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Reflective Freewriting as a Strategy to Improve Pre-Service Teacher's Physics Content Knowledge and Overall Attitude Toward Physics and Physics Teaching

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REFLECTIVE FREEWRITING AS A STRATEGY TO IMPROVE PRE-SERVICE TEACHER'S PHYSICS CONTENT KNOWLEDGE AND OVERALL ATTITUDE TOWARD PHYSICS AND PHYSICS TEACHING

A Master's Thesis

Presented to

The Graduate College of

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In Partial Fulfillment

Of the Requirements for the Degree

Master of Science, Natural and Applied Sciences

by

Kali Ann Shoaf-Laughlin

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ABSTRACT

A pilot study conducted in the pre-service teacher (PST) physics classroom at Missouri State University sought to validate a tool for learning. A writing treatment, in which students were asked to participate in reflective freewriting exercises over the course of the semester was administered to one lab group. The Physics Attitude Scale was used to determine whether a positive impact was made on pre-service teacher attitudes about physics and teaching physics. Classroom exams and lab reports were used to determine whether or not aptitude was affected. This action research study used qualitative data to assess content knowledge and overall shift in attitude as well as qualitative data gathered from the reflective writing assignments to obtain a more comprehensive view of shifting attitudes and aptitudes. The researcher's narrative notes followed implementation and reception of the writing treatment and were used to provide greater insight into effectiveness of the treatment. This study found that PST attitudes did experience a clear shift in attitude but could not, with certainty, attribute the shift to the writing treatment alone. It was also found that aptitude was likely not affected. This research hopes to spur further work to assess the connection between reflective writing and PST perspective and understanding of physics.

KEYWORDS: pre-service teachers, reflective writing, write-to-learn, freewriting, physics, physics education, teacher attitudes, STEM education

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I dedicate this thesis and all my future work to the women who have come before me. It is together that we struggle, together that we succeed, and together that we change the landscape for those to come.

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OVERVIEW OF THE STUDY

The overall goal of this study was to affect two aspects of pre-service teachers: their attitudes concerning physics and physics teaching, and their understanding of physics content. With the knowledge that traditional teacher preparation programs affect pre-service teacher attitudes about science teaching (Jones & Carter, 2007), this study implemented a course of action designed to continue this influence on the views of physics and physics teaching as well as increase understanding of the science itself. This chapter includes the rationale for the study, the purpose of the study, relevant research questions, the hypothesis, and the research design. It also includes the significance of the study, assumptions and limitations for the study, and definitions of terms.

Rationale for the Study

While undergraduate students undergo professional development through teacher preparation programs, they are not only cultivating their science content knowledge, but forming their own attitudes and viewpoints about what science is, who can be a scientist, and about science teaching as a whole. These attitudes inform how and what they will deliver to their own students (Jones & Carter, 2007). Simmons et al. (1999), in their investigation of pre-service teacher (PST) beliefs, found that unlike experienced teachers who held more concrete core beliefs formed by their experience, the PSTs hold less rigid core beliefs. As they move through their preparation programs, PSTs are confronted with various competing notions about science and science teaching practices. In a survey of 116 recent graduates from 10 universities across the United States, Simmons et al (1999) found that nearly all of them fluctuated between student-centered and teacher-centered approaches to teaching science, rather than maintaining a standard set of core beliefs. As these beliefs begin to take shape, there is an opportunity to introduce new curriculum tactics in the classrooms of PSTs in hopes that the tactics will guide the formation of their core beliefs. Additionally, Luft et al. (2011) discusses how the first few years of teaching, post-graduation, are the most influential in this process. If curriculum material can be delivered and made easily accessible to PSTs during their preparation programs, then perhaps as they graduate, they will include it in their first years of teaching, thus further positively influencing their attitudes about science and science teaching.

In addition to being concerned with shaping PST attitudes, there is an opportunity to increase PST knowledge about advanced science topics. Coetzee et al. (2020) and McDermott et al. (2000) both indicate that PSTs, in general, report a desire to increase their content and pedagogical content knowledge concerning more advanced science topics. In this study, the focus was on key concepts in physics at an introductory level with connections to more advanced topics discussed throughout.

Purpose of the Study

The purpose of this action research study was to determine the effect of reflective writing assignments on pre-service teacher's attitudes towards learning and teaching physics as well as their aptitude for the material.

Research Questions

The following research questions were addressed in this study:

1. What difference is present in the attitudinal assessment scores between pre-service teachers who engage in writing assignments and those who do not?
2. Does the addition of assigned reflective writing prompts during physics lab affect the retention of knowledge for the exams taken by pre-service teachers in physics?
3. Do the graded lab assignments of pre-service teachers who engage with the reflective writing assignments show higher grade averages compared to those who do not engage in the writing assignments?
4. Are reflective writing assignments able to lead pre-service teachers to a more positive disposition towards learning and teaching physics?

Research Hypothesis

The addition of reflective freewriting assignments to one group of pre-service teachers will produce an increase in aptitude for the material as well as a positive change in attitude for physics and physics teaching compared to their peers who will not receive reflective writing assignments.

Research Design

Consistent with action research, both qualitative and quantitative data were gathered through attitudinal surveys and aptitude assessments. Quantitatively, content assessments and attitudinal surveys were used to measure student success while qualitative findings from the reflective writing were used to assess the development of ideas the PSTs came to hold. This reflects a quasi-experimental research design. This study's design closely reflects the definition of action research in Mills and Gay (2019) in that it is research conducted by the researcher in the classroom, with the goal of "gaining insight, developing reflective practice, effecting positive changes in the school environment (and on those of educational practices in general), and improving student outcomes and the lives of those involved." (p. 452)

Significance of the Study

A writing treatment was developed to include reflective freewriting assignments that were to be given alongside the regular lab content. The intention was that these writing assignments would lead PSTs to hold more positive attitudes associated with learning and teaching physics as well as deepen understanding of physics content. When shaping PSTs, who in turn shape their students, great care should be taken to lead them to hold positive attitudes about science and science teaching so that they may pass these positive beliefs on to the next generation. Should reflective writing assignments result in a positive change in those attitudes, they should be considered for use in more teacher preparation programs. If they additionally prove to be a useful tool for solidifying content knowledge for teachers then, even more so, it should be considered for use in more programs. In teacher preparation, there is no single approach to ensure positive perception but should this writing treatment prove to be effective; it would be another useful tool in the proverbial toolbox.

Assumptions

The following assumptions were made:

1. The PSTs responded to survey questions with authenticity.
2. The PSTs put forth the same amount of effort into understanding the content regardless of whether or not they received the writing treatment.
3. The researcher's ability to teach labs B and C roughly identically were sufficient to draw data comparisons from.

Limitations

The following limitations for this study were considered:

1. The experience of the researcher as an instructor was limited.
2. The researcher's personal teaching style may have affected student success along with the writing treatment.
3. Highly variable student attendance resulted in a limited amount of available data that could be collected.
4. Student attendance most likely impacted grade data negatively.
5. Student attendance reduced grades received independently of the study's treatment.
6. Class time and number of class meetings were reduced on several occasions with short notice.

Definition of Terms

The following terms were used in this paper:

1. Freewriting – Freewriting is a writing style created by Peter Elbow in 1973. This style of writing relies on non-stop writing for a period of approximately 10 minutes. This writing is unfettered by concerns with grammar, spelling, or any other traditional concerns. The point is to write in a stream of consciousness style that flows on paper as it does in one's mind. Elbow states that freewriting should not be subject to any sort of feedback, instead serving a purpose more similar to brainstorming. However, unlike brainstorming, freewriting is written in sentence and paragraph form (Elbow, 1973).
2. Structured Writing – This study defines structured writing relative to freewriting. Structured writing describes any writing assignment which does not fall into the freewriting category. One example of structured writing may be "Write down 10 detailed observations about the materials before you." A time limit may be given, but the student only writes until the objective is achieved.
3. Expected Writing - This study defines expected writing in relation to both freewriting and structured writing. Expected writing is writing that naturally accompanies the performing and learning of science concepts. This can include writing such as note taking during lecture. This writing can occur both inside and outside of the writing treatment group and was considered a part of the baseline for all students.

REVIEW OF RELATED LITERATURE

Understanding how, why, and when PST belief systems change and solidify allows us to act within those constraints in order to push for change in the positive direction. This study implemented a course of action designed to continue this influence on the views of science and science teaching as well as increase understanding of science itself. For this study, the content knowledge contained algebra-based, introductory physics content in the areas of kinematics, optics, thermodynamics, and electricity and magnetism. In order to assess whether or not PST attitudes or aptitudes were influenced by reflective freewriting, one will first need to understand (a) pre-service teacher's desire to attain content and pedagogical knowledge, (b) the difference between freewriting, structured writing, and expected writing, and (c) a tool for assessment of PST attitudes.

Pre-Service Teacher's Development of Beliefs and Content Knowledge

If there is a desire to create lasting impact on PST attitudes and aptitudes, then one must understand the development of such things. Erdogan and Ciftci (2017) conducted a case study focused on the views of seven pre-service teacher's STEM education practices, and found that largely, these PSTs desired an understanding of more advanced knowledge of STEM education practices for their own future positions. Investigating the specific content knowledge and the confidence of PSTs in teaching said content, Tekkaya et al. (2004) found that while confidence in teaching was generally felt among their participants, there existed "…misconceptions concerning fundamental science concepts…" (p. 57). Similarly, a survey of 119 PSTs found that they had also had "strong beliefs and intentions to teach STEM in their future career(s)," they were limited in their understanding of scientific concepts. Additionally, the PSTs felt that their access to robust information and hands on experiences were limited in their preparation (Kurup et al., 2019). In many of the findings concerning PSTs, we see that the desire to teach and to learn is there, but that PSTs seem to lack the confidence and understanding to bring science into their classrooms in the way they wish to.

The Difference Between Freewriting, Structured Writing, and Expected Writing

Freewriting, an approach created by Peter Elbow in 1973, has a few key characteristics which differentiate it from more traditional writing styles. Freewriting involves the continuous stream of writing, similar to brainstorming in which you would write down as much as you knew about a particular topic in a whirlwind sort of way (Elbow, 1973). Brainstorming allows you to write in incomplete sentences, ignoring grammar and spelling, in a list or simply wherever on the page in somewhat of a cloud formation in some cases. Freewriting contains that same "loose" style but instead asks the writer to write in paragraph form. Many conventions such as proper grammar, spelling, and even coherency is ignored. Freewriting, as Elbow states is a "…piece of writing which, even if someone else reads it, doesn't send any ripples back to you. It is like writing something and putting it in a bottle in the sea" (Elbow, 1973, p. 1). This lack of feedback from outside entities allows the writer to focus on what they can produce rather than how well they can edit. If the writing is not coherent or is "bad," it does not matter. Through the process of freewriting, writers will unchain themselves from the shackles of editing and instead be left with a piece from which they can truly assess their current understandings (Elbow, 1973).

On the other hand, the use of more traditional writing approaches has also been found to deepen connections and increase engagement. Reflective journal writing, in which writers do adhere to grammar rules and spelling, was discussed in Bell (2001), as a potentially effective tool for science learning in PSTs. Over the course of the Bell (2001) study, PSTs not only were able to learn the content better but showed greater enthusiasm for learning and teaching as well. Structured writing has the benefit of assessment. Writing of this nature can be judged more effectively from peer to peer whereas freewriting more whimsical nature does not lend itself well to concrete assessment. The use of freewriting still , centered on relevant topics, has been shown to promote academic success on “factual and conceptual multiple-choice exams” (Drabick et al., 2007, p. 172). Asking the students to write in this manner allows them to engage further with the material, speculate, describe, question, and hypothesize independent of expectations. Additionally, findings from Seven et al. (2007) and Getchell and Pachamanova (2021) show that the inclusion of less structured and more creative writing assignments can have a significant effect on academic success in student as well as suggested that including freewriting activities specifically can increase student engagement. When freewriting exercises are used in curriculum, they are best left as short, ungraded assignments that serve to deepen understanding and not to demonstrate it (Drabick et al., 2007). While structured writing can in fact be used as a tool to assess student’s ability to show a deeper understanding, freewriting has the potential to allow for more honesty in the responses of PSTs. Combining these approaches, creating reflective freewriting assignments has the potential to bring PSTs the benefits of reflective journaling as well as the freedom that is associated with freewriting.

Separately defined as expected writing, the common practice of note taking or answering questions contained in a lab report, are forms of structured writing. This type of writing is expected to occur in any course and will be treated as part of the baseline for all groups present within this study.

Tools for the Assessment of PST Attitudes

In determining an assessment tool for determining the changes in PST attitudes, focus was on three main areas. Do the PST believe that physics learning was beneficial to themselves, their future students, and society at large? Do they express desire to incorporate physics content into their future classroom? How comfortable do they feel with the subject? The Physics Attitude Scale (PAS) is an assessment developed by Kaur and Zhao (2017) is an inventory assessment in which students rank their feelings about various statements on a five-point scale from strongly disagree to strongly agree. This assessment is broken into five major categories with roughly 10 statements in each category. The five categories are enthusiasm towards physics, physics learning, physics as a process, the physics teacher, and physics as a future vocation. This assessment allows for the feelings and beliefs of students to be represented quantitatively so that clear comparisons may be made from initial to final data. Although in freewriting, comparisons are more difficult to make, the general attitude of each writing sample, combined with the in-class observations of the researcher will work alongside the PAS to create a picture of changing beliefs.

Summary

In summary, writing as a tool for learning and attitude improvement has been shown to be beneficial when using tactics such as reflective writing and freewriting. The combination of these writing styles is expected to bring about the benefits of both. In order to assess the writing treatment's impact in terms of PST attitudes and aptitudes, a carefully curated quantitative assessment must be used to track the changes in the areas of concern. The PAS achieves this by sectioning its individual statements into the larger categories of enthusiasm towards physics,

physics learning, physics as a process, the physics teacher, and physics as a future vocation. This quantitative summary of attitudes will be used to determine broad changes in views in connection with researcher narrative and general feelings from the freewriting assignments. As PST beliefs are still highly mailable in teacher preparation programs, it is possible that this study’s approach could not only lead PSTs to understand physics more deeply but to more positive opinions which may carry into their future practices.

METHODOLOGY

In order to determine the effect of the writing treatment on PSTs, both quantitative and qualitative data were collected. Pre- and post-attitudinal assessments were analyzed for all lab sections. Grades obtained in both lecture and lab were used to determine student concept knowledge and again were collected from all lab sections. In addition to these, the writing produced by those in the writing group was assessed for general positive or negative student outlook. The aim of these tools was to track the changes in PST content knowledge and observe possible attitude shifts from the beginning to the end of a semester concerning learning and teaching physics. Given a significant positive change in one or both categories, the writing treatment may be regarded as a useful tool in the development of either PST attitudes or aptitudes. The research design, site of the study, participants, ethical considerations, data collection procedures, instrumentation, the role of the researcher, and data analysis are discussed in this chapter.

Research Design

This study used an action research design, more specifically, it followed a classroom action approach. This style of research dictates that research is carried out by the instructor within their own classroom (Hendricks, 2017). In line with this, the researcher served as the course instructor for labs B and C and kept a journal in order to record the process of implementation as well as perceived student success or struggles throughout. The researcher's interpretation of implementation, student behavior, and resulting data were integral to understanding the results of the study. The data collected throughout this study was used to provide a view of student success and changing beliefs as they received the writing treatment. Graded lab reports and exams showed concrete evidence of understanding, or lack thereof, while the attitudinal assessments showed the dynamic PST beliefs. The combination of researcher narrative and collected data showed a more comprehensive picture of the results.

Site of the Study

This study was conducted at Missouri State University and recorded the progress of 62 undergraduate PSTs in a three-credit hour course titled "Physics for Educators." Completion of this course is required in order to receive an education degree, meaning that the students enrolled should reasonably reflect demographic statistics from the degree path in general. Data from the last available diversity report for this university showed a demographic breakdown of students awarded education degrees from the 2018-2019 school year. The report showed that 18.6% of undergraduate degrees awarded were awarded to men while 81.3% were awarded to women. Further, 93.5% of undergraduate degree recipients identified as white, 1.7% identified as Hispanic or Latino, 1.2% identified as Black or African American, .7% identified as Asian, and finally 2.4% identified as two or more races or as race or ethnicity unknown (Missouri State University, 2019). All lab sections took place in the same classroom on their respective days and lasted approximately 2 hours.

Participants

Participants in this study were elementary and middle school education majors enrolled in Physics for Educators for the Fall semester of 2022 at Missouri State University. Demographic information was not officially collected for this study; however, it was clear that the demographics seen in the university's degree recipients for 2018-2019 was reflected within the participants. In total 62 participants were enrolled in the lecture and split into three self-selected groups upon enrollment. Lab A taking place on Tuesdays from 9am to 11am had 22 students, lab B taking place on Mondays from 3pm to 5pm had 25 students, and lab C taking place on Thursdays from 9am to 11am had 15 students enrolled.

Ethical Considerations

Data collected from the PSTs was voluntary and kept private. Names and personal identifying information were disassociated from the individual and instead a unique participant number was assigned. The rights of each individual participating in the study were protected in accordance with the Collaborative Institutional Training Initiative training program completed by the researcher prior to the start of this study. At the close of the study, any possible collected personal information was destroyed. The details of the study were disclosed to the participants on the first day of class and PSTs were presented with a passive consent form to exclude themselves from the study if they so choose (appendix A). Regardless of participation in the study, all PSTs were required to take any and all assessments, however, should consent not have been given by an individual, or is revoked at any point, the non-consenting PST's data would not have been included in the study and any and all collected information received up to that point would have been destroyed. There were no passive consent forms received over the course of the semester meaning that all 62 students were consenting participants in the study and no measures had to be taken to remove data. A proposal was filed with the Missouri State University Internal Review Board in order to ensure and protect the privacy and rights of the participants as well as to ensure that the principles or research ethics were upheld over the course of this study. This study was approved by the Institutional Review Board/Institutional Animal Care and Use Committee/Biosafety Committee on July 12nd, 2022 and received Approval #FY2022-396 (appendix B).

Data Collection Procedures

Following the presentation of the study and discussion of passive consent forms, the PSTs took the pre-attitudinal assessment. This assessment was used as a baseline for comparison with the post-assessment. To ensure participant confidentiality, the researcher exited the classroom prior to the assessment. The lecturer distributed, proctored, and collected all attitudinal assessments. The PSTs were allotted the final 20 minutes of class to complete the assessment, at the end of that time they were collected and stored in a manilla envelope for privacy and turned in to the researcher. This assessment was not viewed until after the post-assessment had been taken and a third-party assured that no identifying information was present for either assessment. This measure was taken in order to ensure that the researcher was not swayed to cater to the students' initial attitudes. The procedure for the completion of the post-assessment was interrupted by desire of the lecture professor and instead students completed the assessment at home. They were instructed to return the completed post-assessment to the lecture professor on the final day of class. As this was not a proctored event, it was expected that not all students would participate. Because of this, extra credit points were offered to the students who returned completed assessments to the lecture professor. These extra credit points were recorded in the grade book but were not considered in the final grade data of this study. Despite this, roughly 60% of the assessments were returned resulting in 58 initial assessments collected and only 34 final assessments.

The lecturer collected exam grades and final lecture grades. Personal identifying information was removed prior to delivery to the researcher and instead the student's unique ID number was used. In the lab sections, lab B was taught by one graduate student in the Physics, Astronomy, and Material Science department and graded by another. This group conducted classroom and grading practices in accordance with the typical practices of the department's Teaching Assistants. In labs A and C, the lab was taught by the researcher and graded by an undergraduate student in accordance with a detailed key provided by the researcher. In order to remove potential bias this grading process was "double-blinded" meaning that the researcher did not grade nor view the lab reports and the unique identification numbers were used in place of names to remove possible bias on the part of the grader. The grader never met with the students, but these precautions were taken to attempt to remove any subconscious gender, race, or ethnic associations of names on the part of the grader.

The PST's reflective writing assignments were also assessed after the close of the semester to prevent effecting the researcher's ability to treat labs B and C as identically as possible.

Instrumentation

In order to assess the effect of the writing treatment on PSTs, this study used an attitudinal assessment as well as lecture and lab grades. All attitudinal assessments contained identical questions and each lab section regardless of writing treatment was instructed to take them. The attitudinal assessment used was adapted from the Physics Attitude Scale (PAS) developed by Kaur and Zhao (2017). This assessment asks students to rate statements on a five-point scale from strongly disagree to strongly agree. The PAS individual statements are grouped into five more general groups which are enthusiasm towards physics, physics learning, physics as a process, physics teachers, and physics teaching as a future vocation (Kaur & Zhao, 2017). The researcher adapted this assessment to exclude certain questions that were not relevant to the students' possible experiences or worded too ambiguously for students to reliably interpret in roughly the same manner.

Role of the Researcher

The researcher in this study was an active participant, consistent with an action research design, taking on the role of instructor for lab sections A and C. The researcher delivered the lab course content and assisted the students in their weekly experiments. Noted in the limitation section, the lack of teaching experience and the personal class management style of the researcher may have influenced the results of the study. Specifically, when comparing lab sections A and C to lab section B. However, as the same individual taught both labs A and C, the writing treatment group and control group, more direct comparisons were able to be made between the two groups. Because of this, the researcher was responsible for maintaining a consistent approach among lab sections A and C. The different instructor for lab section B allowed for two control groups to exist. One control group, lab C, which was compared to the writing group, lab A, in order to assess its effect and one, lab B, which was compared to the researcher taught labs to assess the effect of the researcher on the results. The researcher was also responsible for keeping a detailed journal for the duration of the study in order to contextualize student progress. Any discussion of those observations did not include personal identifying information in this paper.

Data Analysis

After the collection of data and the disassociation of personal identifying information, the researcher compared the results in order to determine the changes between pre and post assessments as well as the differences in grade performance between the lab sections. Changes in class averages for pre-and post-assessments as well as changes in key individual students were analyzed to determine if a significant change had occurred. As a result of poor student attendance, the number of writing assignments a student had been able to complete consistently was lowered. Grade data was primarily analyzed in terms of average class performance on exams and lab reports. However, individual students determined to be "ideal" students, meaning students that had completed all writing assignments, lab reports, and assessments, were compared to select non-ideal students were also individually assessed. The validity of the hypothesis was measured against the broader class averages rather than the "ideal" student performance. The writing assignments themselves were also collected and analyzed. This writing provided a much more subjective view of changing attitudes, and the content was analyzed for specific language such as phrases like "feeling more confidant" or "more hopeful." The personal narrative of the researcher became relevant here to contextualize the writing with the perceived demeanor of students.

DATA AND RESULTS

In order to determine the validity of the hypothesis and answer the associated research questions, data collected from the course was comparatively analyzed to determine significance. The research hypothesis states that the addition of reflective writing assignments to one group of pre-service teachers will produce an increase in aptitude for the material as well as a positive change in attitude for physics and physics teaching compared to their peers who will not receive reflective writing assignments. the research questions are restated here:

1. What difference is present in the attitudinal assessment scores between pre-service teachers who engage in writing assignments and those who do not?
2. Does the addition of assigned reflective writing prompts during physics lab affect the retention of knowledge for pre-service teachers in physics?
3. Do the graded lab assignments of pre-service teachers who engaged with the reflective writing assignments show higher grade averages compared to those who did not engage in the writing assignments?
4. Are reflective writing assignments able to lead pre-service teachers to a more positive disposition towards learning and teaching physics?

Labs B and C did not receive the writing treatment and further, the researcher did not teach lab B. As a result of both of these conditions, this study viewed both labs B and C as control groups. Lab C was compared to the writing group with the same instructor to assess the effect of the treatment while lab B was compared to both labs A and C to assess the possible effect of the instructor herself. The data is presented here in four main sections (a) grade data from lab sections, (b) attitudinal assessments from lab sections, (c) course-wide grade averages and attitudinal shift, and (d) excerpts from writing assignments.

Grade Data from Lab Sections

During lecture, three unit exams were given near the beginning, middle, and end of the semester. Students enrolled in lab A, the writing lab, scored an average of 86.29% on the first exam, 85.76% on the second exam, and 75.19% on the third exam. Overall, lab A had an average exam score of 82.41%. Students enrolled in lab B scored an average of 86.32% on the first exam, 91.64% on the second exam, and 77.83% on the last exam for a combined average exam score of 85.26%. For lab C, students enrolled scored an average of 82.88% on the first exam, 82.39% on the second, and 79.74% on the third. Lab C had an average exam score of 81.67%. As only the grade for lecture is reported to the student's transcript, the student's total lab grade counts for 20% of the students overall final grade in Physics 101. Labs A, B, and C held averages of 74.67%, 87.16%, and 80.44% respectively for their total lab grades. These scores resulted in averages of 83.41% for lab A, 88.85% in lab B, and 84.55% in lab C for the students total Physics 101 grade.

Looking at the shift for each individual lab over the course of the semester, lab A shows a 0.53% decrease in score from exam one to exam two and a 10.57% decrease from exam two to exam three. Lab B shows an increase of 5.32% from exam one to exam two, but a large decrease of 13.80% from exam two to exam three. In lab C there is a 0.49% decrease and a 2.65% decrease from exam two to exam three. The total class average for exam scores was 83.11%. Comparing the lab section's average lab score we see that lab A's average is 0.70% below the class average, lab B is 2.15% above the class average, and lab C falls 1.45% below the class average. Further comparisons may be made for exams one, two, and three between the three labs and are shown in Figure 1.

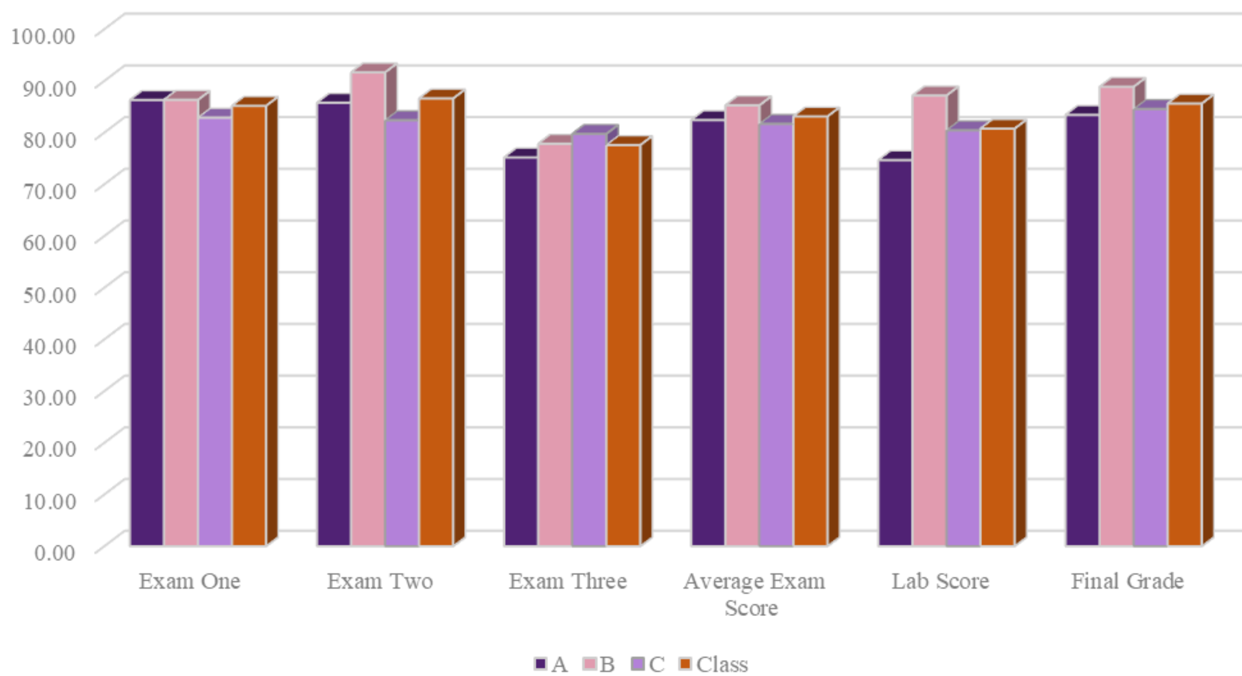

Figure 1. Average scores for each of the unit exams, average exam score, average lab score, and average final grade for each lab section compared to overall class average.

During the lab sections students completed, typically, completed one lab experiment and report per week. The experiments were done in class with guidance from the detailed procedure in the lab manual as well as instructor assistance when needed. In total, 11 labs were completed. Final lab score data shows that lab B had the highest percentage of A's at 56% with lab A at 38.10% and lab C at 31.25%. In terms of failing grades, lab A leads with 28.57% followed by lab B with 12% and lab C with 6.25%. Generally, lab B's average grades for the individual lab reports were also marked higher than both A and C, however labs A and C were roughly even in this comparison as seen in Table 1. In total, the average score on a lab report for all students in all sections was 92.32%. Lab B's average report score was 4.55% higher than this average. Lab B's average report score was 1.28% lower while lab C was also lower than the class average by 3.27%. These scores were heavily influenced by whether or not students turned in their work. In

Table 2 the percentage of collected papers per week is shown, revealing in general, more students handing in papers in lab B. Here the class average turn in rate was 89.24% meaning that lab A's turn in rate was 1.23% higher than the average, lab Bs was 6.76% higher than the average, and lab C's rate was 7.99% lower than the total class average.

Table 1. Average score on completed lab reports per week for the length of the semester.

Weeks	1	2	3	4	5	6	7	8	9	10	11	Avg
A	100%	98%	94%	91%	90%	98%	78%	91%	79%	93%	91%	91%
B	99%	89%	100%	94%	99%	94%	97%	96%	99%	99%	98%	97%
C	100%	94%	88%	94%	89%	93%	79%	97%	85%	69%	92%	89%

Table 2. Average percentage of received lab reports per week.

Weeks	1	2	3	4	5	6	7	8	9	10	11	Avg
A	100%	100%	81%	81%	81%	90%	67%	86%	57%	57%	71%	90%
B	100%	92%	96%	88%	96%	80%	88%	88%	88%	64%	80%	96%
C	100%	94%	94%	88%	100%	94%	88%	88%	81%	75%	88%	81%

Attitudinal Assessment Data for Lab Sections

The PAS (appendix C) was given at the beginning and end of the semester in order to determine the change in PST attitudes. This assessment had 51 statements that the students responded to on a five-point scale from strongly disagree (1) to strongly agree(5). To assess the nature of the responses, a "goal" response was determined. Responses were observed to be either under target, on target, or above target. Each statement's target response also had a target over or under value (O/U) to define whether or not an above or below target response was more or less desirable for individual statements. In the case of statement one, "Studying topics on physics in greater detail is not worth it," the target response was 2, meaning that the student disagreed with that statement. Here, an under-target response was seen as a positive response. However, in the case of statement two, "My confidence level increases by doing physics experiment in laboratory," an above-target response was seen as a positive response. Tables 3, 4 and 5 show this complete data set along with an arrow icon next to data that is on target or is classed as a positive response. From this, it was determined that for lab A, 25 out of the 51 statements received more positive replies on average in the post-test. For lab B, only 18 statements received more positive replies on the post test. Lab C had only 19 replies that became more positive by the end of the semester. Statements considered to be on target increased from 8 to 10 for lab A and increased for lab B from 4 to 5. Lab C, however, decreased from 12 to 11 on target statements. In a much broader view, on average, lab A results stayed roughly constant with about half of the statements moving in the positive direction and half which stayed the same or moved in the negative direction by the post test.

Table 3. Pre- and post-attitudinal assessment comparisons for lab A.

Lab A Pre-Test				Lab A Post-Test			
Avg	Goal	O/U	Goal	Avg	Goal	O/U	Goal
Factor 1							
2.32	2	0.32		2.22	2	0.22	
3.16	4	-0.84		3.44	4	-0.56	
3.84	4	-0.16		3.56	4	-0.44	
3.05	2	1.05		3.56	2	1.56	
3.42	4	-0.58		3.33	4	-0.67	
3.63	4	-0.37		3.78	4	-0.22	
2.26	3	-0.74		2	3	-1	
2.11	3	-0.89		2.33	3	-0.67	

Table 3 continued. Pre- and post-attitudinal assessment comparisons for lab A.

Lab A Pre-Test				Lab A Post-Test			
Avg	Goal	O/U	Goal	Avg	Goal	O/U	Goal
Factor 2							
2.47	4	-1.53		2.78	4	-1.22	
3.68	4	-0.32		3.33	4	-0.67	
3.11	3	0.11	↑	2.78	3	-0.22	
3.47	2	1.47		3.78	2	1.78	
3.84	4	-0.16		3.56	4	-0.44	
2.58	4	-1.42		2.67	4	-1.33	
2.95	2	0.95		2.56	2	0.56	
3.47	3	0.47		3.44	3	0.44	
2.26	1	1.26		2.44	1	1.44	
3.16	2	1.16		3.78	2	1.78	
3	2	1		3.67	2	1.67	
2.32	2	0.32		2.78	2	0.78	
Factor 3							
3.79	4	-0.21		4	4	0	↑
4.11	4	0.11	↑	4.22	4	0.22	↑
2.42	2	0.42		2.44	2	0.44	
2.89	3	-0.11	↓	3	3	0	
3.79	4	-0.21		3.78	4	-0.22	
2.21	2	0.21		2	2	0	
4.05	4	0.05	↑	4.11	4	0.11	↑
3.68	4	-0.32		3.56	4	-0.44	
3	3	0	↓	2.67	3	-0.33	↓

Table 3 continued. Pre- and post-attitudinal assessment comparisons for lab A.

Lab A Pre-Test				Lab A Post-Test			
Avg	Goal	O/U	Goal	Avg	Goal	O/U	Goal
			Factor 4				
1.79	2	-0.21	↓	1.67	2	-0.33	↓
2.47	2	0.47		2	2	0	
3.74	4	-0.26		4	4	0	↑
2.89	2	0.89		2.67	2	0.67	
3.84	5	-1.16		4.22	5	-0.78	
3.11	2	1.11		3.22	2	1.22	
2.74	2	0.74		2.67	2	0.67	
3.26	4	-0.74		4	4	0	↑
3.32	4	-0.68		3.67	4	-0.33	
1.89	2	-0.11	↓	1.67	2	-0.33	↓
2.32	2	0.32		1.33	2	-0.67	↓
3.63	4	-0.37		4.11	4	0.11	↑
			Factor 5				
4	3	1		3.67	3	0.67	
2.95	2	0.95		3	2	1	
2.32	2	0.32		2.89	2	0.89	
3.89	3	0.89		4.44	3	1.44	
2.32	2	0.32		2.44	2	0.44	
2.68	2.5	0.18		3.33	3	0.33	
3.42	3	0.42	↑	2.56	3	-0.44	
3.74	4	-0.26		3	4	-1	
3.47	4	-0.53		2.22	4	-1.78	
3.84	4	-0.16		3.56	4	-0.44	

Table 4. Pre- and post-attitudinal assessment comparisons for lab B.

Lab B Pre-Test				Lab B Post-Test			
Avg	Goal	O/U	Goal	Avg	Goal	O/U	Goal
Factor 1							
2.63	2	0.63		2.93	2	0.93	
2.88	4	-1.13		3.47	4	-0.53	
3.75	4	-0.25		3.33	4	-0.67	
3.08	2	1.08		3.67	2	1.67	
3.25	4	-0.75		3	4	-1	
3.21	4	-0.79		3.07	4	-0.93	
2.04	3	-0.96		2.07	3	-0.93	
2	3	-1		2.2	3	-0.8	
Factor 2							
2.5	4	-1.5		2.2	4	-1.8	
3.42	4	-0.58		3.53	4	-0.47	
3.08	3	0.08	↑	2.6	3	-0.4	
3.83	2	1.83		3.93	2	1.93	
3.96	4	-0.04		3.87	4	-0.13	
2.92	4	-1.08		2.47	4	-1.53	
2.83	2	0.83		2.67	2	0.67	
3.5	3	0.5		4	3	1	
2.5	1	1.5		2.87	1	1.87	
3.29	2	1.29		3.8	2	1.8	
3.29	2	1.29		3.47	2	1.47	
2.42	2	0.42		2.93	2	0.93	

Table 4 Continued. Pre- and post-attitudinal assessment comparisons for lab B.

Lab B Pre-Test				Lab B Post-Test			
Avg	Goal	O/U	Goal	Avg	Goal	O/U	Goal
Factor 3							
3.75	4	-0.25		3.73	4	-0.27	
3.67	4	-0.33		3.73	4	-0.27	
2.5	2	0.5		2.6	2	0.6	
3.08	3	0.08		3.2	3	0.2	
4.08	4	0.08	↓	3.6	4	-0.4	
2.33	2	0.33		2.27	2	0.27	
4.33	4	0.33	↑	4	4	0	↑
3.92	4	-0.08		3.4	4	-0.6	
2.5	3	-0.5	↓	2.87	3	-0.13	
Factor 4							
2.04	2	0.04		1.53	2	-0.47	↓
2.5	2	0.5		1.8	2	-0.2	↓
3.54	4	-0.46		3.6	4	-0.4	
2.83	2	0.83		2.6	2	0.6	
3.63	5	-1.38		4.67	5	-0.33	
2.83	2	0.83		2.8	2	0.8	
2.88	2	0.88		3.13	2	1.13	
3.5	4	-0.5		3.47	4	-0.53	
3.33	4	-0.67		3.07	4	-0.93	
2.33	2	0.33		1.93	2	-0.07	↓
2.29	2	0.29		1.8	2	-0.2	↓
3.54	4	-0.46		3.4	4	-0.6	

Table 4 Continued. Pre- and post-attitudinal assessment comparisons for lab B.

Lab B Pre-Test				Lab B Post-Test			
Avg	Goal	O/U	Goal	Avg	Goal	O/U	Goal
Factor 5							
3.75	3	0.75		4.13	3	1.13	
3	2	1		3.27	2	1.27	
2.65	2	0.65		2.87	2	0.87	
3.88	3	0.88		3.8	3	0.8	
2.3	2	0.3		2.2	2	0.2	
2.96	2.5	0.46		2.87	2.5	0.37	
2.96	3	-0.04		2	3	-1	
3.5	4	-0.5		3.2	4	-0.8	
2.96	4	-1.04		2.2	4	-1.8	
3.75	4	-0.25		3.33	4	-0.67	

Table 5. Pre- and post-attitudinal assessment comparisons for lab C.

Lab C Pre-Test				Lab C Post-Test			
Avg	Goal	O/U	Goal	Avg	Goal	O/U	Goal
Factor 1							
2.2	2	0.2		2.5	2	0.5	
3.4	4	-0.6		3.7	4	-0.3	
4	4	0	↑	3.7	4	-0.3	
3.87	2	1.87		3.6	2	1.6	
3.2	4	-0.8		3	4	-1	
3.4	4	-0.6		3.8	4	-0.2	
1.8	3	-1.2		2.5	3	-0.5	
1.8	3	-1.2		3.1	3	0.1	↑

Table 5 Continued. Pre- and post-attitudinal assessment comparisons for lab C.

Lab C Pre-Test				Lab C Post-Test			
Avg	Goal	O/U	Goal	Avg	Goal	O/U	Goal
			Factor 2				
2.67	4	-1.33		2.9	4	-1.1	
3.87	4	-0.13		3.6	4	-0.4	
2.87	3	-0.13		3.2	3	0.2	↑
3.8	2	1.8		4	2	2	
4.07	4	0.07	↑	3.7	4	-0.3	
2.73	4	-1.27		2.7	4	-1.3	
2.4	2	0.4		2.3	2	0.3	
3.87	3	0.87		3.1	3	0.1	
2.2	1	1.2		2.4	1	1.4	
3.47	2	1.47		3.8	2	1.8	
3.2	2	1.2		3.3	2	1.3	
2.4	2	0.4		2.7	2	0.7	
			Factor 3				
4.29	4	0.29	↑	4.3	4	0.3	↑
4.2	4	0.2	↑	3.8	4	-0.2	
1.93	2	-0.07	↓	2.1	2	0.1	
2.6	3	-0.4	↓	2.6	3	-0.4	↓
3.87	4	-0.13		3.5	4	-0.5	
2.33	2	0.33		2.9	2	0.9	
4.2	4	0.2	↑	4.1	4	0.1	↑
4.07	4	0.07	↑	4	4	0	↑
2.53	3	-0.47	↓	2.8	3	-0.2	↓

Table 5 Continued. Pre- and post-attitudinal assessment comparisons for lab C.

Lab C Pre-Test				Lab C Post-Test			
Avg	Goal	O/U	Goal	Avg	Goal	O/U	Goal
			Factor 4				
1.8	2	-0.2	↓	1.7	2	-0.3	↓
2.27	2	0.27		1.8	2	-0.2	↓
4	4	0	↑	3.9	4	-0.1	
2.73	2	0.73		2.4	2	0.4	
3.8	5	-1.2		4.2	5	-0.8	
2.6	2	0.6		2.7	2	0.7	
2.4	2	0.4		2.4	2	0.4	
3.4	4	-0.6		3.6	4	-0.4	
3.27	4	-0.73		3.7	4	-0.3	
1.8	2	-0.2	↓	1.56	2	-0.44	↓
2	2	0		1.8	2	-0.2	↓
3.8	4	-0.2		3.8	4	-0.2	
			Factor 5				
4	3	1		4	3	1	
2.87	2	0.87		2.7	2	0.7	
2.4	2	0.4		2.9	2	0.9	
4.33	3	1.33		4.2	3	1.2	
2.13	2	0.13		2.5	2	0.5	
3.07	2.5	0.57		3.3	2.5	0.8	
2.87	3	-0.13		2.8	3	-0.2	
3.33	4	-0.67		3.6	4	-0.4	
3.07	4	-0.93		2.8	4	-1.2	
3.73	4	-0.27		3.5	4	-0.5	

Researcher Perspective from the Classroom

The perspective of the researcher is vital to contextualize the results of this study as in action research, the researcher is an active participant the whole way through. Over the course of the semester a variety of shifts were noted. There were initial major differences between labs A and C, the most important of these is the vastly different degrees of participation. Lab A students were generally responsive to the instructor and engaged with the material more openly. Lab C students were generally quiet, even during periods of class where socializing would normally take place. Because of this predisposal to talk more, lab A students often asked questions when they felt stuck and would work through the solution with the instructor rather than waiting for an answer. Lab C was the opposite, questions were few and far between but feeling stuck was not. Students would wait until the instructor noticed that they had stopped working and would respond minimally to assistance. It seemed that many lab A students were more naturally curious and thus led their classmates to join them in that curiosity. Lab C students felt more naturally "too cool for school" and likewise drew others to this stance as well. In addition to this, attendance was very different between lab A and C students with lab A students nearly always being present and lab C having many absences.

Data from Writing Assignments

Qualitative data was also collected through analysis of the writing prompts by lab A. Prompts centered on student feelings rather than understanding of content. In total 7 writing prompts were given. The writing prompt were as follows:

1. How am I feeling about lab after today? (In reference to the first day of class)
2. How can I apply today's experiment in your future classrooms?

3. Can I do physics on my own? (Asked at the beginning of class)
4. Can I do physics on my own? (Asked at the end of class)
5. Does lab work make physics more enjoyable?
6. Does lab work impact my understanding of physics?
7. What could I do to help a student who is frustrated with their physics work?

Attendance was an issue when it came to writing prompts as well. Out of the 22 students in lab A, 7 completed all writing assignments, 8 completed six prompts, 1 completed five, 2 completed four, and the remainder of the class completed 2 or less.

CONCLUSION AND DISCUSSION

In order to determine whether or not reflective freewriting was effective at improving PST attitudes and aptitudes grade and attitudinal data from all students in Physics 101 were compared across the three lab sections. Based on this data, it appears that the effect on aptitude, if it is to be attributed to the writing assignments at all, was minimal. Grade data did not show clear improvement of lab A compared to the other sections or to the overall class average. The most notable changes in lab A were found in PST attitudes. While still minimal, data suggests that there was a somewhat positive change in attitude from the beginning to the end of the semester. In this section, discussions of context and interpretation of results, researcher narrative, and suggestions for implementation in future work are discussed.

Context and Interpretation of Grade Data

The final grades for each lab section vary minimally, suggesting that the writing assignments had no effect on PST academic success. Lecture exam data shows this similarity between sections especially well as each lab section's individual average score is less than 5% off from the class average for any given exam. However, the final Physics 101 grades differ a bit more than what is seen in the exam scores. In the end, lab B's average final grade was 5.44% higher than lab A and 4.3% higher than lab C. It would seem that the reason for this larger gap would be the contributions of the lab scores for each section. A large gap between lab scores would suggest that lab B must have the greatest understanding on content seeing as the average lab score is 12.49% higher than lab A and 6.72% higher than lab C. However, there is important context missing here. For labs A and B the researcher creator standard, rigorous grading keys that were to be used by the grader for those sections. These keys were understood to be very forgiving yet still more rigorous than the traditional way of grading lab reports in Physics 101. In lab B, the standard grading was used. This grading was at the discretion of the sections grader who was not present during lab hours and as such resulted in higher grades on average than the other sections. This is a known issue within the department. That being said, the grading for labs A and C were more forgiving than desired in order to not unjustly affect the students who might've had higher grades in the less rigorous lab section. In response to this, comparisons made solely between lab sections A and C were deemed much more valuable to this project. However, despite this allowance, lab B's less strict grading scale for lab carried into the higher grades in lecture. An empirical cumulative distribution function shows the fact that lab B has a narrow spread of grades than the similar lab A but altogether had higher grades (figure 2).

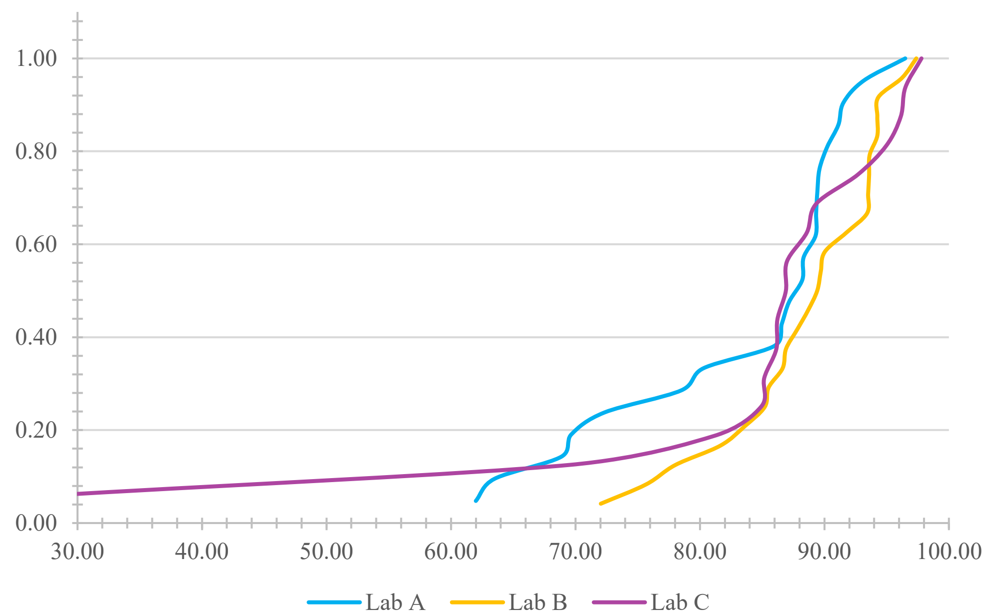

Figure 2. Empirical cumulative distribution function for final lecture grades of each lab section.

Between labs A and C a few differences exist, but ultimately show similar outcomes in terms of average grades each week on lab reports. In table 1 this can be seen. In the end, however, the average overall lab grade for lab A was 5.77% lower than that of lab C. It cannot be concluded that this is a negative effect of the writing assignments or even that the writing assignments had no positive effect, instead, this appears to be largely a result of the rate at which students turned in lab reports. In table 3 a consistently lowered rate of turn in was observed for lab A. Seen also in the empirical cumulative distribution, lab C shows a wide distribution with lowered grades overall. This is almost certainly the reason for the lowered grade average and additionally affects the ability for the sections to be compared accurately. It is for these reasons that it can be concluded that the grade outcomes for each lab section are not statistically significant enough to determine that the writing assignments produced an effect.

Context and Interpretation of Attitudinal Assessments

In the case of attitudinal change, there is more to be observed. In this case as well, it is possible that attendance had a large impact on the results as it is reasonable to assume that students who do not attend class regularly may have or develop negative feelings towards the class. Despite this, the data suggests that attitudes most greatly improved in lab A, the writing course. Researcher observations provide a deeper understanding of what is occurring in this instance. In the first few meetings of class, students seemed apprehensive about physics experiments and the process of learning in this way. The first reflective freewriting assignment asked students to respond to the prompt "How am I feeling about lab after today?" Replies generally expressed frustration and feelings of self-doubt. One student,18407, stated, "This is difficult for me because this is my second time taking this class. I am worried about passing. I think this is too much for me." This same student, 18407, in a later reflective writing activity wrote, "I actually am feeling very motivated to come to lab. I think its is enjoyable because we are in big groups and help each other when we are stuck….I still do not feel super knowledgeable after completing labs. I want to but its hard to read the labs and understand." Writing excerpts such as this give support to the conclusion that aptitude was not deeply affected but attitude was certainly influenced.

Overall, student attitude in class also noticeably improved. As time went on, students were observed more openly discussing their work with others. This shift was easily observed in lab A as students who started class with little follow through, stayed engaged through difficult parts of the experiment through to the end. It was encouraging to see this change, students appeared to find joy in class and in the learning process. Students began to stay after class to ask further questions and expressed a clear desire to understand the concepts separately from upcoming exams. This change can be viewed in the data, but it is not as dramatic as what was observed in class. As the semester progressed it became clear that lab A and C were entirely different. This could be due to the inherent nature of the students of course. Perhaps the "high-fliers" self-selected into the same group but given the distinct change from beginning to end it is also probable that the reflective writing may have influenced them. Students became more noticeably more reflective after the assignments. Overheard conversations included students talking about how they might include the ongoing experiment in their future classrooms or their future work in their preparation programs. This was highly encouraging to see as the goal is to create a long-lasting impact in the PSTs. The increase from 7 to 10 on target statements and the increase in 25 total statements suggests that there was an overall change in attitude with this lab. In contrast, labs B and C had increases in 18 and 19 statements respectively and on target statements only increased by one in lab B and decreased by one in lab C. In lab C, positive change was, in general, not observed. Some students who very obviously formed bonds with their lab partners did appear to become more confident, but overall, a class-wide shift was not present like in lab A. Instead, quite the opposite could be seen. Students appeared to become less engaged as the semester wore on resulting in nearly silent work by the end.

The trouble is sorting out what has influenced this change in students. Most writing samples reference the researcher/instructor positively leading one to believe that the instructors attitude influenced the students more than the writing assignments. One example of this can be found in again in student 18407's reflective writing centered on the prompt, "Does lab work make physics more enjoyable?" The student writes, "Sometimes in lecture something will confuse me but its hard to speak up vs in a smaller group my teacher [researcher] makes lab very fun and I find myself learning a lot in her class. I can tell she cares about me and wants to help me learn." This sentiment was not uncommon in the reflective writing prompts and could explain the difference between lab A and B as they had different instructors. However, great care was taken to ensure that while lab B may be different, labs A and C were treated equally by the researcher making it more likely that the writing intervention was successful in affecting PST attitudes. In summary, the writing assignments may have had an effect on student attitude, but due to the constraints on this project the true effect of the writing assignments is not concretely understood.

Limitations and A Look at an Ideal Subject

There were several constraints which affected the results of this project. At least three class periods were cancelled or majorly altered with less than 24 hours' notice given to the researcher and thus to the students as well. There was too little communication between the lecture professor and the researcher for information to be effectively passed, often leading to misunderstandings for students that the researcher could not clarify. But above all, student attendance altered much of this study. Only 7 students managed to complete all 7 writing prompts. At the close of this pilot study, it was clear that there is much to be changed should this research effort continue. In an attempt to get a clear picture of the study running effectively, it is important that an "ideal subject," a student who has completed all writing assignments as well as the two attitudinal assessments, have their work and responses closely examined. There were only three students who met these criteria, of these, student 18390 was randomly selected and was examined in depth.

Student number 18390 successfully turned in every lab report in addition to completing the writing and the surveys, overall obtaining a 96.88% for their final lab grade. In lecture, a different picture is painted. This student scored a 98% on exam one, a 71% on exam two, and a 68% on exam three with an overall exam average of 78%. Despite this being an "ideal" student results still suggest that the reflective writing assignments did not have an effect on aptitude. However, in the attitudinal data there is a clear effect present. 18390 originally responded with 28 on target statements but had improved to show 44 on target statements on the final assessment. A student who only completed four writing prompts showed an attitudinal change from 20 to 31 on target statements. Student 18400 turned in all but one lab report and held a higher average exam score of 82 in lecture. Further, a student who only completed two writing prompts showed a falling attitude, moving from 20 on target statements to 16. This student held a fantastic average exam score of 98 but also failed to turn in one lab report during the semester. For each of these students, the language used in their writing assignments reflects the attitude changes in their PAS scores (appendix D). These select students serve to further indicate the reflective writing prompt possible ability to affect PST attitudes but not aptitudes.

Change for the Future

Throughout the semester, the students who received the writing assignments appeared to be affected by their presence. However, there are far too many unknowns present to say with absolute certainty that the effect is truly a result of the writing. The data would suggest that attitudes were affected, but in context, it is clear that this pilot project requires a much more rigid approach in order to be able to determine the true effect of the writing. Instead, it is more likely that because the completion of the writing assignments was dependent on student attendance, attendance had far more to do with the development of positive attitudes than any other factor.

With limited teaching experience, the influence of the instructor on her students cannot be ignored. Perhaps the grading could be more or less rigid or perhaps the guidance could be more or less present throughout the experiments. This project would be best run in the classroom of an experienced professor with full control of the curriculum and practices throughout the course. As this pilot took place in a lab section, there was a vast difference between the lecture teaching style and the lab teaching style as the lecture was taught by an experienced professor. While it is the perspective of the researcher that the reflective writing helped the students develop a more positive attitude about physics and physics teaching, it is possible that with no prior teaching experience that this perceived effect is the natural progression of students over the course of a semester. It is recommended that further research include more rigid implementation, meaning that students be required to complete the writings. It is also recommended that attendance be required and monitored, and that this effort take place in the classroom of a more experienced teacher with full and total control over the direction of the course. In summary, this pilot showed promise despite the issues with implementation. It is hoped that further work will reveal the true benefits of reflective freewriting on the development of PST teachers in preparation programs.

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APPENDICES

Appendix A: Informed Consent for Participation

Passive Consent Form

Missouri State University
College of Natural and Applied Sciences

WRITING AS A STRATEGY TO IMPROVE PRE-SERVICE TEACHER PHYSICS CONTENT KNOWLEDGE AND OVERALL ATTITUDE TOWARD SCIENCE AND SCIENCE TEACHING

Investigator: Kali Shoaf-Laughlin

Introduction
Your participation is requested for a research study. As a student currently enrolled in PHY 101, **you may revoke your participation in this study at any point during the semester**. As a participant, it is important that you read and understand the following explanation of the study and the procedures involved. The investigator will also explain the project to you in detail. If you have any questions about the study or your role in it, be sure to ask the investigator. If you have more questions later, Kali Shoaf-Laughlin, the person mainly responsible for this study, will answer them for you.

The investigator's contact information:

Kali Shoaf-Laughlin
Kali626@live.missouristate.edu

Signing and returning this form **removes** you from participation in this study but in no way affects your enrollment in the PHY 101 course or associated lab section.
Taking part in this study is entirely your choice, you may revisit this form anytime and revoke consent with no consequence and with no reason given.

Purpose of the Study
The purpose of this study is to observe changes in pre-service teacher aptitudes and attitudes as they progress through an introductory level physics course as a result of specific writing interventions. This study will corelate overall grades and assessment data, such as data from the Physics Attitude Scale (PAS), with the implementation of writing interventions and draw conclusions about the change over the course of a semester with students among 3 different groups of lab sections.

Description of Procedures
All students will attend regular lecture three times a week as well as lab section once per week. On the first day of class, students will be presented the study and the passive consent form. They will also take the PAS. All students will take part in regular class work, discussion, and any regular assessments writing integrations will be worked into regular class time. All assignments will be graded by a separate grader. At the end of class, students will again take the PAS. Data will be collected from the regular assignments and writing integrations of those who are participating in the study by the grader. The grader will disassociate any and all identifying information prior to turning over the raw data to the investigator for analysis.

What are the risks?
There are no known risks to you as a result of participating in this study.

What are the benefits?
Benefits may include an increased understanding of physics concepts or a more positive attitude about physics and physics teaching.

How will my privacy be protected?
The results of this study are confidential and only the investigators will have access to the information which will be kept in a locked facility at the University. Unique identification will be used in place of names and all information you provide will be disassociated from personal identifying information before being delivered to the researcher for analysis. Neither your name nor personal identifying information will be used in any published reports of this research. All information gathered during this study will be destroyed at the close of study in May of 2023.

Consent to Participate
If you **DO NOT** wish to participate in this study, Writing as a Strategy to Improve Pre-Service Teacher Physics Content Knowledge and Overall Attitude Toward Science and Science Teaching, you are asked to sign below:

> By signing this form, I confirm my **withdraw** from participation in this study. I acknowledge that I will still be asked to participate in any and all writing integrations as a part of PHY 101 labs but that my data will not be collected or used. I have received a copy of this form for my own records.

____________________________ ________________
Signature of Student Date

____
Printed Name of Student

Appendix B: IRB Approval Forms

To:
David Cornelison
Physics Astronomy & Material S

RE: Notice of IRB Approval
Submission Type: Initial
Study #: IRB-FY2022-396
Study Title: Writing as a Strategy to Improve Pre-Service Teacher Physics Content Knowledge and Overall Attitude Toward Physics and Physics Teaching
Decision: Approved

Approval Date: July 12, 2022

This submission has been approved by the Missouri State University Institutional Review Board (IRB). You are required to obtain IRB approval for any changes to any aspect of this study before they can be implemented. Should any adverse event or unanticipated problem involving risks to subjects or others occur it must be reported immediately to the IRB.

This study was reviewed in accordance with federal regulations governing human subjects research, including those found at 45 CFR 46 (Common Rule), 45 CFR 164 (HIPAA), 21 CFR 50 & 56 (FDA), and 40 CFR 26 (EPA), where applicable.

Researchers Associated with this Project:
PI: David Cornelison
Co-PI:
Primary Contact: Kali Shoaf-Laughlin
Other Investigators: Kali Shoaf-Laughlin

Appendix C: Physics Attitude Scale (PAS)

Physics Attitude Scale (PAS)

Please answer as accurately as you can.
Use a check mark, "X", or something similar to indicate your answer.
Please do not add your name or any other identifying marks.
Instead, use your assigned number if available.

FACTOR I: ENTHUSIASM TOWARD PHYSICS	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
Studying topics on Physics in greater detail is not worth it					
My confidence level increases by doing physics experiment in laboratory					
The basic knowledge of physics is useful for everyone					
Physics is a boring subject for me					
The successful completion of a physics experiment excites me to do other experiments					
I am punctual with physics homework					
I wait eagerly for physics period					
I discuss physics with my friends					

FACTOR II: PHYSICS LEARNING	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
I feel very pleased and satisfied on answering the questions in physics class					
Laboratory work in physics improves individual productiveness					
I keep on practicing the problems done in the class till I attain proficiency					
I feel stressed in my physics class					
Active participation of students in practical and theory classes result in effective understanding of physics					
I try to correlate the physics problem with daily life situation					
I try to focus more on memorizing laws and derivations given in textbook rather than solving physics problems					
There are many situations in physics which are difficult to visualize					

It is very difficult to succeed in physics exam without cheating					
Difficult topics in physics do not interest me					
I study physics only when my exams are around					
Learning physics is beyond my capability					

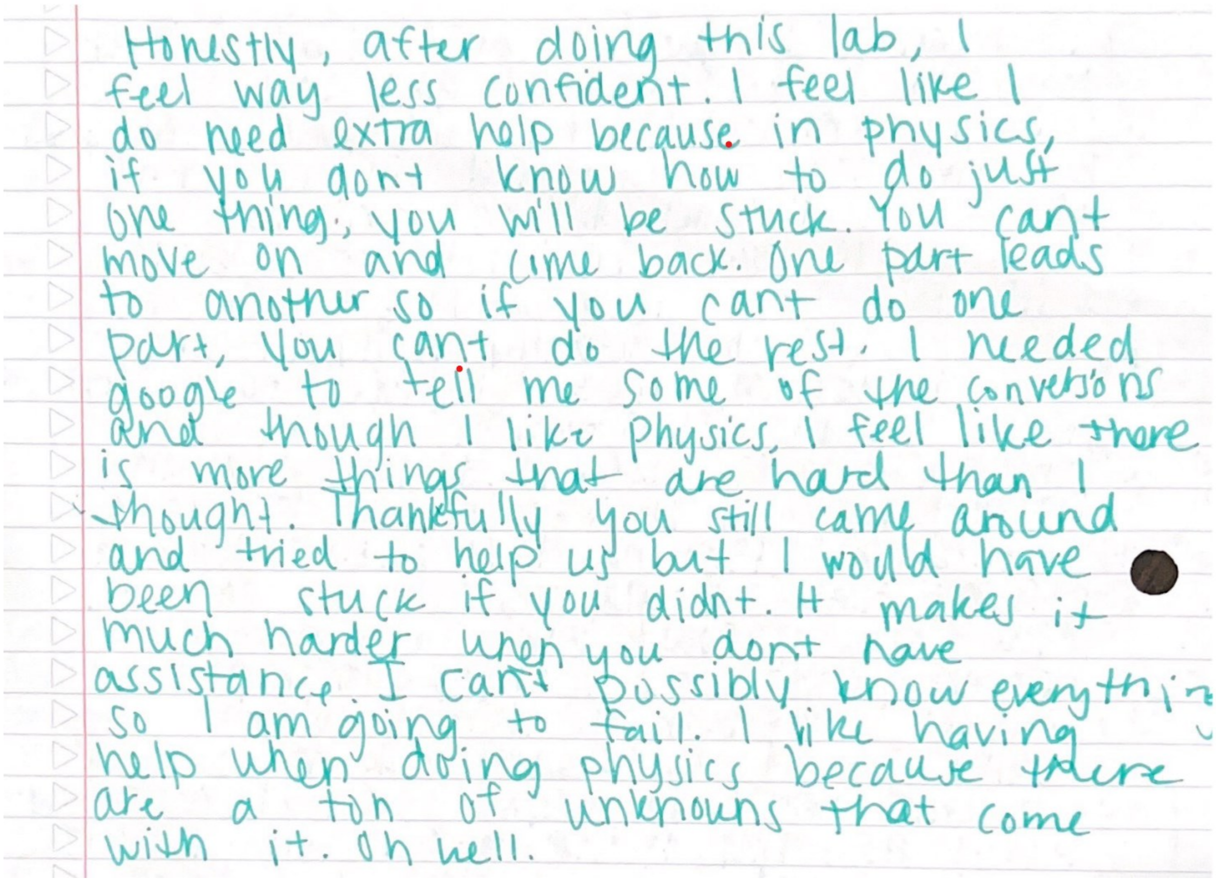
FACTOR III: PHYSICS AS A PROCESS	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
The subject of physics is ever evolving					
Physics is not just knowledge but is a process of gaining knowledge					
There is no need to further verify the laws already discovered					
The results of physics experiments are very slow					
Physics play an important role in the advancement of civilization and society					
There is nothing creative about physics; it's about memorizing laws and formulas					
Physics has contributed greatly to science and other fields					
Physics helps develop person's mind and teaches him to think					
Huge infrastructure is needed to build a physics laboratory in order to understand the subject					

FACTOR IV: PHYSICS TEACHER	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
I am scared of my physics teacher					
My physics teacher always overburdens the students with assignments					
My physics teacher encourages problem solving					
My physics teacher rarely discuss the numerical problems related to a physics topic taught in the class					
My physics teacher always comes to the class regularly					
My physics teacher does not encourage raising doubts in the class					

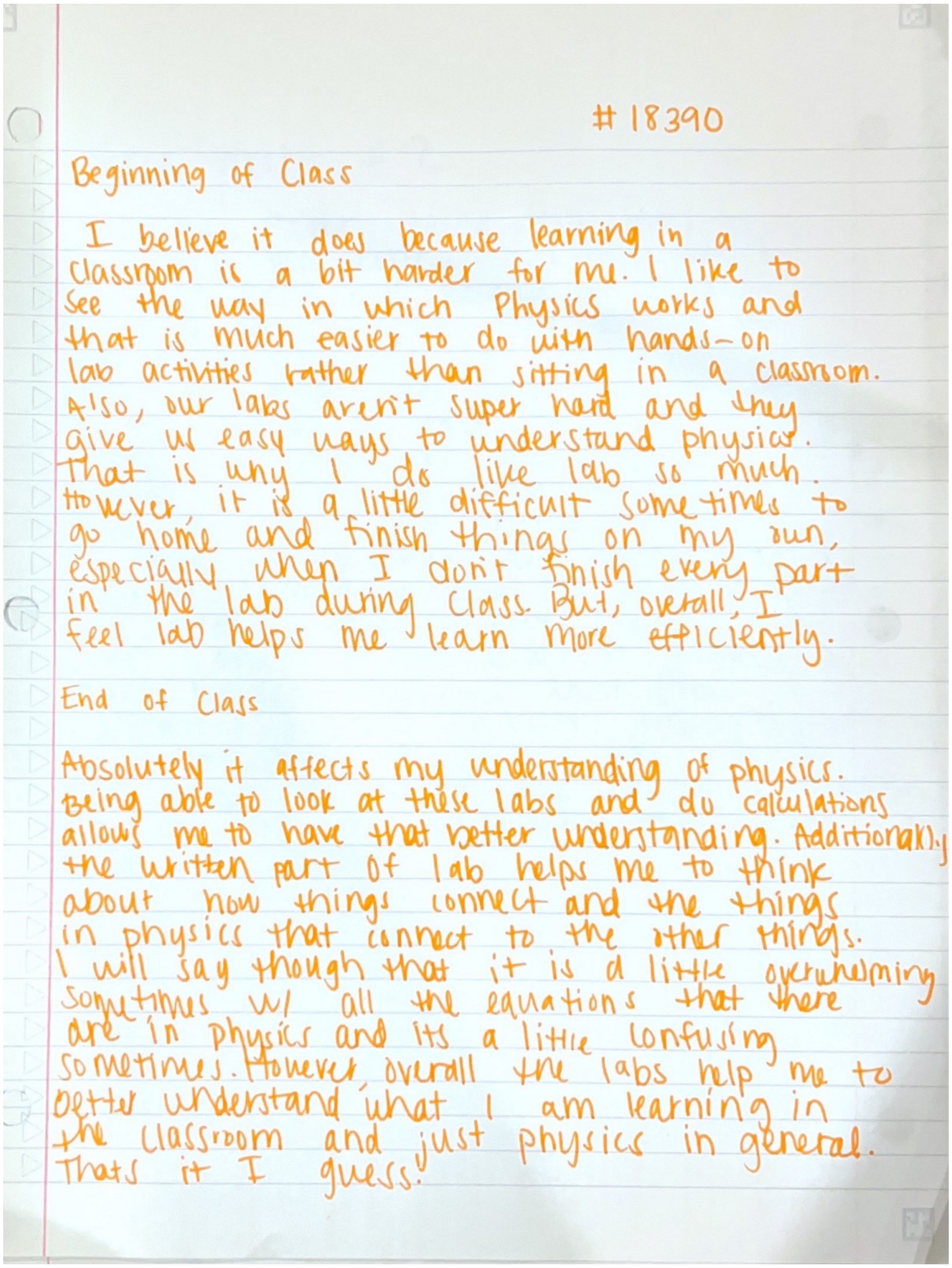
My physics teacher does not make coherent statements on the topic taught in the class					
My physics teacher uses a combination of teaching aids while teaching in the class					
My physics teacher spends the necessary amount of time helping me understand physics concepts					
My physics teacher does not believe that I am capable of learning physics					
My physics teacher often becomes frustrated with me					
My physics teacher emphasizes on understanding and not just memorization					

FACTOR V: PHYSICS AS A FUTURE VOCATION	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
Immense patience and tolerance is required to pursue physics					
The progress of a physicist is rather slow					
There is lack of job opportunities in physics					
Physics is beneficial for those who want to pursue engineering courses					
Physicist is a highly dedicated individual working toward the improvement of society					
Physics as a vocation lacks creativity					
Physicist spends his life by doing physics experiments					
Studying physics at a higher level leads to glorious future					
Physicists waste public money as all the research work does not have practical applications					
Physicist generally remains isolated from society					

Appendix D: Writing Assignment Excerpts


Honestly, after doing this lab, I feel way less confident. I feel like I do need extra help because in physics, if you dont know how to do just one thing, you will be stuck. You cant move on and come back. One part leads to another so if you cant do one part, you cant do the rest. I needed google to tell me some of the conversions and though I like physics, I feel like there is more things that are hard than I thought. Thankfully you still came around and tried to help us but I would have been stuck if you didnt. It makes it much harder when you dont have assistance. I cant possibly know everything so I am going to fail. I like having help when doing physics because there are a ton of unknowns that come with it. Oh well.

18390 – “How do I feel about today’s lab?”



#18390

Beginning of Class

I believe it does because learning in a classroom is a bit harder for me. I like to see the way in which Physics works and that is much easier to do with hands-on lab activities rather than sitting in a classroom. Also, our labs aren't super hard and they give us easy ways to understand physics. That is why I do like lab so much. However, it is a little difficult sometimes to go home and finish things on my own, especially when I don't finish every part in the lab during class. But, overall, I feel lab helps me learn more efficiently.

End of Class

Absolutely it affects my understanding of physics. Being able to look at these labs and do calculations allows me to have that better understanding. Additionally, the written part of lab helps me to think about how things connect and the things in physics that connect to the other things. I will say though that it is a little overwhelming sometimes w/ all the equations that there are in physics and its a little confusing sometimes. However, overall the labs help me to better understand what I am learning in the classroom and just physics in general. Thats it I guess!

18390 – “Does lab work make physics more enjoyable?” & “Does lab work impact my understanding of physics?”

I feel that I would be able to do Physics on my own if I practised a lot more. Physics is not really in my everyday life, so I don't feel the need to think about outside of my lab & lecture. If I was a science major or minor, I think I would want to pursue or motivate myself to work to understand physics better. I do better with hands on activities to understand concepts. I've missed some labs, so I feel that I never really fully understand some topics in class. I want to teach English Language, so I don't see myself doing Physics on my own. Maybe I can do physics with a partner so we can help each other out.

(2) I cannot do physics on my own. I realized I need a group to be with & work on problems. We can collaborate & help each other out if we are confused. In some problems I felt that I wasn't able to figure out to use a simple equation or answer a question without help. I struggled a lot & still am. I can do well with the math part but figuring out which unit to use is what got me. Some things look the same or are too confusing so I don't know if I'm doing it right w/o someone checking on me after every problem.

18422 – "Can I do physics on my own?" from the beginning and end of class

In todays lab I felt okay but not confident. I wish our numbers wouldve came out better/more accurate. Callie was telling us its okay that they werent spot on but im kind of a perfectionist and it was making me mad. When doing the pin part (before the measuring), that part was good because I knew what I was doing after asking questions.

18400 – "How do I feel about today's lab?"

I think labs definently make physics better. On top of it being hands on + the sterotype of being "fun", I learn better this way to. Seeing things played out + seeing where numbers are coming from is more interesting + helps me learn it better too. I think it could make it more stressful for people but thats how I learn so its easier.

end:

I think lab does impact my understanding. You having to exicute it yourself forces you to know what is happening and how you got there. Although it helps most of the time, today it kinda just shut me down because the instructions were so unclear. So instead of helping, it kinda hurt me + the learning with it.

18400 – "Does lab work make physics more enjoyable?" & "Does lab work impact my understanding of physics?"