EVALUATING HOMEWORK IN HIGH SCHOOL PHYSICS

by

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ABSTRACT

What are the best and most effective methods of administering homework in the high school physics class to maximize learning? The project to investigate this question was conducted at Harwood Union High School, a school of about 550 students. I worked with two standard algebra-based physics classes. Two specific policies were analyzed: Checking off for completion only and collecting and grading on correctness. The effectiveness of the policies were measured by giving student quizzes based strictly on previous assigned and completed homework and tracking improvement in seven areas: identifying knowns and unknowns, equation usage, substitution skills, algebraic manipulation, calculations and concept understanding. The results of the project show that the same growth in problem solving skills was obtained whether homework was just checked off for completion or thoroughly examined for correctness. The one area that did seem to make a difference was student's understanding of physics concepts. Students seemed to put in much more thought in answering conceptual questions when they knew their work would be graded on correctness. I also surveyed the other teachers of science and math at my school to see what their homework policies were.

INTRODUCTION AND BACKGROUND

The high school where I teach is Harwood Union High School (HUHS) in South Duxbury, Vermont, the only high school in the Washington West Supervisory School District. Harwood had a 2015-16 enrollment of 659 students. For the most part, the district consists of middle to upper middle-income families. The percentage of students who receive free or reduced lunches at the school is 26 % (WWSU, 2016). Major industries in the area include several ski resorts, Ben and Jerry's Ice Cream's main corporate factory and Green Mountain Coffee Roasters central office. The racial background of Washington County where the school is located is 96% White, 1.9% Latino, 0.9% Afro-American and 0.9% Asian (WCQF, 2016).

The science department at HUHS consists of six faulty, two chemistry, two biology, one earth space science and one physics teacher (me). My teaching load is generally two standard algebra based physics classes one AP Physics calculus based class and one lower level combined physics and chemistry class. My research concerned itself with how homework is assigned and evaluated in my standard algebra based physics classes. The two physics classes that I used for this study were fifteen and eighteen students in size. The classes meet on the same days and occur back to back.

The concept of homework is almost as old as public education itself, as is the controversy over its value. I am a firm believer that for a person to master a task or intellectual concept they must practice it. The best way for this to be accomplished is through independent study, i.e. homework. Aside from giving students an opportunity for mastering and understanding concepts, homework has other hidden values. First, I believe it helps students learn self-discipline and the value of organizing their time. Second, when it comes to learning the skills of problem solving, homework gives an excellent opportunity for a student to privately reflect on the dynamics of how particular problems can be solved. Unfortunately, the way most schools presently run, there are limited opportunities for students to practice and master lessons on site. This leads to the necessary requirement for practice problems and concept development questions to be done outside of class.

The problem is how to motivate students to do the required work to reinforce the new learning and to develop those important problem-solving skills. Traditionally teachers have used a carrot and stick approach to encourage students to do the assigned work. On the one hand, teachers could use the direct approach, rewarding students by grading homework. This gives credit to those students who make an effort to do the work and learn the material and penalizes those students that do not. Of course, this encourages students to copy work that they have not done in order to get the credit, thus undermining the original reason for giving credit for the assignment in the first place. On the other hand, teachers could use the indirect approach by quizzing or testing on assigned work. The idea here is that students who have done the homework and mastered the material will do well and those students who have not will do poorly. Of course there could be very bright and talented students who do not do the homework but have a good idea of the concepts and therefore do well on these quizzes. There could also be other students who have done all the required work but are still struggling in their understanding of the concepts and will do poorly on the quizzes. This evaluation method denies credit to those students who may be developing the discipline and problem solving skills by doing the homework, but who still struggle with understanding basic concepts. The other concern is that it gives credit to those students who are avoiding developing those secondary homework skills. Then of course there is the time factor. Not only does it take away from precious teaching contact time to give these quizzes but it also burdens the teacher with additional grading. Another problem is accommodating students who missed the initial quiz and have to make it up at a later time.

Clearly then, the concept of assigning and evaluating homework is more complicated that it might first appear. The focus of my study was: what are the most effective ways to give and evaluate homework in a standard algebra based high school physics class that will promote student learning and problem solving skills in the best possible way?

CONCEPTUAL FRAMEWORK

The nature and value of giving homework in the American high school has been controversial for over 100 years. During the first half of the twentieth century there was an active effort to abolish homework by leading educational reformists (Gill & Schlossman,1996). Homework was thought of as harmful to children and unfair to parents. In many areas homework was eliminated from the public school curriculum altogether. The apex of the antihomework movement was reached in 1941 when an article in the *Encyclopedia of Educational Research* (1941) concluded that the advantages of assigned homework were too small to off set the disadvantages. The justification for this antihomework movement was the distaste that educational reformers had for its dependence on "recitation," the teaching technique where students would memorize facts only to recite them back to the teacher the next day (Gill & Schlossman, 2000). The antihomework movement was pushed back somewhat after the launch of Sputnik in 1957. Educators were concerned that there was a lack of rigor in American schools and that more rigorous homework would be a partial solution to the problem. The antihomework movement was back by the 1980's when learning theorists thought it could be harming students' mental health. Since then the homework debate has gone back and forth (Marzano & Pickering, 2007).

Despite the controversy that has existed over the past century, there is strong evidence that homework does have a positive association with academic achievement. The nature of this association is somewhat complex. Time spent on assignments, as well as the nature of the assignments are important (Maltese, 2012). For junior high school students the maximum amount of time seems to be about one to two hours per night, more than that and the benefits decrease (Cooper, 1989). One rule of thumb might be the "10 minute rule" where the amount of homework assigned is 10 minutes multiplied by the students' grade level (Cooper, 2007). Time spent on homework does show a moderate increase in standardized test scores for secondary students. However, considering the large amount of time spent on homework, there should be much greater gains in academic achievement. There needs to be a reevaluation of the goals of homework and a reworking of the nature of the assignments in order to promote greater student understanding and engagement of the material (Maltese, 2012). Another factor in doing homework is parent involvement. Often parents feel unprepared to help their child and this often causes stress between parent and child. This can be mitigated if parents take a role of reviewer in cases where the assignment is for the child to explain a concept, or if the child needs to conduct an interview for a social studies or similar class (Good & Brophy, 2003).

If students are to do homework, motivating them to complete assignments is the next obvious challenge. In a study conducted at the United States Air Force Academy between the years of 2008 and 2012, several motivating mechanisms were examined. The authors of the study looked at grade incentives, homework-based quiz problems and intrinsic motivation for 16 semesters of introductory mechanics and electricity and magnetism classes. When homework was a percentage of the final grade, maximum results were obtained at about 15% of the final grade. Intrinsic motivation worked for some students only when discussions on the value of homework were regularly incorporated in the lessons. Basing quizzes on homework was also a motivator especially when students could use their assignments as reference when taking the quiz (Konturi & Terry, 2014).

In other research, it was determined that the real motivation for doing homework was in the nature of the homework itself. Homework completion by students was broken down into four areas: completers, slackers, bewildered and cheaters. Completers were those students that did the work correctly, demonstrating mastery of the topic. Slackers included those students who do not have the support at home and do not fully understand the topic. These students frequently gave up with little understanding of the concept to be mastered. Bewildered were students who complete the assignment but did it incorrectly. Lastly there were the cheaters, those students who copy the assignment, giving no indication to themselves or the teacher whether or not they understand the concept. All of these responses by students to homework are often the result of poor homework design and implementation. Teachers, assign work either as an afterthought or because the lesson ran short and the student needed to do independent study or practice. Instead, teachers need to carefully integrate the homework into the lesson so all students understand the task at hand and use it to reinforce the learning process (Fisher, Lapp & Frey, 2011).

Giving students the opportunity to choose the homework problems as well as some of the problem solutions has also been a successful motivator. In a method that explicitly tells students that homework is a tool for learning and not a tool for evaluation, students could chose from a collection of problems to solve and be graded on effort more than correctness. Solutions to some of the problems were also provided several days before they were due to help students through any difficulties they may have had. The problems were rated on a level of difficulty A, B and C. If a student could consistently work out 'A' level problems he or she would most likely get an A for the course. In the end, when students were surveyed about this homework policy, most students liked the policy and worked more problems than were required (Bao, Stonebraker & Sadaghiani, 2008).

In the end, maybe it is more a labeling problem than anything else. In the article entitled Homework on Homework, it suggests that we do away with the term "homework" and replace it with a term like "independent study." Homework has the connotation of a chore or task to be accomplished instead of an opportunity to explore on ones own, which denotes freedom and independence (Nelms, 2008).

METHODOLOGY

In order to assess the different policies for assigning and evaluating homework in a high school physics class, I studied and appraised two different homework methods to analyze two different aspects of physics understanding: problem solving and understanding of concepts. During a four-month period from November through February, I evaluated the two different policies of assessing physics homework assignments. All homework assignments had the same general format (Appendix A). They each had two conceptual questions, which required written explanations, and two problems, which required skills in identifying given and sought information, use of correct equations, performing correct substitutions, algebra, calculation and conversions and units. Each policy treatment period was nine class days in length. Because of holidays, midterms and the fact that classes meet every other day, the actual time period in weeks varied. The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for working with human subjects was maintained (Appendix B).

The first policy treatment was grading the homework for completion. Homework was checked to see if students had only attempted it by a quick visual scan. This began in the second week in November and ended four weeks later during the first week of December. Because of the Christmas holiday and midterm exams in January, the second policy treatment did not begin until mid January and continued to mid February. During this time, all homework was collected and evaluated on correctness. Homework was then returned at the beginning of the following class. In both treatments the homework was reviewed at the beginning of class by having students put their work on the board and discussing the solutions and answers to the conceptual questions.

To evaluate the effectiveness of the homework policy, the students were given a Two Question Quiz at the end of class that was based on the previous assignment (Appendix C). The quiz consisted of one multiple-choice question evaluating the student's conceptual understanding and one word problem to evaluate the student's problem solving skills. The correct answers for the conceptual multiple choice questions were tallied for each quiz and the two treatments were compared using a t-test. The word problem was appraised using the Problem Solving Rubric (Appendix D). The six categories evaluated using this rubric were scored as Yes or No. A score of Yes = 1 and No = 0. Each category was tallied and the percent correct was listed and the difference between the checked only group and the collected group was compared using a t-test to evaluate the effectiveness of each method. These quizzes occurred at the end of the class period where the solutions were discussed, resulting in four quizzes during each policy treatment. A t-test was performed comparing the quiz results of the two treatments in each of the six areas of problem solving. In every area of problem solving skills, the t-test critical value for 95% confidence indicated that the change in how students performed on the two sets of quizzes was not significant. Nominal gains of the class average between the first quiz of the first treatment (quiz 1) and the last quiz of the second treatment (quiz 8) were also computed. These scores were then ranked according to the scale: $g \geq 0.7$

(high); $0.7 > g \geq 0.3$ (medium) and $g < 0.3$ (low) to get an overall indication of class improvement (Hake, 1998).

Before the first policy treatment and after the last treatment, the students were given the Student's Self Evaluation on Skills at Solving Word Problems Survey in order to assess their own confidence level at solving word problems (Appendix E). The first survey was compared to the results of the first homework assignment on problem solving given the first week of class to see where the students actually were on their problem solving skills. The last survey was compared to results of the last homework assignment of treatment 2. I also administered the Student's Attitudes on the Kinds of Homework Assignments survey to evaluate student's attitudes towards different homework polices (Appendix F). This survey was given at the beginning of the treatment and the again at the conclusion of the last policy treatment to see if student's attitudes toward homework may have changed as a result of the treatments.

A second part of my study consisted of evaluating the attitudes and practices of the science, math and STEM teachers. Each teacher was given the Science, Technology, Engineering and Mathematics Teacher Survey on Homework to see how often these teachers administered homework and how it was evaluated (Appendix G). There was also a space for any general comments that they had on the subject. A summary of the research questions of my study and my data source are outlined in the triangulation matrix (Table 1).

Table 1
Triangulation Matrix

Research Questions	Data Source 1	Data Source 2
Applying Physics Concepts	Pre and Post Survey	Conceptual Multiple Choice Questions
Known and Unknown Value Identification	Pre and Post Survey	Rubric Evaluated Problems
Equation Identification	Pre and Post Survey	Rubric Evaluated Problems
Ability to Substitute Values into Equations	Pre and Post Survey	Rubric Evaluated Problems
Algebraic Skills	Pre and Post Survey	Rubric Evaluated Problems
Computations and Conversions	Pre and Post Survey	Rubric Evaluated Problems
Teacher Attitudes Toward Homework	Survey	

DATA AND ANALYSIS

The results of the Student's Self Evaluation on Skills at Solving Word Problems survey prior to my research indicated that 81% of the students felt that they were skilled at identifying the information supplied in a word problem. The pretreatment assignment indicated that only 72% of the students could actually identify the information correctly (*N*=27). When it came to identifying the things the problem was asking for, 89% of the students felt they could do that successfully. However, the pretreatment assignment showed that only 57% of students knew what the problem was asking for. A similar pattern continued through the survey when matched against the results of the pretreatment assignment. When asked how well they thought they could decide which equation to use to solve the problem, 74% felt they could do this but only 62% succeeded in the actual task. Once students knew what information the problem supplied and what it asked for and they knew what equations to use, the mechanics of problem solving is all that remained. Students perceived skills were consistently higher then their actual abilities, 89% verses 76%. Student's perception of their problem solving skills changed little as the result of the both treatments. The only noticeable exception to this was a drop in their perception to correctly identify the correct equation to use when solving a problem. In this area, students felt they could only identify the correct equation 65% of the time, a drop of 9% (Table 2).

Table 2
Perceived Skills vs. Actual Skills, (*N*=27)

	Students' Perception of Skills (Pre Treatment)	Actual Measure of Skills (Pre Treatment)	Students' Perception of Skills (Post Treatment)	Actual Measure of Skills (Post Treatment)
Identify Given Information	81%	72%	92%	85%
Identify What Problem is Asking to Solve For	89%	57%	89%	97%
Identifying Correct Equations	74%	62%	65%	90%
Substituting Correctly	85%	69%	93%	90%
Preforming Correct Algebra	89%	76%	88%	86%
Calculations and Conversions	92%	66%	92%	82%
Labeling Units	81%	76%	81%	91%

Students' abilities to problem solve consistently improved during the first treatment (quizzes 1 - 4) of only checking homework without grading it for correctness. Students' ability to identify given information after the first quiz was 90%. After the conclusion of the first six-week treatment this had improved to 97% (*N*=31). The students' ability to identify what the problem was asking for, the unknowns, increased from 58% to 84%. The third area of improvement was in the ability to list the correct equations needed to solve the problem. Here the skill level rose from 77% to 90% post treatment. The areas of least change were in students' abilities to preform the correct substitution of values into the equation and to do the algebra needed to solve for the unknowns. In their capability to do correct substitution there was a slight decline from 97% to 94% but their algebraic skills increased slightly from 90% to 94%. The last area of improvement was in doing the final calculations and conversions. Initially the successes rate was 65% but by the end of the final homework it had risen to 90% (Figure 1).

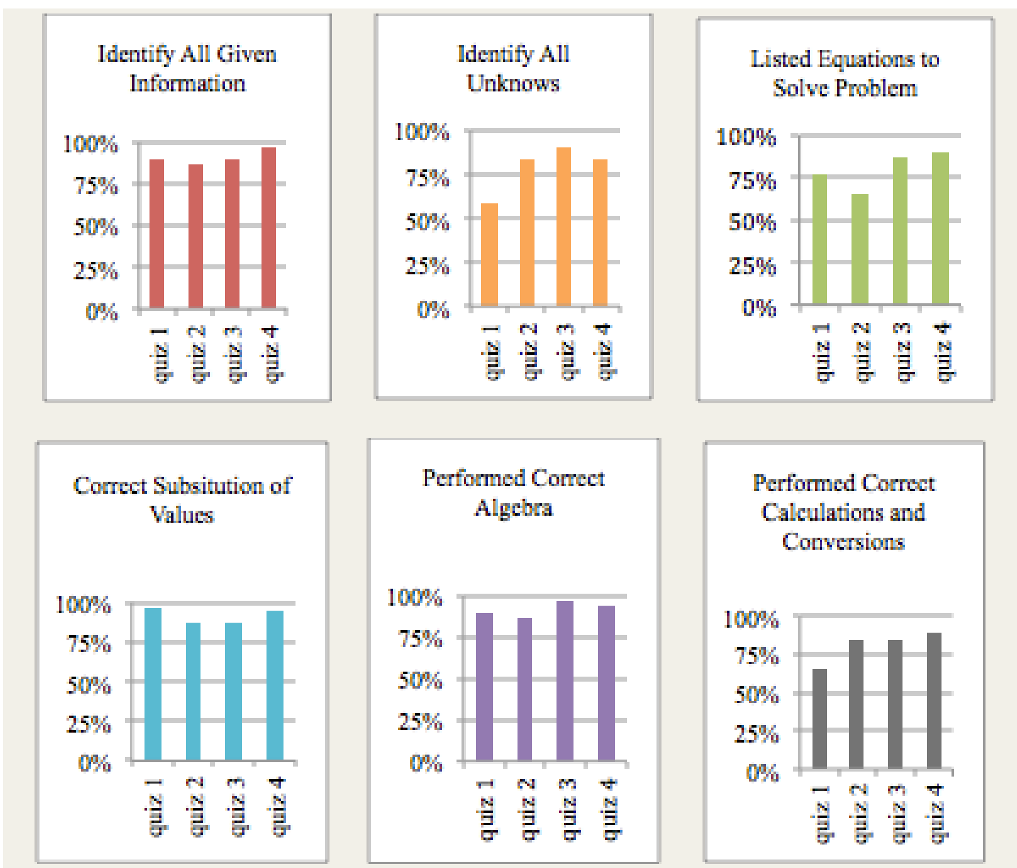

Figure 1. Overall change in problem solving skills post treatment 1, (*N*=31).

The change in students' problem solving skills as a result of the second treatment (quizzes 5 – 8) involving collecting and grading all homework was similar to the first treatment where homework was just checked off. Students' abilities to identify the information given in a problem and what the problem was asking to solve for both rose from 90% to 97% at the end of the six week treatment (*N*=29). Recognizing the correct equation to use rose from 69% pretreatment to 83% post treatment. Correctly substituting in the values into the equation began at 66% and ended at 90%. Being able to use the calculator correctly went from 76% to 97% at the conclusion of the study (Figure 2).

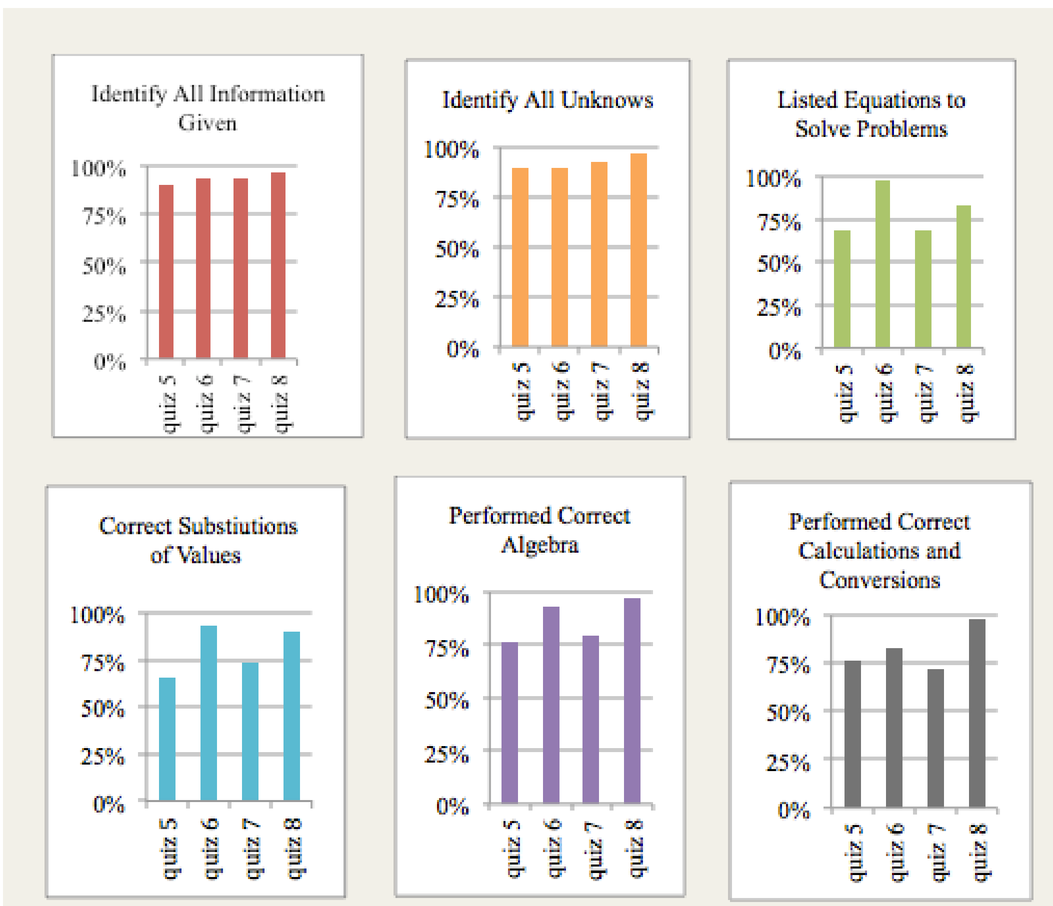

Figure 2. Overall change in problem solving skills post treatment 2, (*N=27).*

The results of a t-test of the problem solving skill areas indicated that there was no significant change in students' ability to list equations and do correct calculations.

Here the confidence level was between 50% and 75%. For students to identify given information and perform the correct algebra the confidence level ranged from 80% to 85%. Lastly, the students' ability to identify all the unknowns in the problem and replace the variables with the correct values had a 90% to 95% confidence level (Table 3).

Table 3
T-test Problem Solving Results Comparing the Two Treatments

t-test Problem Solving Results (critical value for 95% confidence = 2.48)			
Area	t- statistic	Confidence Level	Significant (Y/N)
Identify given information	0.88	80%-85%	N
Identify all unknowns	1.84	90%-95%	N
List equations to solve	0.03	50%-75%	N
Replace variables with values	1.54	90%-95%	N
Performed correct algebra	1.02	80%-85%	N
Correct calculations and conversions	0.16	50%-75%	N

Even thought the results of the t-test indicated that there were no significant change in students' ability in problem solving skills overall, the nominal gains for identifying the unknowns was 0.93, and for using the correct equation 0.74, both considered a high gain. The mean of the pre/post skills rose 20% from 68% to 88% over the course of the entire study. One student commented: "I got a lot better at solving the problems but I still don't like them." Still another commented: "All the problems we did really helped my algebra."

The second category that was evaluated was student's conceptual understanding of physics ideas. During the first treatment scores did improve but were consistently below 80%. The average score of first four multiple-choice questions was 72%. For the second treatment, there was little improvement between the first quiz (quiz 5) and the last quiz (quiz 8). The average scores improved with average score of 86% (Figure 3).

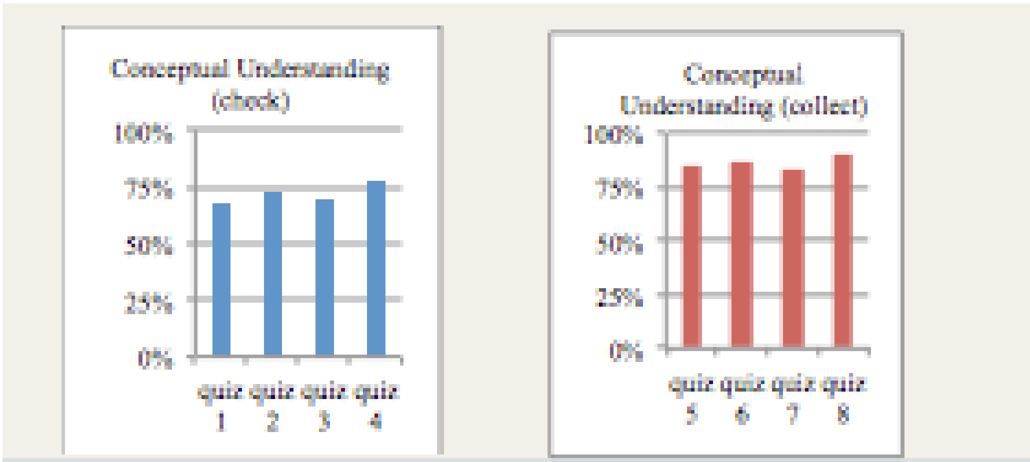

Figure 3. Changes in conceptual understanding between the two treatments.

Evaluating the difference in student understanding, a t-test indicated that there was a significant improvement in student's understanding of concepts using the collected and grading method over the check only with a t-test confidence level of 99.5% to 99.9% (Table 4).

Table 4

T-test Conceptual Understanding Results Comparing the Two Treatments

t-test Conceptual Understanding (critical value = 2.48)

Area	t-statistic	Confidence Level	Significant (Y/N)
Conceptual Understanding	4.95	99.5%-99.9%	Y

Students' attitudes towards the value of homework did change over the course of my investigation. There was an increase in student's dislike for short answer reading comprehension assignments from 7% to 31%. Although students disliked these kinds of assignments, they did find them useful however. Student's attitudes towards questions dealing with understanding concepts stayed relatively unchanged except for a drop in the number of students that liked and found them very useful from 32% to 19%. Students that liked and found simple "plug and chug" problems useful increased from 32% to 46% over the course of the study. The attitudes toward solving word problems and finding them useful increased from 11% to 31%. It should be noted that the percentages do not add up to 100% in each category because not all students answered all questions on the survey. I also rarely had 100% attendance so the student body that took the surveys changed slightly from survey to survey.

The last area I investigated was how often teachers in the science, math and STEM departments assigned and evaluate homework. There are six science, six math and two STEM teachers. The first question I asked the teachers was how often they assign homework. Seven of these teachers assign homework 50% to 75% of the days they are teaching a unit (as opposed to days of review, testing and labs). Five of the teachers will only assign homework if they feel students need extra work on a particularly difficult topic, one teacher never assigns homework and one teacher (myself) assigns homework at least 75% of the days of teaching a unit (Figure 4).

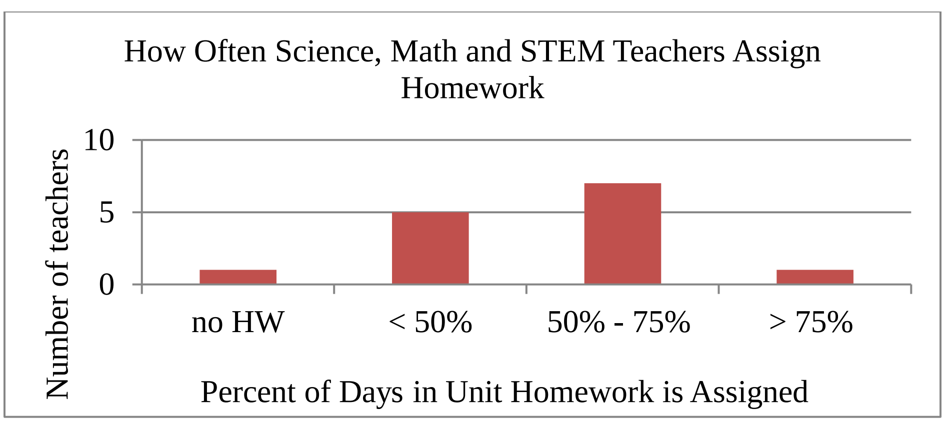

Figure 4. How often science, math, and STEM teachers assign homework.

The second question I asked was how it was evaluated and what percentage of the grade it would make up. The teachers of freshman do not assign grades but evaluate student's work on proficiencies. To that end, homework is regarded as formative assessment and is evaluated in terms of 'Habits of Work' (HoW). All three-freshmen teachers evaluate as such. One teacher does not count homework towards a student's grade at all but requires it to be done if a student is to retake any test or quiz. Five teachers count homework as less than or equal to 10% of the grade. One teacher counts it as 20% and one teacher (myself) as 25% of the grade (Figure 5).

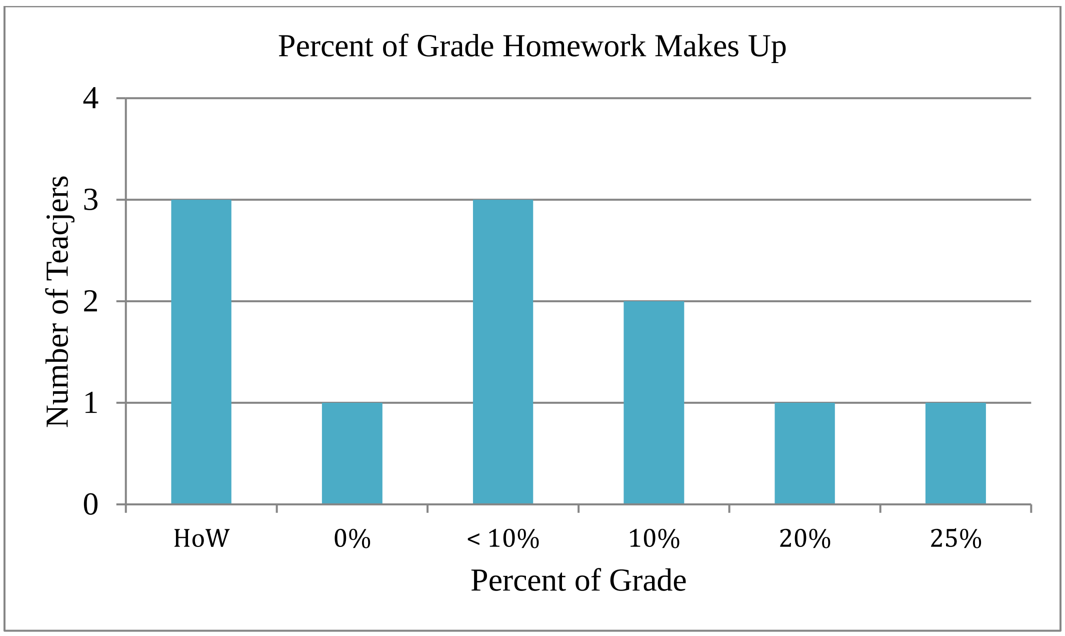

Figure 5. Percent of grade homework makes up.

The final issue regarding homework I surveyed the teachers about was how they evaluate and check homework. Of the six options on the survey, there was a pretty even spread among the choices (Figure 6). The written comments were more informative then the check off questions that I had provided on the survey however. One teacher commented "I think that homework can be helpful if there is content that they would benefit from practicing multiple times (solving math problems)." This view was reflected in several teachers' comments. To a large extent however homework was downplayed as another teacher commented "I much prefer my students to do classwork rather than homework so they can have the support of each other, public documents [worked out examples on the board] and me." The approach of having students practice problems in class with the support of the teacher and fellow classmates was a common theme among most of the teachers that I surveyed. Homework was generally regarded as extra practice and not considered as an integral part of the teaching process.

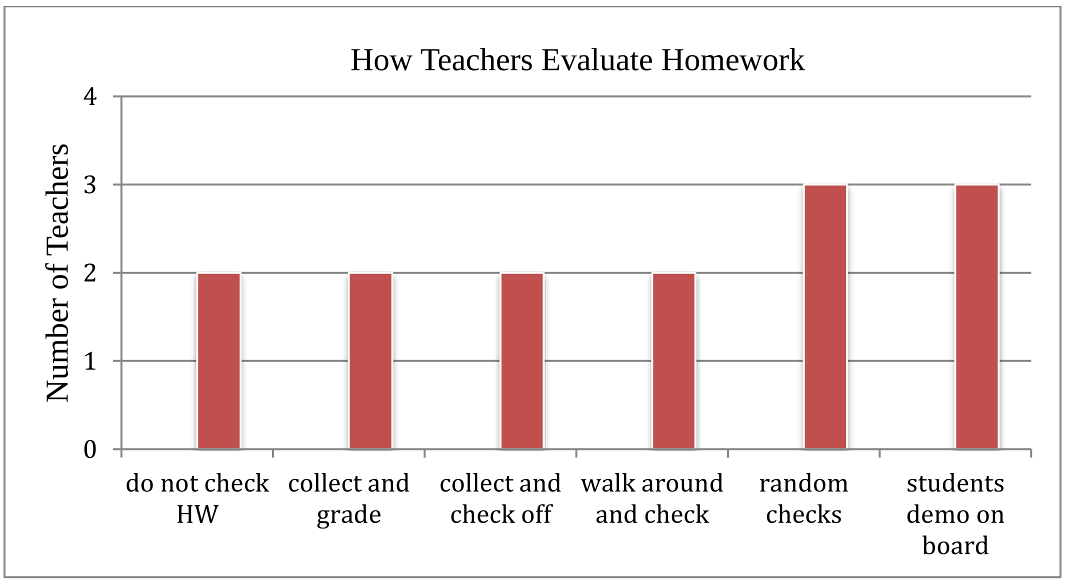

Figure 6. How teachers evaluate homework.

INTERPRETATION AND CONCLUSION

The solving of the mathematical type problems generally found in high school physics is something that students have not had much exposure to by the time they are a senior and take physics. Things like identifying the quantities that are given in a problem and the quantities that are needed to solve for confuses more than a few students. Even simple algebraic techniques that were learned as freshman are often forgotten.

The t-test I preformed comparing the quiz scores of the two treatments showed little difference whether I just check off the homework assignments or carefully grade them on correctness; student performance in solving problems is the same. I believe there is a good reason for this. As the class progressed through fall into the winter, students continually worked on their problem solving skills, both in class and as homework assignments. Regardless of how the homework was evaluated, most students' problem solving skills improved. Another issue I think was that as treatment two was implemented, the sheer number of equations for students to use increased dramatically compared to what was available during treatment one. The increase in the number of equation made choosing the correct equation much more difficult for the student.

The one area that did make a difference was students understanding of physics concepts. During the first treatment I had noticed that most students would only write a few words or short phrase when answering conceptual questions and often had an incomplete explanation when called upon during the review of the assignment. When homework was collected, and students knew their answers would be carefully read, much more thought went into composing their responses. As a result of students spending more time and effort answering these kinds of questions in their homework, there was a definite improvement in the scores of the multiple choice sections of the quizzes.

This year my school began an 80 minute, A / B block schedule. This doubled the amount of class time teachers met with students on a given day but halved the number of meeting days. Most teachers in the science and math departments used these longer periods not to cover more material but to have students practice the day's lesson independently and in groups. As a result, homework was minimized. Half of the fourteen teachers I surveyed indicated they assigned homework 50% to 75% of the day's lessons are taught but many of the assignments were for students to finish work that was not completed during class. The actual number of students that had homework was unknown.

As our school moves to proficiency based grading, class work and homework are considered formative assessments and are not included in the student's final evaluation. This is clearly reflected in the low percentage that homework is used in calculating a student's final grade in the class. Of the eleven teachers that answered the survey question regarding the percentage of the grade homework makes up, nine made it less than 10% or included it in the students' "Habits of Work" (HoW). The only teachers that considered homework 20% or more was the one of the STEM teachers who gave take home projects that he considered homework, and myself.

Since homework was not a major part of a student's grade, evaluation of it by teachers was fairly casual. As indicated in Figure 6, teachers either did random checks or had students demonstrate their solutions on the board. This seems to be an effective way to evaluate student's work since it allows taking ownership of their work and seeing that many students will make the same mistakes as themselves when solutions are shown on the board. It also reduces the amount of time teachers use to evaluate homework.

The goal of my study was to find the most effective ways to give and evaluate homework in a high school physics class. To a large extent I had believed that students would be better motivated to spend more time on problem solving if they knew the instructor would carefully grade it. This appeared not to be the case. What did motivate students were the quizzes that were based on homework as found by the study of Konturi & Terry, (2014). The other aspect of my study that seems to parallel this is the detailed review of conceptual questions. Students were most likely to spend time on these if they knew their answers were to be reviewed by the instructor.

Although I did not examine a “no homework” policy, it seems clear that there is little advantage to collecting and grading problems as opposed to just checking for completion. My findings have somewhat underlined what was stated in the *Encyclopedia of Educational Research* (1941) which said that the advantages of assigned homework were too small to off set the disadvantages. Clearly, student growth in problem solving was minimal at best for all the effort it took me to go over them in detail.

Examining what the other teachers do, especially with math, having the homework be a carry over from class work may be a better approach. It may be more of a labeling issue than anything else. As Nelms (2008) found in his study, maybe calling it independent study that is left over from class work will remove the stigma that the term “homework” implies and motivate the student to complete a task he or she has already started.

VALUE

I was somewhat surprised by the findings of my study. Being a 30-year veteran of teaching high school physics, I was a firm believer in the value of homework as a tool to help students develop and reinforce their problem solving skills and their understanding of concepts. Expecting students to take the path of least resistance when it came to the learning process, it seemed only natural that they would put more effort into and get more out of homework if they knew it would be carefully reviewed by the teacher as opposed to being casually checked off. The results of this study showed there was little difference in the growth of problem skills regardless which method of homework evaluation was used. What did make a difference was to encourage students to write out answers and reflect on conceptual type questions.

Reflecting on my teaching style, I can see that I give students many opportunities to hone their problem skills with sample problems on the board, in class work and homework. Time to consider and think about conceptual questions is limited however. When students knew their answers would be critically assessed they put more time and thought into them which resulted in a deeper understanding of the ideas involved as evidenced by the improved scores on the multiple choice questions on the quizzes and exams.

Taking a page from what many of the math teachers do, giving students an opportunity to work problems in class with the immediate help from the instructor and peers seems to be a more effective method of improving student’s problem solving skills than assigning homework and doing a comprehensive grading of it. The new 80-minute block my school has moved to is ideal for this. My only issue is the loss of teaching time. With a forty minute class I was guaranteed a period of time for instruction before student’s attention began to wane. With the 80-minute class my instruction time cannot be twice as long so less material is being covered. I suppose this is a case of plowing deeper but not as broad.

As further evidence of the results of my research, there are the outcomes of student performance following my study. In the unit that followed treatment two I did not check or collect homework nor did I give quizzes based on homework. Although I did not statically analyze the results, the unit exam showed about the same level of performance on problem solving but a noticeable decrease in student's understanding of concepts.

This capstone paper is the first in depth, professional research paper I have done. The influences it has had on me as a teacher have come from two aspects of the project. The first is the step-by-step, methodical way I was directed through the process. In the past I have shunned giving students independent class projects because of the lack of structure in the process. The three-semester program that was used here with definite outcomes, deadlines and targets has made me rethink and rework how to handle student projects. Last semester I used many of the techniques used by the MSSE program on a student directed project in my environmental science class. The project was broken down into clearly defined steps with deadlines for students to meet. For the most part, the final results of the students work were much better than projects I received in the past and evaluating the work was greatly simplified.

The second and maybe deeper impact this study has had is showing me exactly how this kind of research should be done. My general fog of how studies are done has been replaced with a specific structure that I readily share with my students. As my school moves to proficiency based learning and evaluations, I see myself sharing the skills I now have acquired with students when they do their research projects and with other teachers when we develop proficiencies for the course work and for graduation.

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APPENDICES

APPENDIX A

HOMEWORK ASSIGNMENT SAMPLE

Physics **Name**______________________________
HW 1

Conceptual Questions

1. Explain why two objects of different masses will accelerate at the same rate in a vacuum

2. What does it mean for a system to be in mechanical equilibrium.

Problems

1. A 65 kg bicyclist applies a force of 50 N to the pedals. What is her acceleration?

2. What is the acceleration of a 3 kg cat that falls out of a window if the air resistance is 20 N?

APPENDIX B

IRB EXEMPTION

David Johnson: IRB approval 11/16/16

INSTITUTIONAL REVIEW BOARD

For the Protection of Human Subjects
FWA 00000165

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MEMORANDUM

TO: David Johnson and John Graves

FROM: Mark Quinn *Mark Quinn CJ*

DATE: November 16, 2016

SUBJECT: *"A Study on the Implementation and Evaluation of Homework in High School Physics Classes"* [DJ111616-EX]

The above research, described in your submission of November 14, 2016, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

_X_ (b) (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

_X_ (b) (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.

____ (b) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement}, survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.

____ (b) (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.

____ (b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.

____ (b) (6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it. If you wish a review and committee approval, please submit 3 copies of the usual application form and it will be processed by expedited review.

APPENDIX C

TWO QUESTION QUIZ SAMPLE

Physics **Name__________________**
Quiz 1

<u>Conceptual Multiple Choice</u>

1. If an object is in mechanical equilibrium then which of these statements must be true:

A) The object must be accelerating
B) The object's velocity is constant
C) The net force on the object equals its weight
D) The object is in free-fall
E) The object <u>must</u> be at rest and not moving

<u>Problem</u> *(Solve the problem showing all work, equations, and units for full credit)*

A baseball pitcher throws a ball with an average force of 35 N with an acceleration of 55 m/s^2. What is the mass of the baseball?

APPENDIX D

PROBLEM SOLVING RUBRIC

Skill to be evaluated	***Yes / No***
Student identified all information in the problem	
Student identified all information sought in the problem	
Student listed any equations needed to solve the problem.	
All equations listed were correct	
Student replaced all variables in equations with correct values	
Student correctly performed all necessary algebra correctly	
Student correctly did all calculations	
Student correctly labeled answer with units	

APPENDIX E

STUDENT'S SELF EVALUATION ON SKILLS AT SOLVING WORD PROBLEMS

Student's Self Evaluation on Skills at Solving Word Problems

	I have great difficulty in doing this	*I can do it but sometimes am unsure of what I am doing*	*I can do this pretty well but sometimes make mistakes*	*This is very easy for me and I rarely make a mistake*
I can identify exactly what I am trying to solve for				
I have a good idea what each value in the word problem represents				
I have a good idea what equations to use when I start the problem				
I can substitute in the correct values in the equations				
I can correctly do the required algebra to solve for the unknown				
I can correctly put the values into my calculator to get the correct answer				
I know the correct units to put to my answer				

APPENDIX F

STUDENT'S ATITUDES ON THE KINDS OF HOMEWORK ASSIGNMENTS

Student's Attitudes on the Kinds of Homework Assignments

	Choose only one of these choices				**Check if you agree**
	It is a pointless waste of time and I get nothing out of it	***Don't like it but I do get something out of it***	***Don't mind it and it is somewhat useful***	***I like it and it really helps in understanding the material***	***INSTEAD of having HW we should do this work in class***
Short answer questions based on the reading					
Evaluation questions based on understanding the concepts					
Simple plug and chug problems					
Longer word (story type) problems					

As a Student, how would you like HW to be handled?

	HW is not checked but teacher reads off answers	***HW is checked off but not graded on correctness***	***HW is collected and graded and then reviewed in class***	***What percentage do you feel HW should be part of the final grade?***
Which method of dealing with HW do you think is best?				

Other____

APPENDIX G

STEM TEACHER SURVEY ON HOMEWORK

Science, Technology, Engineering and Mathematics Teacher Survey on Homework

For a given unit, what percentage of days in the unit do you assign HW?

________Every day we are in the unit (>75%)

________Only if there are skills that need to be practiced (50% to 75%)

________Only if students need extra work mastering the material will I give HW, otherwise not (<50%)

If you assign HW, how much of the student's grade does it make up?

____________ (N/A if you never assign HW)

If you assign HW, how do you evaluate it?

________I always collect it, grade it on correctness and then review it in class

________I always collect it and check it off if done then review it in class

________I always walk around the room and check it off if it is done (more or less)

________Depending on how the students are doing, I may or may not check it off but I go over it on the board

________Generally I go around the room and get student responses and have students demo their solutions on the board

*Other*____

____

What is your over all view of homework in STEM classes as opposed to in class work?

____

*Years you have taught*__________ *Circle major area you teach:* S T E M