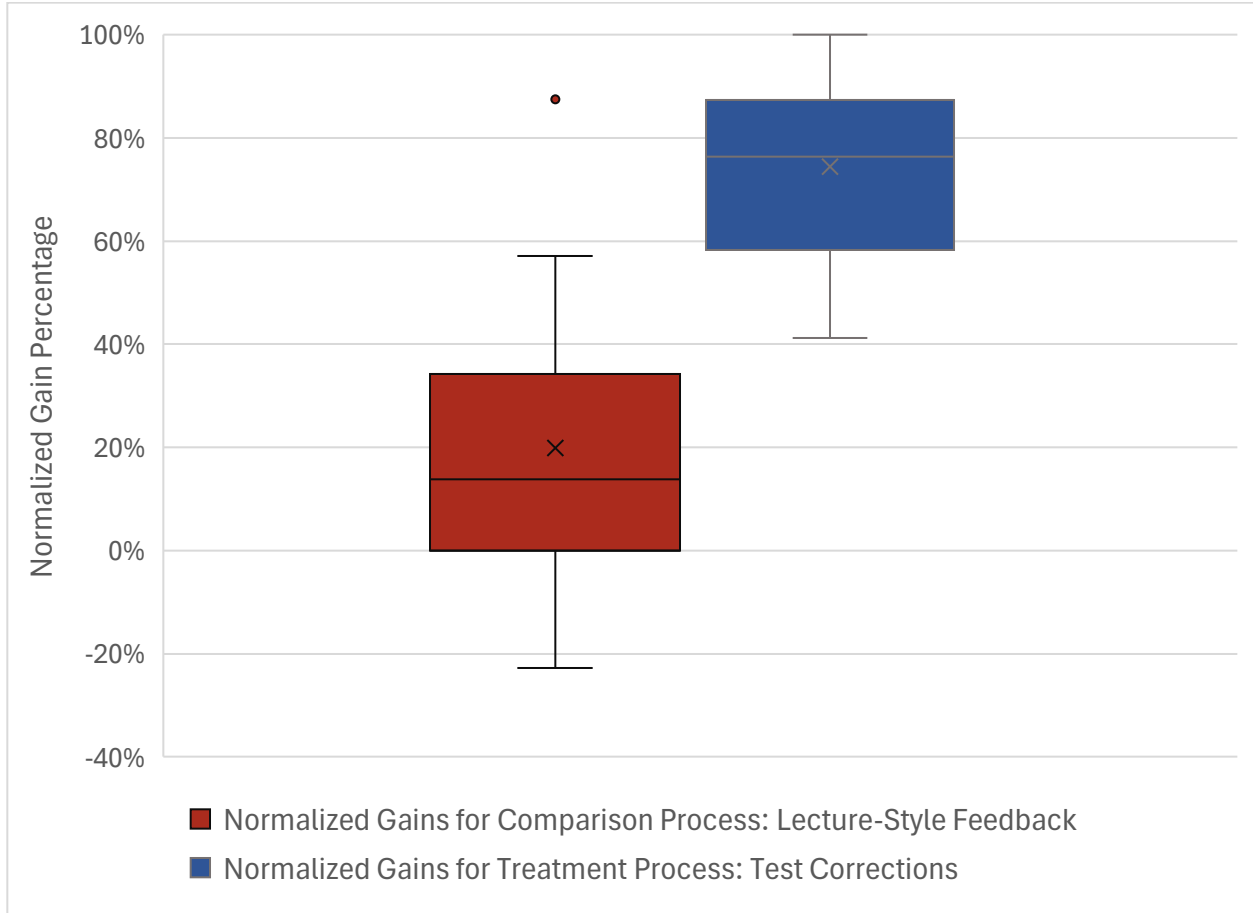


Figure 3. Normalized gains percentages for comparison and treatment process, ($N=18$).

A Wilcoxon Signed-Rank test returned a p-value of 0.00023, much lower than the $\alpha=0.05$ threshold for statistical significance. This allows the null hypothesis to be rejected and provides solid statistical support for a meaningful increase in grade improvement following the treatment process.

Teacher observations help to provide some potential reasons for this larger gain with the treatment process. During the lecture-style feedback of the comparison process, only a minority of students actively participated by asking questions. Twenty-five percent of students in my first class period ($n=8$) asked questions during the feedback process and 20% ($n=10$) in my second

class period. During the treatment process, 100% of students across both sections ($N=18$) actively participated and asked questions of their peers. In addition to the majority of students not asking questions during the lecture-based comparison process, 50% ($n=8$) of section 1 students and 60% ($n=10$) of section 2 students demonstrated distracted or otherwise unengaged looks or behaviors at some point during the process. While there was variance in the number of questions asked by students during the treatment process, all students ($N=18$) did actively participate and engage with their peers throughout the entire time allotted. The questions asked by students in both methods were relevant to their own test answers and problem-solving process, but the significantly higher participation percentage suggests that many more students were actively engaging with their prior work. All students ($N=18$) achieved above 90% on their re-graded corrected assessments, showing both correct answers and correct error analysis. These results demonstrate the large effectiveness of the treatment process on student content knowledge retention.

Student Confidence

Student confidence was also significantly improved through implementation of the treatment process. Likert survey results (Figure 4) were aggregated into two categories: direct measures of student confidence (Items 1, 2, 3, and 7) and process utility measures (Items 4, 5, 6, and 8) that investigated the reasons behind the confidence scores. Direct measures of student confidence (aggregated in Figure 5) show an improvement from 58.3% of responses ($N=60$) answering either *Agree* or *Strongly Agree* when surveyed about the comparison process to 77.8% of responses ($N=72$) answering similarly following the treatment process. In the open-ended section of the survey, one student replied “I like the corrections and feel that it helped me feel

more confident about my grades. I like that we have another chance to get the correct answer.”

During the treatment process, teacher observations of student conversations showed frequent questioning of their peers as to the reasons behind correct answers. After receiving these explanations, students sometimes gave replies to their peers (“I knew this, why didn’t I put this down?” “I was only one little piece away from having these correct”) that indicated that they did have much of the requisite content knowledge.

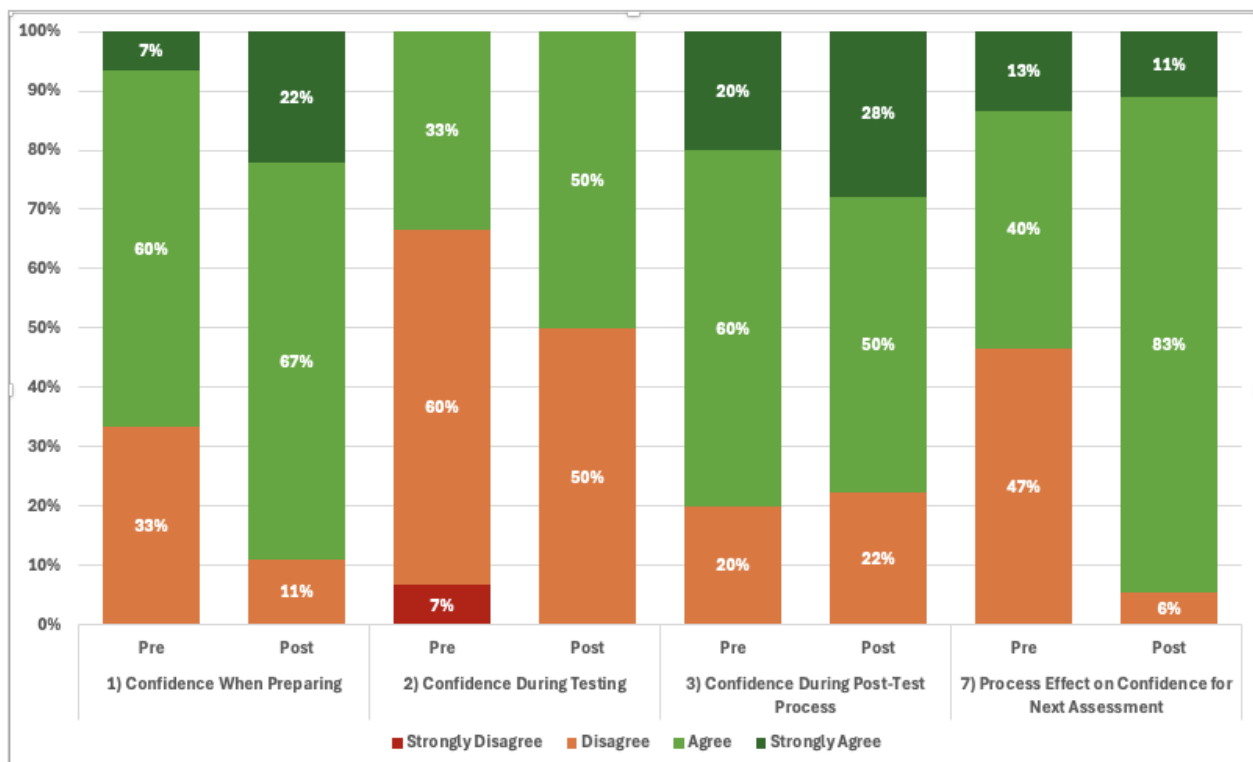


Figure 4. Likert responses for items directly measuring student confidence, ($N=15$ respondents for comparison group, $N=18$ respondents for treatment group).

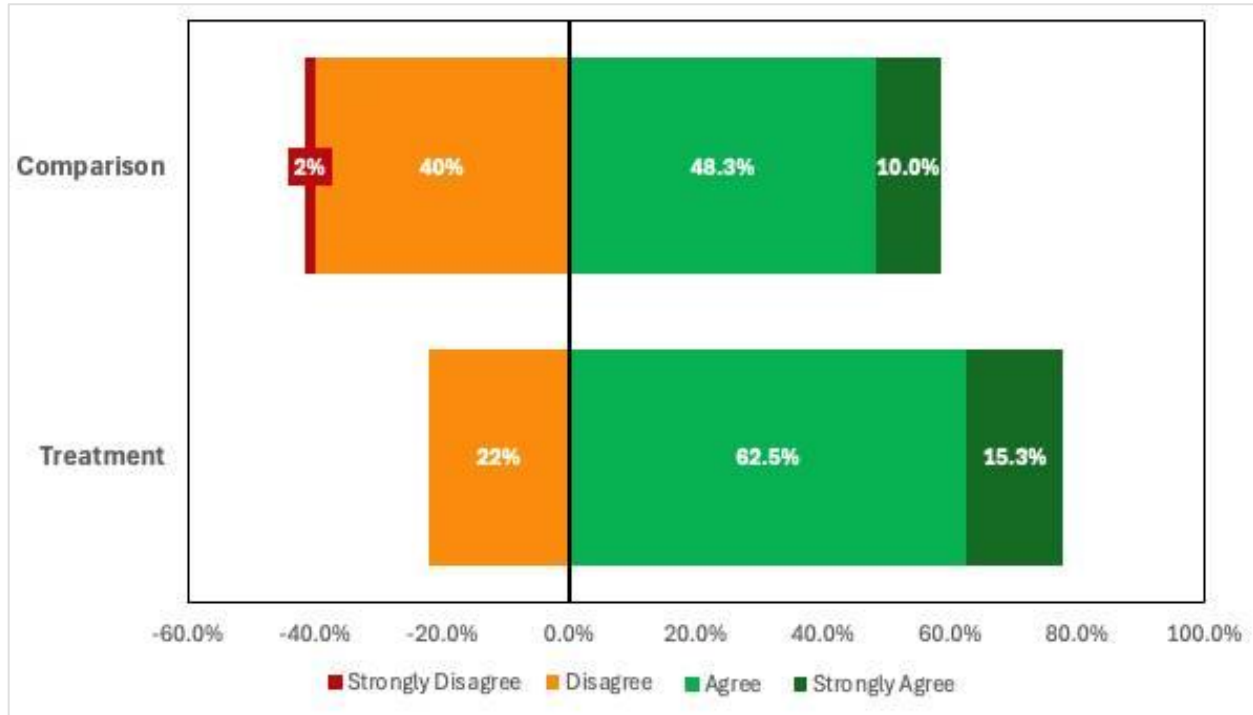


Figure 5. Aggregated Likert responses for items directly measuring student confidence, ($N=60$ responses for comparison group, $N=72$ responses for treatment group).

A Mann-Whitney U-Test performed on the aggregated confidence survey results yielded a p-value of 0.02, which is lower than the threshold value of $\alpha=0.05$. This result shows that the improvement in confidence scores is statistically significant and that the null hypothesis may be rejected.

Similar analysis was conducted on survey items 4, 5, 6 and 8, which measured process utility, defined as students' perception of the value of the post-assessment process. Results show that students found both the comparison and treatment process to be useful and worth the time spent in class, but there was higher benefit in the treatment process (Figure 6). Both processes yielded almost exclusively *Agree* or *Strongly Agree* responses, but there was a shift towards *Strongly Agree* in the treatment process (Figure 7). Comparison survey results showed 35% of

respondents ($N=60$) answering that they strongly agreed the post-assessment process was useful, and this percentage increased to 66.7% of responses ($N=72$) for the treatment process.

In the open-ended section of the survey, several students identified specific areas of the corrections process that they found useful. One student noted that correcting their test “made me think of new strategies to studying all of the content.” Another student reported that “I definitely find that I go back and notice mistakes that were made that could've been avoided” when evaluating the process. During the treatment responses, students were frequently observed asking their peers questions that targeted specific errors in their work or problem-solving process: “Why did you make this linear? [peer answers] Oh I see” or “I see #6 is supposed to be D, but why? [peer gives explanation of process] Oh that helps so much.”

There were also several survey responses that identified positive aspects of the comparison process (“I feel like after all the corrections and final grades we should go over the test as a group specifically on problems we struggled on as a class”) and requesting that future post-test processes include a mix of both methods. These responses support the positive Likert responses for both comparison and treatment methods.

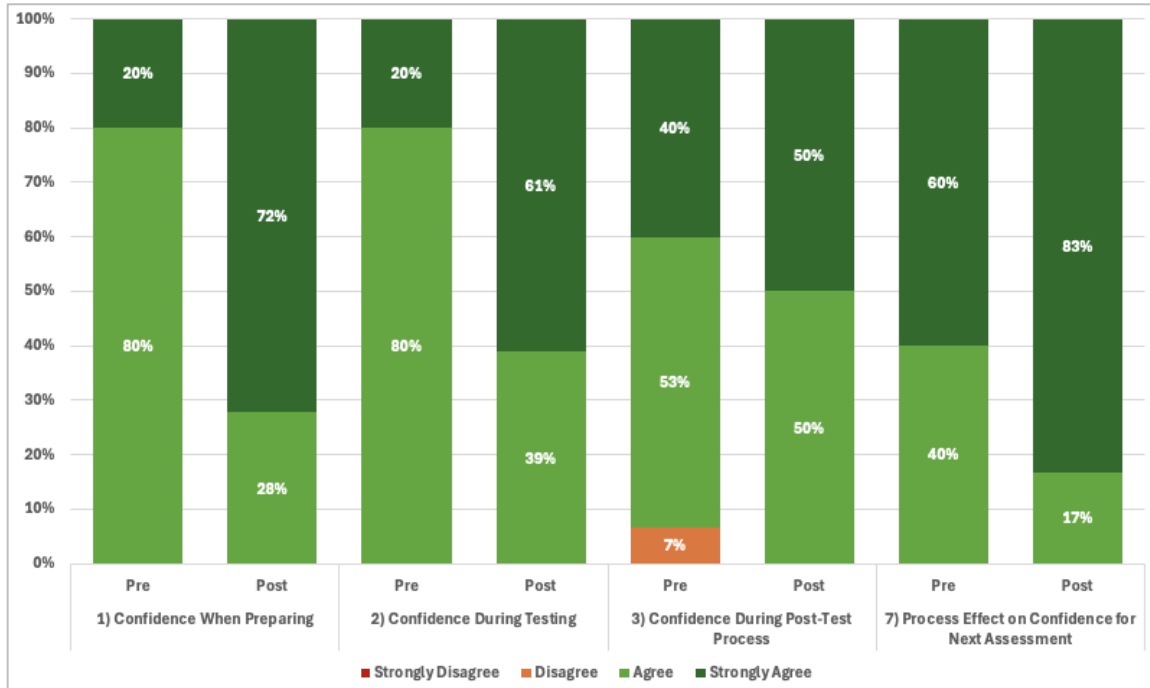


Figure 6. Likert responses for items measuring student perception of utility of post-assessment process, ($N=15$ respondents for comparison group, $N=18$ for treatment group).

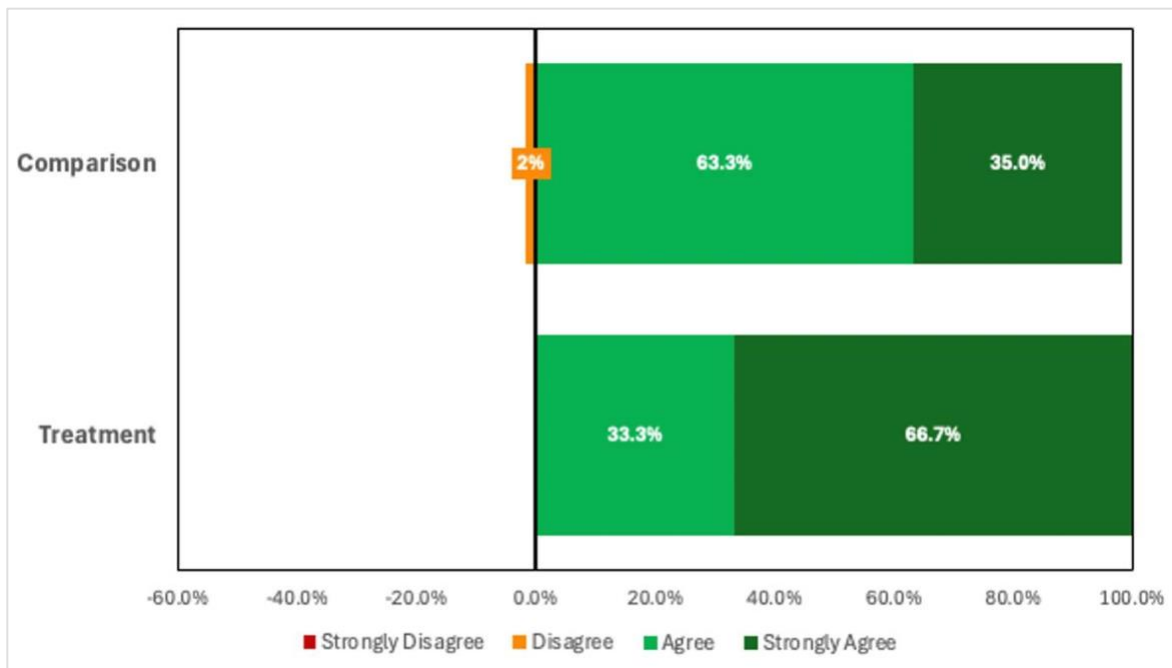


Figure 7. Aggregated Likert responses for items measuring student perception of utility of post-assessment process, ($N=60$ for comparison group, $N=72$ for treatment group).

A Mann-Whitney U-Test run on the aggregate responses for the process utility group yielded a p-value of 0.0001. This result is much lower than the $\alpha=0.05$ threshold, showing very high statistical significance in the upward shift towards strongly agree and demonstrating the increased value students placed on the test correction treatment process.

CHAPTER FIVE

VALUE: REASONING AND REFLECTION

Claims From the Study

The intent for this study was to investigate the effectiveness of replacing my existing lecture-driven post-assessment feedback process with a test corrections process. Data collected in this study showed statistically significant improvement in both long-term content knowledge retention and student confidence within my classroom setting.

Long-Term Content Knowledge Retention

Students retained significantly more content knowledge following the corrections process implemented in this study. While both the comparison and treatment process demonstrated positive mean normalized gains on delayed re-assessments, statistical analysis revealed the gains were significantly higher following the treatment process. Qualitative data such as open-ended surveys and teacher observations supported the quantitative result, showing high levels of engagement and student satisfaction with the corrections process.

The heightened engagement and questioning during test corrections may explain the significant post-treatment gains. Students engaged with peers for deep discussions about content as well as problem-solving process, and also had opportunities to reflect upon and analyze their errors in their original assessment. Correction of these errors helped to solidify correct problem-solving processes, correct misconceptions, and provided an opportunity to re-learn missing content knowledge in the context in which it was assessed. These opportunities directly align with best practices described by Resbiantoro (2022), Metcalfe (2017), and Black and William

(1998). The opportunity to use a summative assessment as a tool to facilitate continued learning is also aligned with the ideas of mastery learning (Guskey, 2010). The success of students in this study in demonstrating large improvements in long-term retention is another piece of evidence supporting the value of this type of continued learning opportunity.

Student Confidence

Measurement of student confidence in both pre- and post-treatment Likert surveys revealed students both felt more confident about the testing process following the corrections process and felt that the corrections process was more useful for their learning. Direct measures of student confidence showed statistically significant shifts towards *Agree* and *Strongly Agree* answers and much fewer *Disagree* responses. While students generally agreed that both the comparison lecture-style feedback and the treatment corrections process were useful and worth the time taken, there was statistically significant shift from *Agree* responses to *Strongly Agree* responses following the treatment process. Teacher observations and student quotes provided qualitative sources that further supported the quantitative survey results.

The grouping of Likert items into direct measures of confidence and process utility as described in Chapter 4 helps offer some reasoning for the increased confidence measurements. The opportunities to directly address individual questions and problem-solving mistakes and to ask specific questions and receive individual feedback from peers were observed several times during the correction process. These moments were commonly followed with statements like “Oh now I see” or “That makes so much sense.” These statements helped reveal the individual impact of the process on students and helping to explain why their survey results showed increases in feelings about process utility and confidence about future assessment performance.

The measured increases in student confidence are in alignment with results in the literature, specifically Henderson and Harper (2009) and Malespina and Singh (2022).

Value of the Study and Consideration for Future Research

This study offers support for changes to the typical assessment process that have many potential benefits for students. From a content-knowledge perspective, the treatment process demonstrated the effectiveness of test corrections in improving long-term knowledge and enabling continued learning as students move towards mastery, which should be a goal for all teachers. These goals are especially relevant for classes with large final summative evaluations, such as the Advanced Placement 1 exam students in this study take at the end of the course.

Improving student confidence on high-pressure assessments is also an incredibly important factor for achieving student success. Students are continuously facing increased pressure to succeed on high-stakes standardized exams and to achieve high grades in advanced coursework and often put enormous pressure on themselves for success. Not achieving high scores, even in a difficult subject such as Advanced Placement Physics, can have strong negative effects on students' self-perception of success in a field. Enabling students to feel more confident for future assessments helps them build skills not just in regard to test taking but also in the actual content mastery and problem-solving ability and allows them to consider further study in a subject they may not otherwise have considered. Taken together, the positive effects demonstrated in this study on both content knowledge retention and student confidence reinforce the large value that a test corrections process can offer a teacher concerned with students' performance in a challenging academic environment.

Future research on this topic could collect more robust data measuring student performance across multiple units. Expanding the research to include more units or reversing the instructional sequence could better define the boundaries of these results. Research could also be conducted into the effectiveness of specific methods of test correction implementation.

Impact of Action Research on the Author

This action research project has impacted my teaching in several ways. The most direct impact is on my plans for future assessments in class and my plans to offer this test corrections process as much as possible across all levels that I teach. The value of the process was clearly demonstrated to me by my students' results, and it is clear from these results that my students would benefit from using this process much more often. I had used less structured methods of test corrections in previous years after particularly challenging assessments, but was never sure of the value or the effectiveness of this process. Being able to collect data through the action research process gave me clear evidence that this process was very effective in my classroom setting. I also serve in a leadership role within my department as Department Chair, and plan to share the positive results of this process with colleagues to hopefully enable more students to access the gains in learning enabled by this process.

I was also struck by the interest of my students in the actual research process itself, and how willing they were to participate. Engaging in a scientific investigation with my students reinforced the value of science as a whole and why we learn scientific problem-solving, and the honest discussions with students were refreshing and eye-opening. Several of my AP Physics students are also enrolled in AP research, and the much deeper understanding of the research process gained from my own participation in action research allows me to have many more

discussions with students about topics that they are interested in investigating. Being able to investigate and reflect on my own teaching in a methodical, evidence-based manner made me feel much more confident that not only was I correct about my suspicion that this treatment process would be effective, but that I now have the ability to pursue this process to enable future positive changes in my pedagogy.

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APPENDICES

APPENDIX A: MONTANA STATE UNIVERSITY'S
INSTITUTIONAL REVIEW BOARD COMPLIANCE

IRB Protocol #2025-2412-EXEMPT APPROVED

From NoReply@TOPAZTI.net <NoReply@TOPAZTI.net>

Date Tue 12/9/2025 12:58 PM

To Anderson, Jessica <jessica.anderson40@montana.edu>; O'dell, Thomas <thomas.odell1@student.montana.edu>; Szott, Brenna <brenna.szott@montana.edu>

****External Sender****

Hello O'dell, Thomas,

Your protocol was reviewed by the IRB and has been approved.

PI: O'dell, Thomas

Approval Date: 12/9/2025

Title: Impacts of Student-Centered Test Revision on Learning Outcomes in an AP Physics Classroom

Protocol #: 2025-2412-EXEMPT

Review Type: Exemption

Expiration Date: 12/9/2030

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.
- > 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 anytime at <https://nam10.safelinks.protection.outlook.com/?url=https%3A%2F%2Fmontanaprod.topazti.net%2FElements%3FemailLink%3D11%252c102%252c14919&data=05%7C02%7Cthomas.odell1%40student.montana.edu%7C4c82d4db35d54922de0808de374c8d4b%7C324aa97a03a644fc91e43846fbced113%7C0%7C0%7C639008999117739627%7CUnknown%7CTWFpbGZsb3d8eyJFbXB0eU1hcGkiOnRydWUsIlYiOiJlLjAuMDAwMCIsIlAiOiJXaW4zMlslkFQljoITWFpbCIsIlldUljoyfQ%3D%3D%7C0%7C%7C%7C&sdata=2%2FjQMatuiV2DUngUtxSNvLTptgn0tyfvqfYlJivlJyE%3D&reserved=0>.

APPENDIX B: CONTENT KNOWLEDGE ASSESSMENTS PRE
& POST REVIEW

Original Free Response Question from Rotation Test

(Reviewed Using Teacher-Led Review):

1. A non-uniform bar is attached to a wall by a fixed pivot at its left end, as shown in Figure 1. The bar has length L and mass M . Its mass is distributed such that the bar's center of mass is a distance $\frac{3L}{4}$ from the bar's pivot end and the bar's rotational inertia about the pivot is $\frac{ML^2}{2}$. A string is attached to the bar at the far end as shown, holding the bar horizontal.

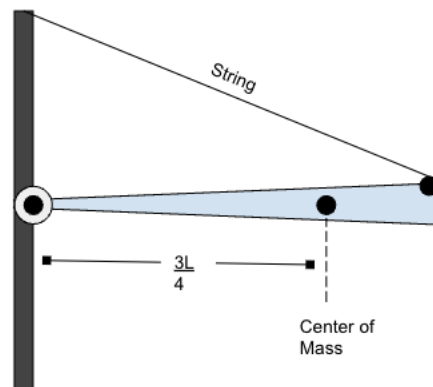


Figure 1

The bar is shown again in Figure 2, and the dots in the figure are located at the point of attachment for the string and at the bar's center of mass.

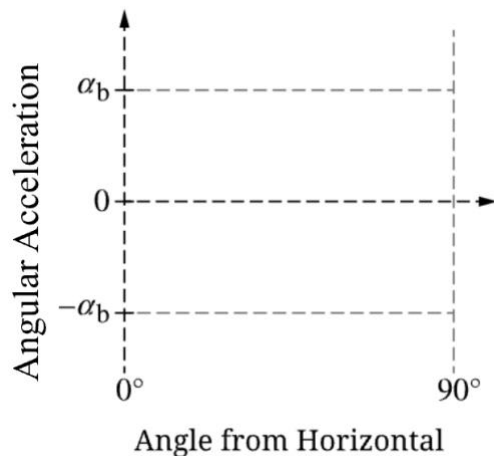
- a. On the figure below, **draw** and **label** arrows that represent the forces that are exerted on the bar.



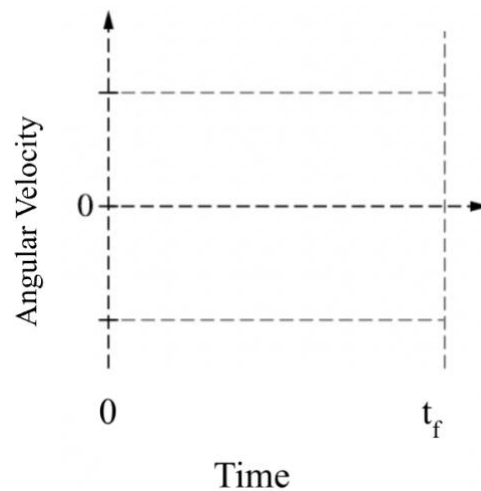
Figure 2

- b. The string is cut, and the bar starts rotating from its initially horizontal position. As the bar rotates, a constant frictional torque of magnitude $\frac{1}{9}MgL$ is exerted on the bar by the pivot. Starting with Newton's 2nd Law in rotational form, derive an expression for the bar's angular acceleration immediately after the string is cut. Express your answer in terms of L , M , and physical constants.

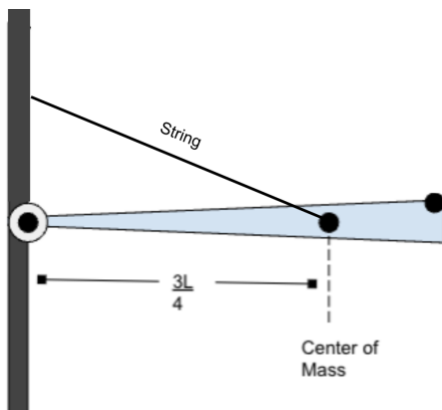
c) On the axes below, **draw** a graph of the bar's angular acceleration as a function of the bar's angle from the horizontal. Take the positive direction to be clockwise, the direction in which the bar rotates before hitting the wall. α_b on the vertical axis represents the angular acceleration you found in part (b).



d) On the axes below, draw a graph of the bar's angular velocity as a function of time for the time period from which the bar is released ($t=0$) until the time at which the bar hits the wall ($t=t_f$). Take the positive direction to be clockwise.



- e) The bar is returned to the horizontal position. Another string is then attached to the bar, as shown below. This time, the string is attached to the bar so that it is lined up with the bar's center of mass. The string is also attached to a lower location on the wall so that it is oriented at the same angle as the original string. **Other than the force exerted by the string**, indicated how all of the force(s) represented in the diagram you drew in part (a) would change, if at all:



Delayed Rotation Re-Assessment

(To be given one to two weeks post review)

2. A non-uniform bar is attached to a wall by a fixed pivot at its left end, as shown in Figure 1. The bar has length L and mass M . Its mass is distributed such that the bar's center of mass is a distance $\frac{4L}{5}$ from the bar's pivot end and the bar's rotational inertia about the pivot is $\frac{ML^2}{3}$. A string is attached to the bar at its midpoint as shown, holding the bar horizontal.

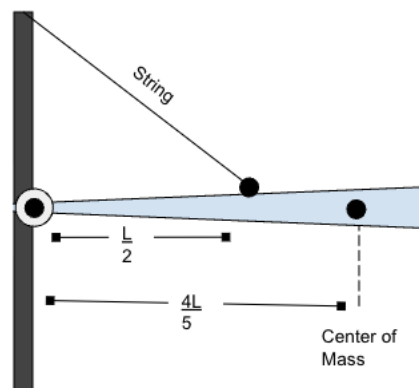


Figure 1

The bar is shown again in Figure 2, and the dots in the figure are located at the point of attachment for the string and at the bar's center of mass.

- a. On the figure below, **draw** and **label** arrows that represent the forces that are exerted on the bar.

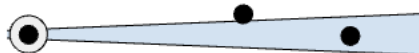
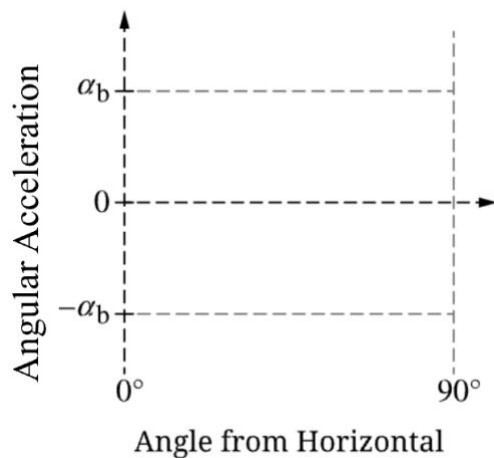


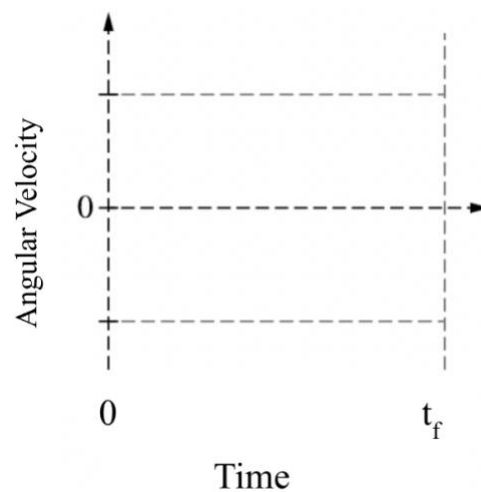
Figure 2

- b. The string is cut, and the bar starts rotating from its initially horizontal position. As the bar rotates, a constant frictional torque of magnitude $\frac{1}{10}MgL$ is exerted on the bar by the pivot. Starting with Newton's 2nd Law in rotational form, derive an expression for the bar's angular acceleration immediately after the string is cut. Express your answer in terms of L , M , and physical constants.

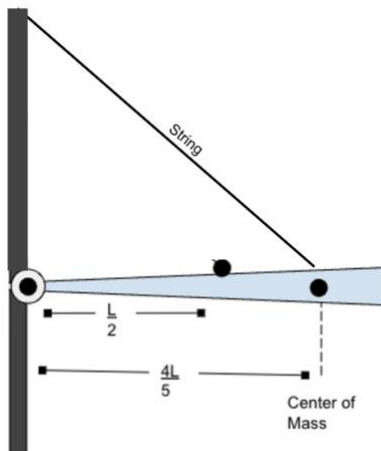
c) On the axes below, **draw** a graph of the bar's angular acceleration as a function of the bar's angle from the horizontal. Take the positive direction to be clockwise, the direction in which the bar rotates before hitting the wall. α_b on the vertical axis represents the angular acceleration you found in part (b).



d) On the axes below, draw a graph of the bar's angular velocity as a function of time for the time period from which the bar is released ($t=0$) until the time at which the bar hits the wall ($t=t_f$). Take the positive direction to be clockwise.

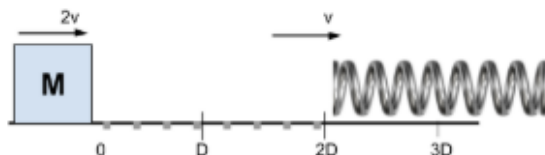


- e) The bar is returned to the horizontal position. Another string is then attached to the bar, as shown below. This time, the string is attached to the bar so that it is lined up with the bar's center of mass. The string is also attached to a higher location on the wall so that it is oriented at the same angle as the original string. **Other than the force exerted by the string**, indicated how all of the force(s) represented in the diagram you drew in part (a) would change, if at all:



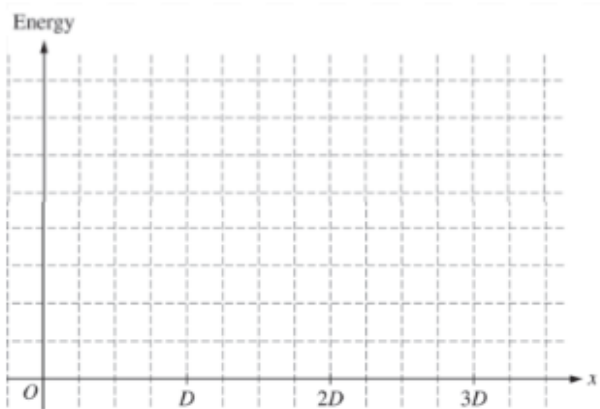
Original FRQ from Energy Test

(To be reviewed using student-centered review process)

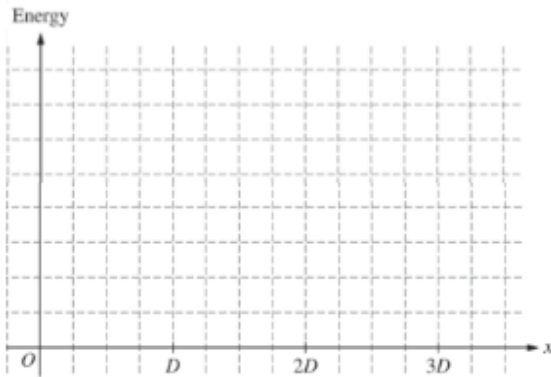


2. A block of mass M is traveling to the right on a track at a speed $2v$ when it reaches a rough section of track. The block travels a distance $2D$ over this rough section and is now traveling at a velocity of v . At the end of this section is a spring. When the block hits the spring (spring constant $= k$), it compresses the spring by a distance D and then comes to rest.

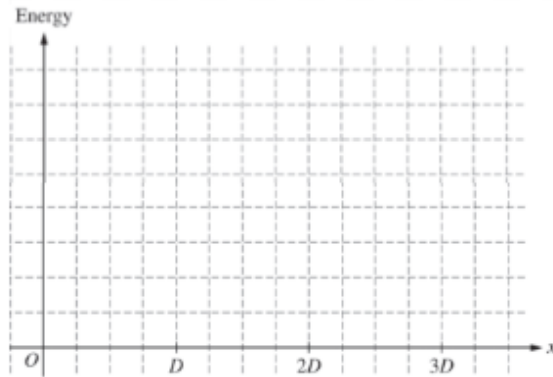
- a. Draw a graph of the kinetic energy of the block-spring system vs distance traveled as the block moves over the entire trip described above. Label the vertical axis in terms of the given variables (M , v , D , or k):



- b. Draw a graph of the elastic potential energy of the block-spring system vs distance traveled as the block moves over the entire trip described above. Label the vertical axis in terms of the given variables (M , v , D , or k):

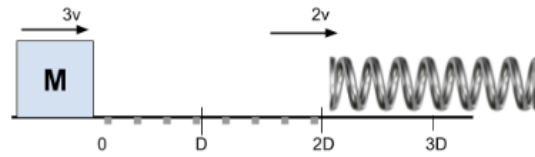


- c. Draw a graph of the total mechanical energy of the block-spring system vs distance traveled as the block moves over the entire trip described above. Label the vertical axis in terms of the given variables (M , v , D , or k):



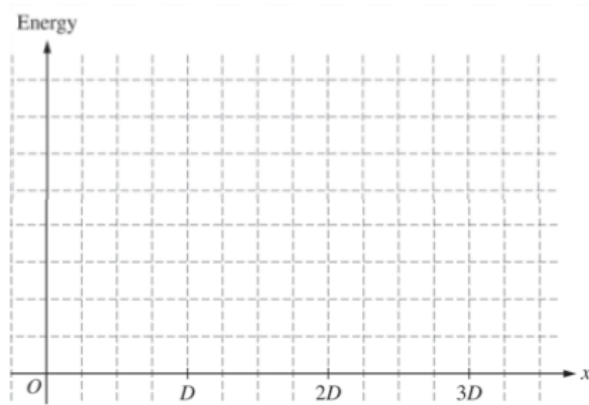
Delayed Energy Re-Assessment

(To be given one to two weeks post review)

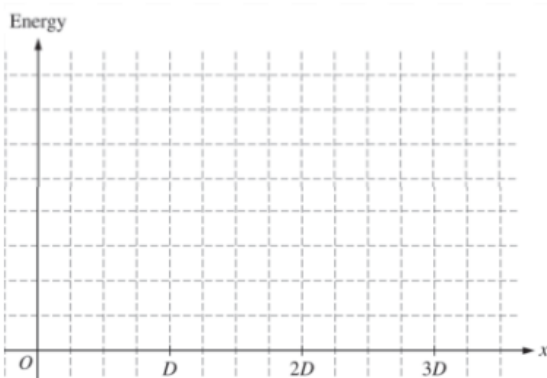


2. A block of mass M is traveling to the right on a track at a speed $3v$ when it reaches a rough section of track. The block travels a distance $2D$ over this rough section and is now traveling at a velocity of $2v$. At the end of this section is a spring. When the block hits the spring (spring constant $= k$), it compresses the spring by a distance D and then comes to rest.

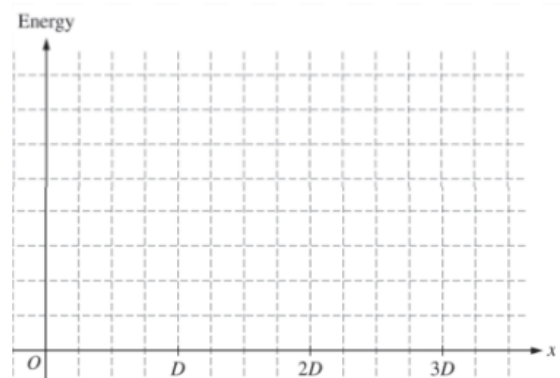
- a. Draw a graph of the kinetic energy of the block-spring system vs distance traveled as the block moves over the entire trip described above. Label the vertical axis in terms of the given variables (M , v , D , or k):



- b. Draw a graph of the elastic potential energy of the block-spring system vs distance traveled as the block moves over the entire trip described above. Label the vertical axis in terms of the given variables (M , v , D , or k):



- c. Draw a graph of the total mechanical energy of the block-spring system vs distance traveled as the block moves over the entire trip described above. Label the vertical axis in terms of the given variables (M , v , D , or k):



APPENDIX C: PRE AND POST TREATMENT LIKERT
SURVEY

Please answer the following questions as thoughtfully as you can. This survey is anonymous, and your answers or participation (or non-participation) will not affect your grade in any way.

1. I feel confident about physics knowledge when preparing for a test:

Strongly Disagree Disagree Agree Strongly Agree

2. I feel confident about physics when taking a test:

Strongly Disagree Disagree Agree Strongly Agree

3. I feel confident about physics when reviewing a test:

Strongly Disagree Disagree Agree Strongly Agree

4. I feel that the test review process helped me identify specific areas I can improve:

Strongly Disagree Disagree Agree Strongly Agree

5. I understood the content better after reviewing the test:

Strongly Disagree Disagree Agree Strongly Agree

6. I understood the problem-solving mistakes I made after reviewing the test in class:

Strongly Disagree Disagree Agree Strongly Agree

7. The way we reviewed this test helped me feel more confident I can succeed on the next test:

Strongly Disagree Disagree Agree Strongly Agree

8. The time we spent reviewing this test was worth it:

Strongly Disagree Disagree Agree Strongly Agree

Is there anything else you'd like me to know about our post-test process?

APPENDIX D: STUDENT ENGAGEMENT &
METACOGNITIVE OBSERVATION PROTOCOL

Focus Area	Targeted Indicators	Observations & Tally Counts
Student Engagement	• Number of students participating/ asking questions • Number of students taking notes / writing • Number of students exhibiting off-task behavior	
Collaboration	• Number of students engaged in peer discussion • Sharing of solutions, reasoning or problem-solving methods.	
Confidence	• Positive/Negative statements about self • Enthusiasm	
Metacognition	• Students recognizing errors or “aha moments” • Statements reflecting a change in understanding	