4-18-2011

Preparatory Physics for Scientists and Engineers: An Interactive Course Supplement based on the Assessment of the Initial Conditions of Physics Experience

R Wesley Foster

To the University Council:

The Thesis Committee for R. Wesley Foster certifies that this is the final approved version of the following electronic thesis: “Preparatory Physics for Scientists and Engineers: An Interactive Course Supplement based on the Assessment of the Initial Conditions of Physics Experience.”

Donald Franceschetti, Ph.D.
Major Professor

We have read this thesis and recommend its acceptance:

Sally Blake, Ph.D

Elizabeth Gire, Ph.D

Acceptance for the Graduate Council:

Karen D. Weddle-West, Ph.D.
Vice Provost for Graduate Programs

Preparatory Physics for Scientists and Engineers:
An Interactive Course Supplement based on the Assessment of the Initial Conditions of Physics Experience

by

R. Wesley Foster

A Thesis

Submitted in Partial Fulfillment of the

Requirements for the Degree of

Master of Science

Major: Physics

The University of Memphis

May 2011

Abstract

Foster, R. Wesley. M.S. The University of Memphis. May 2011. Preparatory Physics for Scientists and Engineers: An Interactive Course Supplement based on the Assessment of the Initial Conditions of Physics Experience. Major Professor: Donald Franceschetti, Ph.D.

There are several factors that contribute to the low success rates of introductory, calculus-based physics courses. A significant factor is prior experience. The Physics Experience Survey instrument that measures a student's prior experience learning physics will be discussed. A student is classified as either a novice learner, continuing learner, or experienced learner based on their responses to questions about prior coursework and confidence with specific physics topics. Administration of this survey to 123 students is an attempt to identify novice physics learners in calculus-based introductory physics courses who might benefit from a low-cost, 7-week (14 total contact hours) course supplement emphasizing fundamental skills and topics. Correlations between experience level and final course grade, first exam grade, and learner level are discussed. The course supplement and its impact on novice physics learners' conceptual understanding (as measured by the Force Concept Inventory) and problem solving skills (as measured by the Problem Solving Assessment) is described.

Table of Contents

List of Figures

Introduction

A large number of college students lack the literacy and mathematics skills needed to learn at the postsecondary level (Spann, 2000). To be successful in introductory physics, students need to be able to read a statement that describes a problem situation, understand what the situation is, and extract important information to be used in the solutions. They need to be able to use geometric and algebraic reasoning and perform symbolic manipulations. They also need to know how to effectively study for a physics exam. Accessing these reading comprehension, mathematics and test preparation skills and helping students strengthen them are likely to be key components in removing barriers to the students' success in introductory physics. The physics department can support student success more effectively than current traditional remediation by having an intervention that is specific to the introductory physics course. This thesis, based on a study of the first semester introductory physics course, explores one approach to intervention. At the University of Memphis, PHYSICS 2110 is the first semester, calculus-based mechanics course, and it has a large attrition and failure rate. There are multiple reasons for both attrition and failure, this pilot study focuses on prior experience as a significant factor. Students with limited prior formal study of physics represent a significant percentage of the students who receive D's, W's, or F's in these courses, which are intended to provide the foundation for further study of physics, chemistry or engineering. Fifty-four percent of introductory physics students are successful at the University of Memphis (2010). Dr. Shah Jahan said, "Students have come here to learn and graduate—not to fail, we want to make sure they understand—" (Spencer, 2008).

Currently, most post-secondary education provides developmental education to help students gain the knowledge and skills necessary to be successful in college-level work (Cohen & Brawer, 2003). The number of students entering institutions of higher education who need developmental education continues to grow (Cohen & Brawer, 2003). Students receive intervention in the form of "a class or activity" intended to meet the needs of students who initially do not have the skills, experience or orientation necessary to perform at a level that the institutions or instructors recognize as 'regular' for those students (Grubb et al., 1999, p. 174). Traditional remedial course offerings do not seem to be the answer. In general, remedial placement appears to result in student dropout (Boylan & Saxon, 2001). However, intervention focused on skill specific needs, without the stigma of "remediation," may help students build the competence and confidence to succeed in physics and other courses. By offering a course supplement, the stigma can be minimized. The term "remedial" is deliberately avoided. This term implies that students who take these courses are lacking in mental capabilities rather than missing some form of experiences to support learning. In order to avoid bias, interchangeable reference of remediation as intervention is used, in this document, unless otherwise noted. This need for intervention points to the research question of: will addressing the issue of lack of physics experience with a course supplement increase success rates in introductory physics courses?

With the aid of a survey based on previous coursework and self-efficacy in physics, we identify three groups of introductory physics students: (a) novice physics learners, (b) continuing physics learners, and (c) experienced physics learners. It is likely that the novice and continuing physics learners are the groups most affected by a lack of experience studying physics. Students with little experience studying and little prior knowledge of physics may be at a disadvantage in introductory physics. Due to the demands of the university's academic schedule, instructors only have limited time they can spend reviewing basic skills. Furthermore, there may be a mismatch between what instructors assume their students know walking into the classroom and what the students actually know. In this case, instructors may inadvertently spend too little time explaining points that they consider obvious but may not be so obvious for the students. Instructors may also explain concepts in terms that do not adequately reach novice learners.

An attempt is made to improve success rates by analyzing students' prior experience levels and using this analysis to administer a course supplement as an intervention in the areas of reading comprehension, mathematics skills and test preparation. In this course supplement, students engage in peer instruction, desk-top laboratories, and other forms of interaction.

The Prior Experience Survey (PES) given before the semester begins categorizes students based upon their prior preparation (PP) and self-efficacy (SE) (Mullins, 2010). Even though several studies have found that prior preparation has no effect on constructive cognitive strategies, consideration of a coupling of prior preparation and self-efficacy as an encompassing construct for categorization of physics learners is a possible avenue of understanding (Shaw, 2003). Our classification of learners into three categories attempts to measure progress from the lowest experienced learner to the highest experienced learner and to level the playing field for introductory physics students by raising novice physics learners (NPL's), and continuing physics learners

(CPL's) to the level of experienced physics learners (EPL's) through a seven session course supplement.

Literature Review

There are three barriers students confront in introductory physics courses that provide a background for our research question: will addressing the issue of lack of physics experience with class supplements increase success rates in introductory physics courses? This section begins by describing these three barriers. Since self-efficacy is a central issue in this study, these barrier descriptions are followed by a review of the prior work done in the area of self-efficacy by Albert Bandura, Lauren Kost, and Kimberly Shaw and how our work is related. This section ends with a summary of how peer institutions have tried to increase their introductory physics course success rates.

Barrier I: Mathematics Skills

Students' difficulties with mathematics create a barrier to success in technical fields like physics. While some students do not have requisite mathematical skills, it is more common for students to possess these skills but fail to know how to use them in contexts outside of mathematics courses. The successful interpretation of new contexts is crucial to learning (Koch, Adina, Eckstein, & Shulamith, 1995). Translation of formulae and numerical definitions into language has a baffling effect for students when working physics problems. It must be remembered that math skills used in physics courses seem to be different from math skills used in mathematics courses. Research by Saul, Steinberg, Wittmann, and Redish (1996) indicates that introductory physics students don't apply what is learned in math classes to problems in physics classes – a reality that many physics instructors have observed first hand. In other words, students sometimes perform well in algebra class and do poorly in physics class. This can be explained by seeing “physics math” as more complicated than “algebra math.” For example, mathematically summing forces is seen as more complicated than drawing individual forces. Typically, poor math skills are generalized into one category rather than seeing that the context of the math skills dictate student’s difficulties. Feedback from students on this issue tells us they know there is a huge difference between algebra math problems and physics math problems (Van Heuvelen, 1991). Research on expert and novice problem solving has shown that external representations are a helpful – and sometimes necessary – tool in the problem solving process (Kintsch & Greeno, 1985).

Barrier II: Reading Comprehension

Physics technical language must be addressed in order to break down the barriers to reading comprehension. Peculiar terms are distinguished in every technical field, and physics is no exception. Usage of these terms and their ambiguity adds to the confusion of the novice learner’s experience. When reading problems, many students skip over key words they don’t understand because they have been taught to skim long passages. This has led to a habit of skipping over many key words in both short and long passages. Comprehension of these passages is diminished where contextual meaning should be the sole device for translation (Barnes, 2002, p. 55). Reading comprehension is an analytical skill that has been lost to an overemphasis on speed of reading (Koch et al., 1995).

Barrier III: Test Preparation

Test preparation is neglected as a key barrier when asking students to perform well. Typically, students spend many arduous hours preparing for tests only to find they didn't study correctly. Hours and hours of inappropriate preparation lead to failure and frustration. Many students give up. Course supplements address this issue directly in a course specific manner. Knowledgeable instructors break down these barriers by giving practice tests, study guides, recommendations, and tutoring sessions. Instructors must interact with students to teach this skill since every subject has its own method of mastery. Reading comprehension and mathematics are preliminary to test preparation but test preparation must be an equal part of the formula to eliminate these barriers. Unfortunately, test preparation has been relegated to short term methods by students that do not work (Briggs, 2001). These methods provide impetus for "doing just enough to get by" and this attitude pervades the work ethic of many students in introductory physics.

Albert Bandura's Work on Self-Efficacy

Self-efficacy is defined by Bandura (1994) as "beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments." A working definition applied to physics might read: beliefs in problem solving strategies one can capably organize and execute in order to have success in PHYSICS 2110. The Physics Experience Survey (PES) uses 15 key questions pertaining to Mechanics to measure self-efficacy as defined by: a student's belief in what they think they can do in an introductory physics course.

Bandura and Schunk (1981) described self-efficacy as "people's judgment of their capabilities to organize and execute courses of action required to attain designer types of performance" (p. 391). This slight difference in describing self-efficacy adds the aspect of individual control or design into their performance. They also found that people's performance is better predicted by their beliefs about their capabilities than about what others think they are able to do. Individuals perform beyond the expectations of what the measurer predicted. Schunk (1995) further defines self-efficacy in the learning process as students' judgments about their cognitive capabilities to accomplish a specific academic task or obtain specific goals. Self-efficacy is one's self-judgments of personal capabilities to initiate and successfully perform specified tasks at designated levels, expend greater effort and persevere in the face of adversity (Bandura, 1986, 1988; Parajes & Graham, 1999). This definition of self-efficacy begins with Bandura's capabilities to organize and specifies that the context or environment of performance influences the final outcome. Even average-ability students are sometimes known to do poorly in specific subject areas while performing up to standard in others. Pajares (1996a, 1996b) found that self-efficacy of gifted students in algebra classes made an independent contribution to the prediction of problem solving in middle school students. If students are able to perform a task successfully, then their self-efficacy can be raised. By contrast, if students are not able to perform a task, then they may believe that they do not have the skills to do the task which, in turn, lowers their self-efficacy. The atmosphere created during test periods sometimes mimic this case. Students feel like they have put forth a laborious effort that will lead to failure. Several negative feedback loops form leading to low performance. If recall doesn't occur instantaneously students can default into anxiety and not perform to their fullest potential. Personal goal setting through problem solving is influenced by their self-appraisal of capabilities. The stronger people perceive self-efficacy, the higher the goals or challenges that they set for themselves and the firmer their commitment to them (Bandura, 1991). Higher goal attainment is our hope in physics education, and self-efficacy perceptions can be used to raise confidence levels. Clearly ability is not a fixed attribute residing in one's behavioral repertoire. Rather, it is a generative capability in which cognitive, social, motivational, and behavioral skills must be organized and effectively orchestrated to serve numerous purposes (Bandura, 1993). Therefore, problem solving skills are an ability that can be awakened by our supplemental course outreach. The chronology of the supplemental course we have offered in this study is synchronous to the lecture course and this organization enhances all students' skills and adaptability to the physics classroom environment. Once this adaptation occurs a firm foundation can be built upon for future physics and engineering courses. Mathematics learners' academic performance is influenced by how learners themselves are influenced by environmental factors. This performance, in turn, builds on itself in cyclical fashion (Center for Positive Practice, 2005). Environmental influences, such as peer instruction, synchronous laboratories and supplemental intervention enhance academic success, and increase academic effort, which builds student self-efficacy. This, in turn, enhances environmental influences, academic success and effort. Indeed, it seems that "beliefs are far more influential than knowledge in determining how individuals organize and define tasks and problems and are stronger predictors of behavior" (Pajares, 1992, p. 311). Looking for ways to impact success rates will use all environmental and cognitive factors to cascade into a success model. Knowing that mathematics and physics learners' performance depend upon not only environmental factors that are being built upon but also that belief systems can be 'myth-busted' to influence positive outcomes, we can surmise that a course supplement has the potential of improving success rates in introductory physics courses. There are four sources of self-efficacy: mastery experience, vicarious experience, social beliefs, and emotional/physiological states (Bandura, 1986). The focus of this study is on the mastery experience source.

Lauren Kost-Smith's Work on Self-Efficacy

Lauren Kost-Smith's work on self-efficacy at the University of Colorado, Boulder, concentrates on the gap in performance between males and females in interactive teaching environments. She has found that females are less likely to take high school physics courses but equally likely to take high school calculus due to the stigma that surrounds physics courses of being a male pursuit. Pre and Post-test results were gathered using the Force and Motion Concept Evaluation (FMCE). This instrument is similar to the Force Concept Inventory (FCI). In her studies, factors of attitudes and beliefs are measured with the Colorado Learning about Science Survey (CLASS) (Adams, 2006). Her work has focused on measurement of self-efficacy whereas our PES focuses on measuring experience by coupling prior preparation with self-efficacy. When learning is defined by actualized gain rather than normalized gain and compared to prior knowledge, she found gender has no bearing. This must be noted when we take a second look with our treatment groups, to analyze our data in the future, by categorizing into gender specific NPL, CPL, and EPL's. She also found that actual gain combined with differential preparation of male and female students suggests that gender gap can be largely attributed to differential preparation. The prior preparation section of the PES could be enhanced by adding questions that focus on gender specificity. Kost-Smith has further investigated the gender gap's impact on introductory female students after giving a 15-

minute writing exercise completed at the beginning of the semester. She found this exercise can increase female performance on the FMCE post-survey. Data also showed that due to the fear of confirming a stereotype about one's gender, self-affirmation is more beneficial for females who moderately endorse the stereotype, rather than fully endorse the stereotype. These results were also confirmed in final exam and course grades.

Future application of Kost-Smith's work to our study will take into account the female composition of our introductory student population. Further insight for gender focus will use other concept evaluation methods in conjunction with the FCI and PSA and leads to a broader perspective in measurement. Since females compose part of our population of introductory students, the course supplement can be enhanced by giving the self-affirmation exercise at the beginning of the course.

Kimberly Shaw's Work on Self-Efficacy

Kimberly Shaw developed an SE instrument for physics specific classrooms. Gender studies using this instrument have found that the locus of control assessments skew overall assessment results that focus on SE. Locus of control assessments survey students' belief about whether their actions will affect later outcomes. Shaw's study indicated a significant difference in male and female self efficacy scores for trig-based physics courses only. The PES does not include locus of control questions and pertains only to calculus-based physics courses in this pilot study. Her assessment recommended evaluating all assessment questions by exit interviews of each question, something that should be considered also when reformulating the PES. Her studies have shown that self-efficacy does not predict grades. While prediction of grades is not a priority, the task is to measure outcomes of success for introductory physics students. This study has shown similar results in that we cannot associate any correlations between self-efficacy and 1st exam grades or between self-efficacy and final grades. Her findings show that engineering and science majors have higher self-efficacy than other majors. This result can possibly provide insight into how non-physics major introductory students perceive enrolling in this course. Her results showed that self-efficacy can predict deep functional understanding of physics. Our goal in this pilot study focused on surface points such as basic problem solving skills rather than deeper level skills such as synthesis in calculus-based introductory physics course. Shaw has also concluded that measuring self-efficacy can be correlated to performance which the FCI and CSME do not explicitly evaluate. Performance enhancement in our study was determined by a supplemental course offering.

Peer Institutions' Attempt to Address the Problem of Low Success Rates

The University of Alabama Birmingham has a 3- hour preparatory physics course that requires prerequisites of trigonometry and pre-calculus. This course covers vectors, kinematics, dynamics and conservation laws and does not satisfy degree requirements. At Arizona State University, University of South Florida, and Georgia State University only departmental tutoring is used as an intervention. At the University of Louisville, University of Oklahoma, University of Pittsburgh, and University of South Carolina there is no established outreach for students. At the University of Illinois Chicago a one hour workshop is given: *Problem-Solving Workshop for General Physics I (Mechanics)* This course can only be taken concurrently with General Physics and is focused on computer simulations to solve similar problems covered in the traditional course and to also give more challenging problems in an honors format. Grading for this course is in a pass or fail format. At the University of Houston, a course is offered for students with weak problem skills entitled: *Physics Problem Solving Techniques*. This course does not satisfy any degree requirements. Florida International University is offering a course similar to ours entitled: *Problem Solving for Physics I & II*. This course is described by their schedule as, “these 1 credit hour courses are a great supplement. They are intended to give you additional insight in how to solve the kinds of problems that you will encounter in your homework and on the exams. We will go over various techniques and some general rules of thumb for solving physics problems. The hope is that these courses will help you achieve a better grade in your physics course. The instructors also teach or have taught the regular physics classes and therefore are very familiar with the kind of difficulties that you encounter in your physics class.” Apparently, these courses are in high demand to the extent that they are being expanded into other courses that have had low success rates. After contacting the Department of Physics, they said that no data has been collected on the impact this course has had on introductory students.

In a separate study, Florida International University studied the positive impact of modeling instruction on self-efficacy and analyzed its impact on introductory physics courses. Favorable grade impact was witnessed. This work is not directly related to our study of physics experience at this time but modeling instruction should be considered as a part of reconstruction of introductory physics courses with course-lab synchronicity that enables modeling and peer instruction.

Methods of Research

Experimental Design of the Research

The scientific design employed was a quasi-experimental design:

> There are many natural social settings in which the research person can introduce something like experimental design into his scheduling of data collection procedures (e.g., the when and to whom of measurement), even though he lacks the full control over the scheduling of experimental stimuli (the when and to whom of exposure and the ability to randomize exposures) which makes a true experiment possible. Collectively, such situations can be regarded as quasi-experimental designs. (Shadish, 2002)

The first attempt in scientifically designing this project was to look at the One-Group, Pre-Post design. In this design, one group is given a pre-treatment measurement or observation, the experimental treatment, and a post-treatment measurement or observation. The post-treatment measures are compared with their pre-treatment measures. This statistical design is commonly used in educational studies (Sytsma, 2009).

Figure 1 shows the project design consisted of: PES pre-survey, FCI & PSA pre-test, supplemental course, FCI post-test, PES post-survey,-interview, and PSA post-test:

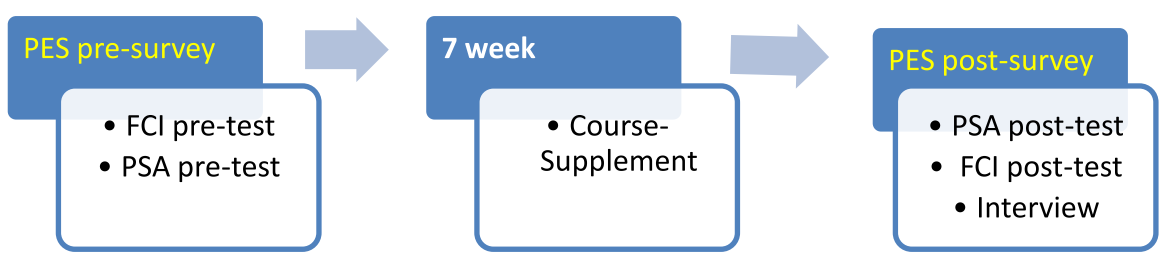


Figure 1. Project design.

Instructional Settings of the Research

The project was initiated on students in the PHYSICS 2110, calculus-based introductory course in the fall semester of 2010 at the University of Memphis. Two sections of this course were taught: one by a traditional lecture instructor and another by an interactive lecture instructor. The two courses used the same curriculum and the interactive section used personal response systems and peer instruction. The study focused on first semester calculus-based introductory physics and included two sections of Physics 2110 taught by different instructors. A voluntary course supplement was offered once a week for two contact hours. This course supplement covered core conceptual mechanics and how to use mathematics skills, reading comprehension, and test taking techniques. The voluntary course supplement was designed to raise levels of success for Novice Physics Learners by focusing on “surface” skills which course instructors might be tempted to skim over. The course was also designed to acclimatize introductory physics students to the rigors of physics in order to survive the first exam successfully.

A control group consisted of students who did not participate in the course supplement, including: (1) 34 students from the interactive section (Control Group G) and (2) 89 students from the traditional section (Control Group M). The treatment group was formed by students who voluntarily attended the course supplement. Six students attended the first meeting and 23 attended the second meeting. For analysis purposes, the treatment group consists of the eight students who attended all seven meetings of the course supplement. The treatment group was assessed w/ the FCI for conceptual understanding. The PSA assessment was given to only the interactive part of the control group. The pretest, post-test and normalized gain were analyzed within the treatment group only. Table 1 describes the project similarly.

Table 1

Logistical Setting of Project

Testing	Timing		Population	*N*
	Pre	Post		
PES	Week 1	----------	Control & Treatment, Section M & G	89 + 34 = 123
PES	Week 1	Week 7	Treatment	8
FCI	Week 1	Week 7	Treatment	8
PSA	Week 1	Week 15	Control & Treatment, Section G only	34
Interviews	-----------	Week 7	Treatment	6

All students were surveyed the first week of classes using the Physics Experience Survey. The PES addresses the self-efficacy source of mastery experience. In the PES, students are asked to indicate their beliefs in their ability to solve 15 different problem types essential in understanding Newtonian Mechanics, addressing the source of mastery experience. In the PES, students evaluate fifteen key questions that are essential in understanding Newtonian Mechanics. A four point Likert response scale was used to prevent soft responses.

After assessing with the PES, we used a tri-modal intervention categorization scheme as follows (and as shown in Table 2): (a) students who have no prior coursework and have a self-efficacy rating of 1.00-1.99 are categorized as novice physics learners (NPL) (b) students who have passed at least one prior physics course in high school or college and have a SE rating of 2.00-2.99 are categorized as continuing physics learners (CPL) and (c) students who have passed more than one prior physics course and have a self-efficacy rating of 3.00-4.00 are categorized as the experienced physics learners (EPL). If either of the two criteria for a particular categorization is not met, the category shifts down one level.

Table 2

Tri-modal Classification of Learners

Classification	**Prior Preparation**	**Self-Efficacy**
Novice Physics Learner (NPL)	No prior courses	1.00-1.99
Continuing Physics Learner (CPL)	One prior physics course	2.00-2.99
Experienced Physics Learner (EPL)	> One prior physics course	3.00-4.00

The Force Concept Inventory (FCI) established by Hestenes, Halloun, and Wells, in 1992, was administered during the first week and after the 7 week supplemental course to the treatment group only. We used the FCI to assess student’s understanding of mechanics concepts. The Problem Solving Assessment (PSA) designed by Jeff Marx and

Karen Cummings in 2009, was administered to the students of the Physics 2110 interactive section only as a pre/post test during the 1st and last weeks of class. We used the PSA to assess student's problem solving abilities in mechanics

Course Supplement

This outline of the supplemental sessions will be interjected with *italicized* discussion in order to emphasize how to vanquish the barriers of mathematics skills, reading comprehension and test preparation.

<u>Session 1 Treatment (Wednesday, 01 Sep from 1:00 to 3:00)</u>

The topic for this session is linear kinematics.

1. Acceleration will be verbally defined emphasizing words with examples of increasing speed, decreasing speed and curving. Students will be notified that changing speed will be the only thing emphasized at this time.

2. Students will be encouraged to think of acceleration in terms of "meters per second each second".

3. Students will be given a "**<u>numerical example</u>**" for a uniformly accelerated object from rest.

Since algebra skills are needed to get pieces of the problem puzzle satisfied in order to achieve solution, a pattern analysis can expose simple methods of attaining solutions to kinematics problems. Additionally, using whole numbers is successful in explaining operations before using calculators. Fractions typically seem to puzzle most novice learners. Using easy numbers can help by initiating intuitive cognitive processes to invent relationships between such subjects as distance, speed and time. This inroad helps students to understand more complicated mathematics.

(i) Instantaneous speeds at whole number time intervals will be determined (without a calculator).

(ii) Average velocity will be determined from instantaneous speeds.

(iii)Displacements for whole number time intervals will be determined using average velocity x time.

Adding variables to any analysis requires a multi-tasking mentality that cannot always be explained unless the student practices working out the mathematics. Summing forces, distinguishing between incremental velocities, or *incorporating direction into velocity with negative signs are skills that must be practiced immediately after being taught.*

4. Clickers will be used to allow students to practice numerical analysis without calculators for both horizontal and vertical scenarios.

5. A **reading exercise** will be used to enable students to find the three given values in a simple linear kinematics problem and to select the correct equation to be used for the determination of unknowns.

Frequent practice in the exercising of reading associated with mathematical equations helps students overcome the fear of mathematics instilled by our current culture. Reading from beginning to the end of a problem can be adjusted to looking at the problem from the end to the beginning, thereby adding agility to the analysis.

6. A specific problem-solving strategy will be outlined and practiced for going from x (t) to v (t) to a (t) and in reverse order.

7. If time permits, students will be given instruction on how to use a graphing calculator to solve.

Evidence of these hurdles can be seen in translating written text into mathematics, a challenging exercise that draws on several cognitive abilities. Emphasizing words that are not used in everyday conversation such as acceleration gives concept access to students who cannot easily visualize these technical terms. Acceleration, for example, can be illustrated with examples of increasing speed, decreasing speed and curving.

Session 2 Control Group occurs in PHYS 2110 Physics Professor will lecture, give demonstrations and show example problems on MWF from 11:25 to 12:30. Help sessions after class will be available for all students on Mondays and Fridays.

Session 2 Treatment (Wednesday, 08 Sep from 1:00 to 3:00)

The topic for this session is vector addition.

1. Students will be given scenarios in which two vectors are combined and have radically different outcomes although the magnitudes remain unchanged.

2. A thought experiment will take place in which vectors are combined in parallel, perpendicular and anti-parallel situations. Clickers will be used to promote discussion. Students will express in their own words the rules for combining vectors under these three specific conditions.

Thought experiments can be used to emphasize reading comprehension. When students express in their own words the rules for combining vectors in parallel, perpendicular and anti-parallel situations, they can fully engage word puzzles analytically since left and right brain cognition is taking place. Lately, student response systems are being employed to give students a sense of *anonymity when they respond with incorrect answers. Mistakes must be seen as a bridge to correcting poor reading comprehension. Dialogue between students also helps students to increase their database of vocabulary. In fact, small group discussion and table top demonstrations lead to increased awareness of what is being asked in word problems. For example, emphasizing strategies about problem solving is the final step to reemphasizing the skill of adding vectors. These strategies are verbalized in writing complete sentences in an algorithmic pattern. Even algebraic problems are made easy by simply having students read the problems and write down every step to solution. In the same manner, the steps to analyzing projectile motion can be organized using tables, an organizational tool that can work with reading.*

3. A geometry lab will be conducted in which physical definitions of sine, cosine and tangent for right triangles are developed using cardboard triangles. Students will be in small groups.

4. A specific <u>**problem-solving strategy**</u> will be outlined and practiced for the combination of three coplanar vectors for The Method of Components. Students will verbalize mathematical steps using complete sentences.

For example, if two vectors are combined their magnitudes can remain the same but have radically different outcomes. Using student response systems and dialoging the radically different outcomes make an imprint unlike a generalized math class solution which glosses over the applicability of solutions. After discussion, hands-on activities reemphasize formulas such as the Pythagorean Theorem by using cardboard triangles to prove trigonometric definitions. Living the mathematics puts the context into the real world and out of the text book. Accessing the language (reading) and the logical (mathematical) sides of the brain are essential in breaking down the barrier of poor mathematical skills. Interactive teaching methods, such as using small white boards to convey their work, encourage students to express their work kinesthetically.

5. Combination of two vectors with Law of Sines & Law of Cosines will be addressed <u>if time allows</u>.

<u>**Session 3 Control Group occurs in PHYS 2110**</u> Physics Professor will lecture, give demonstrations and show example problems on MWF from 11:25 to 12:30. Help sessions after class will be available for <u>all students</u> on Mondays and Fridays.

<u>**Session 3 Treatment (Wednesday, 15 September from 1:00 to 3:00)**</u>

The topic for this session is projectile motion.

1. Students will approximate “numerical examples” of projectile motion for three different scenarios using clickers. Scenarios include each of the following-
2. (i) Launched horizontally above y = 0.
3. (ii) Launched and returned to the same height in the format used for the “Range Equation”.
4. (iii) Launched at an angle above y = 0.
5. Students will use a graphing calculator to analyze motion in parametric mode.

   Graphing calculators break down the algebraic math context into the physics math context. Novice learners can be more easily raised to the level of experienced learners simply by applying graphical representations of position, velocity and acceleration

6. A specific algebraic problem-solving strategy will be outlined in complete sentences using a table to analyze projectile motions.
7. A simple hands-on experiment will be done using a Nerf™ Foam Dart system to connect to the real world. (a) Foam dart is launched horizontally from a table top and the initial velocity is estimated from measurements. (b) Foam dart is launched at an angle from the ground and initial velocity is estimated from measurements.

Session 4 Control Group occurs in PHYS 2110 Physics Professor will lecture, give demonstrations and show example problems on MWF from 11:25 to 12:30. Help sessions after class will be available for all students on Mondays and Fridays.

Session 4 Treatment (Saturday and Sunday) 18 and 19 September with time TBA

Sessions 4 – 6 should be compressed into 10 to 14 days. Weekend sessions will be offered on both Saturday and Sunday in order to avoid conflict with personal religious services and work. Alternate arrangements will be made to accommodate all participants if the above plan does not suffice.

The topic for this session is Newton’s First Law of Motion.

1. Small groups of students will be presented with the following three scenarios:
2. (i) Hanging weights at rest
3. (ii) Blocks sliding at constant speed along a level surface
4. (iii) Blocks sliding up/down inclines at constant speed
5. Students will practice drawing free-body diagrams and constructing the corresponding force equations for forces perpendicular and parallel to the

motion of sliding blocks or parallel and perpendicular to gravity for hanging weight.

6. Clicker questions used to check for discrimination between 1st Law and 2nd Law of Motion.

7. Static and kinetic coefficients of friction will be measured in a small group experiment using three unique approaches: (1) Sliding block on incline, (2) Vernier™ Force Probe, (3) Sliding block on level surface.

8. Groups will see alternate problem-solving approaches using Substitution, Law of Sines and Law of Cosines and Matrices.

Session 5 Control Group occurs in PHYS 2110 Physics Professor will lecture, give demonstrations and show example problems on MWF from 11:25 to 12:30. Help sessions after class will be available for all students on Mondays and Fridays.

Session 5 Treatment (Wednesday, 22 September from 1:00 to 3:00)

The topics for this session are Newton's Second and Third Laws of Motion

1. Students will be placed into small groups where they will be asked to experimentally replicate physics problems from the textbook and collect data using motion sensors and force probes. This is an attempt to connect book problems to Real World Experiences.

2. Individuals will then be allowed to verbally compare and contrast the previous scenarios and respond to several quantitative questions using clickers.

3. A specific algebraic problem-solving strategy will be outlined in complete sentences to analyze problems involving unbalanced forces acting on (i) a single mass system on level surfaces and inclined planes and on (ii) multiple-mass system using lightweight, frictionless pulleys and string to connect the masses and on (iii) multiple-mass systems in direct contact

Session 6 Control Group occurs in PHYS 2110 Physics Professor will lecture, give demonstrations and show example problems on MWF from 11:25 to 12:30. Help sessions after class will be available for all students on Mondays and Fridays.

Session 6 Treatment (Saturday and Sunday) 25 and 26 September with time TBA

Sessions 4 – 6 should be compressed into 10 to 14 days. Weekend sessions will be offered on both Saturday and Sunday in order to avoid conflict with personal religious services and work. Alternate arrangements will be made to accommodate all participants if the above plan does not suffice.

The topic for this session is Centripetal Forces.

1. Students will be given 8 problems that are typical centripetal force problems. Using clickers, students will be asked to classify each as a horizontal circular plane or a vertical circular plane.

2. Free body diagrams will be constructed for each problem in a large-group setting.

3. Using the horizontal, circular plane problems only, students will be asked to respond with clickers for each force of each problem- "Is this force (A) purely radial, (B) completely perpendicular to the radius or (C) both A and B?

4. Radial and perpendicular force equations will be constructed for the horizontal problems.

5. Using vertical problems only, students will be asked to respond with clickers for each force of each problem- "Is this force (A) purely radial, (B) purely tangent to the circle or (C) both A and B?

6. Tangential and radial force equations will then be constructed.

Session 7 Treatment (Wednesday, 29 September from 1:00 to 3:00)

The topics for this session are (i) post test of Forces Concept Inventory and (ii) Test preparation skills

1. Students will be given one hour to complete the FCI and their Hake gain will be determined.

2. Test preparation and test taking strategies will be outlined.

   Test preparation can be efficiently accomplished by constant exposure to the test-taking atmosphere. Incorporating long- term skill attainment methods, such as problem solving strategy gives preparation and accomplishes long-term success. Test problem identification is a preparation skill that can be successfully applied to all disciplines. Being able to recognize what is being asked accesses stored information and this retrieval results in successful work. Drawing diagrams has a similar effect. Writing mathematical steps in words engages right and left brain cognitive skills for success in future problem solving. Not only mathematical mistakes but also reading mistakes plague most novice learners in general. Interactive coaching and peer instruction can help all learners to avoid these pitfalls. Asking if answers make sense is one way to avoid mistakes. Several forms of checking answers are known to be time and work efficient. For example, knowing the simple skill of dimensional analysis is a simple check that should be considered at the end of any physics problem. Applying checking techniques empowers students and results in confidence during testing periods rather than despairing panic.

Results

This pilot study was implemented with the expectation of prior experience being a measurable way to impact low success rates through a course supplement. This measurement was used to compare self efficacy and prior experience with two control groups and a treatment group. Each of these figures shows the trends observed (Figures 2-14).

Self-Efficacy

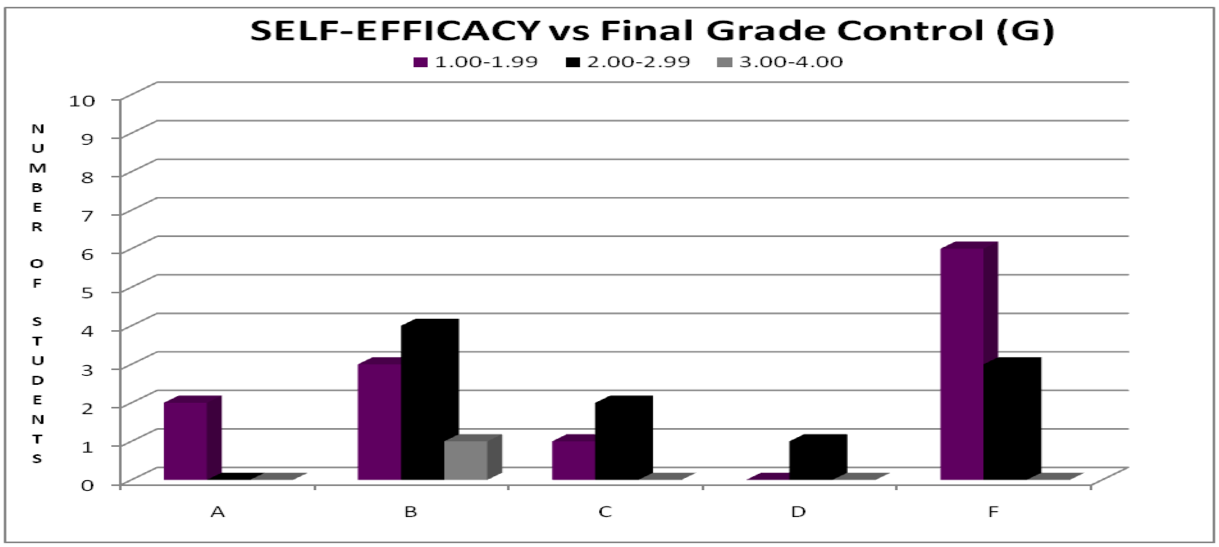


Figure 2. Grade distribution for self-efficacy.

In figure 2, consisting of a 34 student control group, the initial confidence levels are compared to final grades. The graph shows that low self-efficacy students were more likely to fail. One expects that initially low self confidence students would score lower. Here it is verified from past studies that self-efficacy does not predict grades since other confidence levels are randomly distributed over all grades.

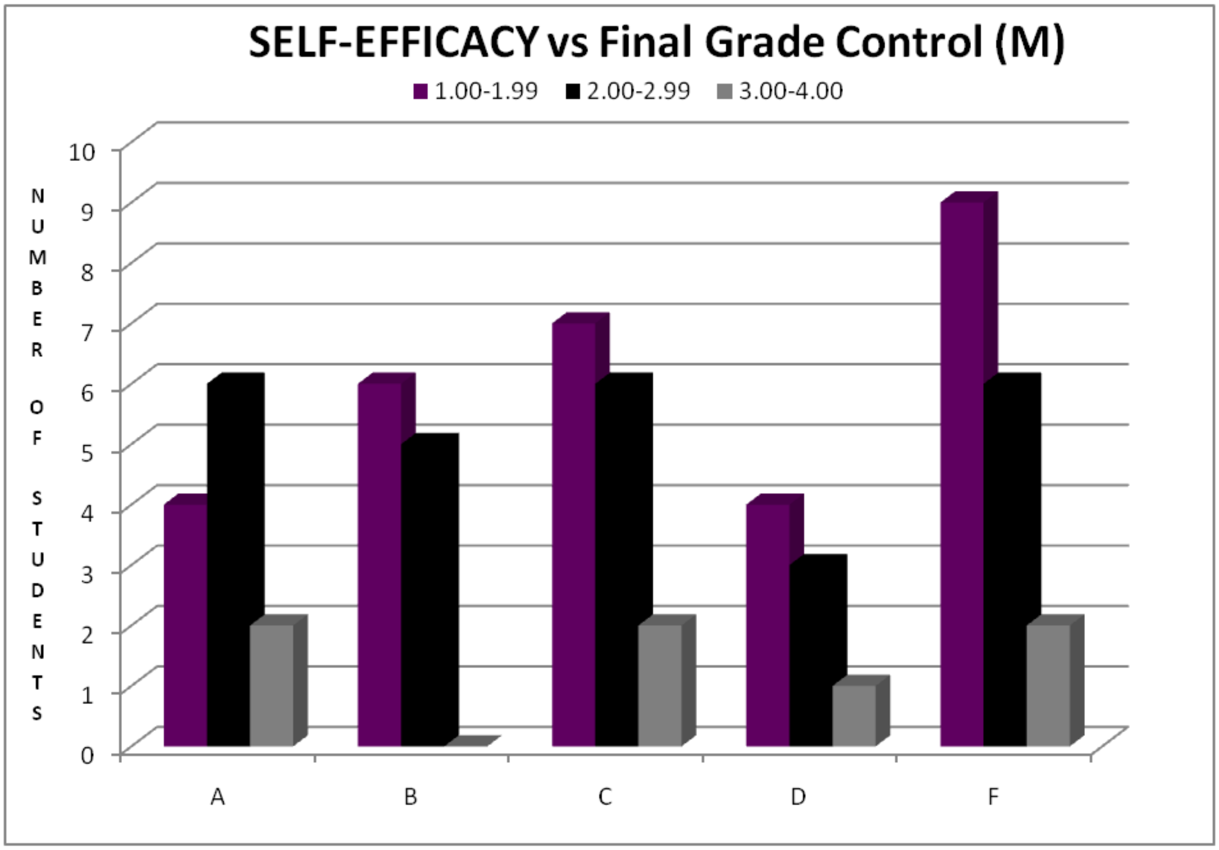


Figure 3. Grade distribution for self-efficacy.

In figure 3, consisting of the 89 student control group, as expected the low self-efficacy students were more likely to fail. Other confidence levels are randomly distributed which verifies past studies of self-efficacy's non-predictability of final grades.

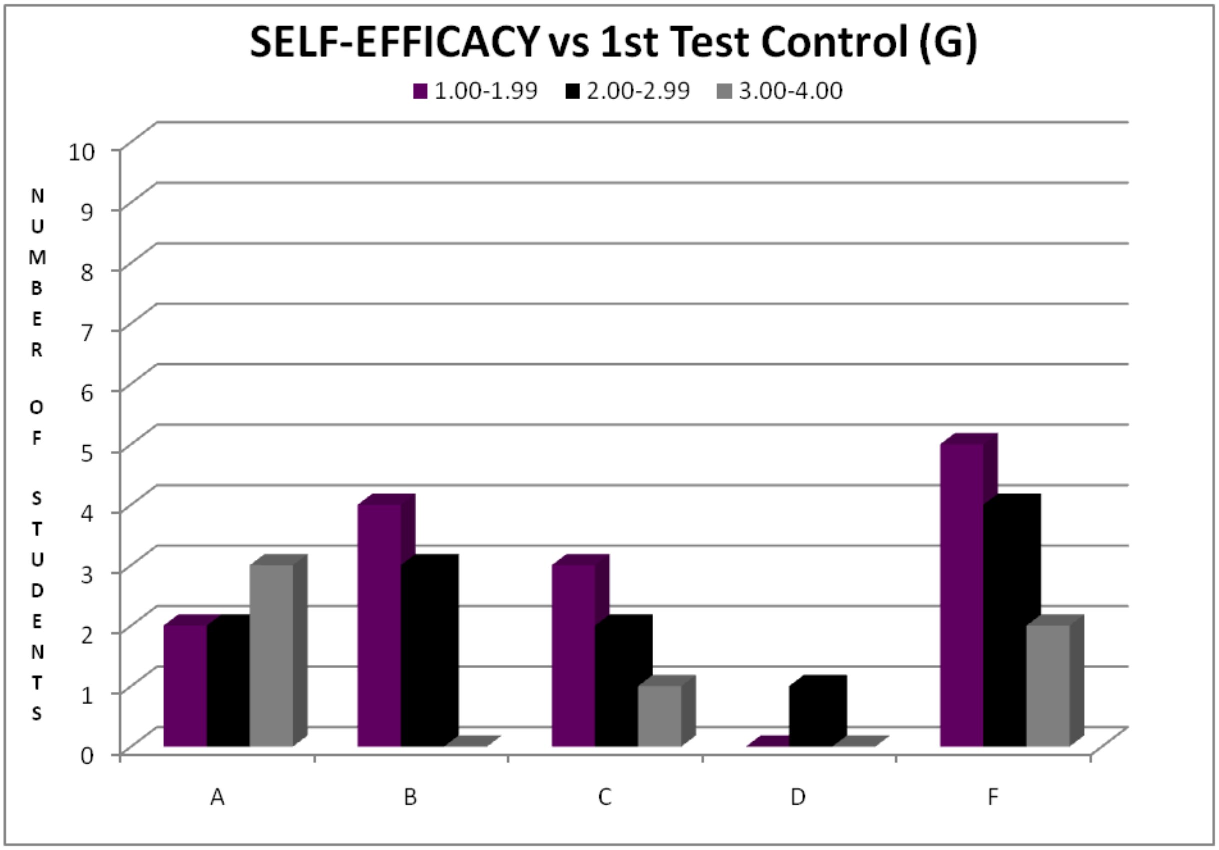


Figure 4. Grade distribution for self-efficacy.

In figure 4, initial self-efficacy is compared to 1st test grades in this graph. One expects initial self-efficacy to have more bearing on the 1st test than the final course grades since students that are adapting to the physics classroom environment and confidence levels has a greater impact during the first weeks of introductory courses. This graph shows there is a random distribution of grades for low self-efficacy unlike what was expected, although low SE students scored the most F's.

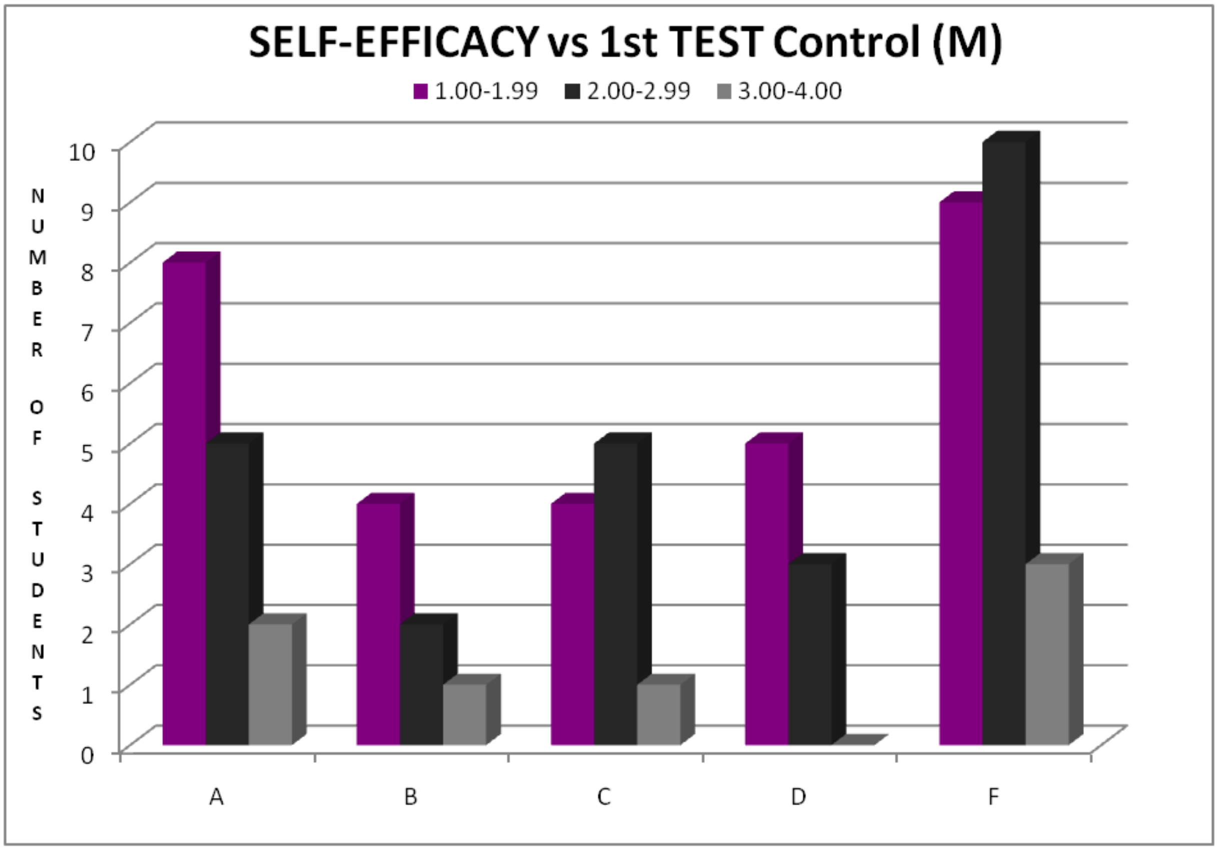


Figure 5. Grade distribution self-efficacy.

As in figure 4, self-efficacy vs. 1st test, in figure 5, a similar result is seen by a random distribution of grades. Although, dividing between success and non-success groups shows a possible unhealthy sense of confidence with medium and low self-efficacy students, it appears that not only can self-efficacy not predict final grades but also it cannot predict 1st test grades.

Prior Experience

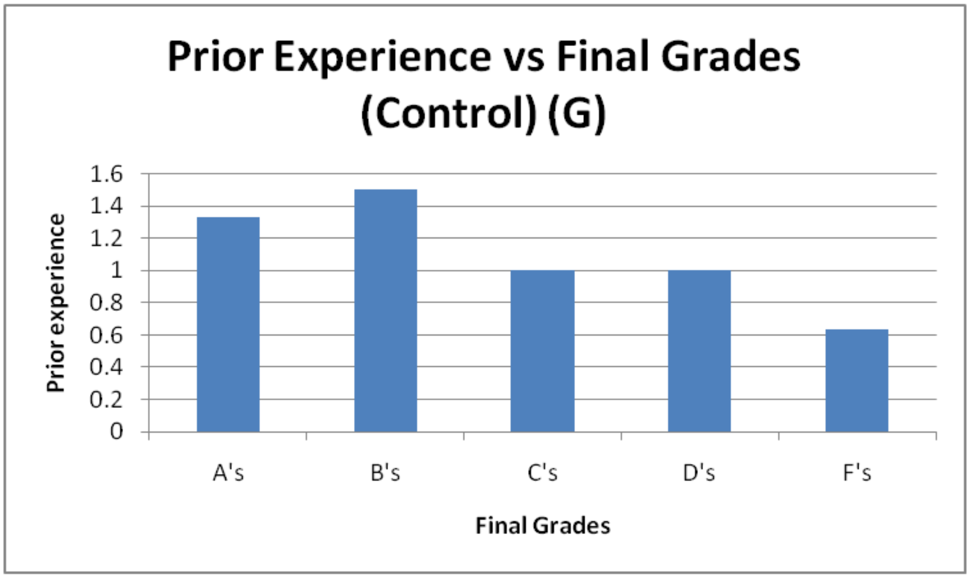


Figure 6. Grade distribution for prior experience.

In figure 6, the initial prior experience levels are compared to final grades. One expects prior high prior experience students to be more successful than those without prior experience. The graph also shows average prior preparation is higher for students with successful grades.

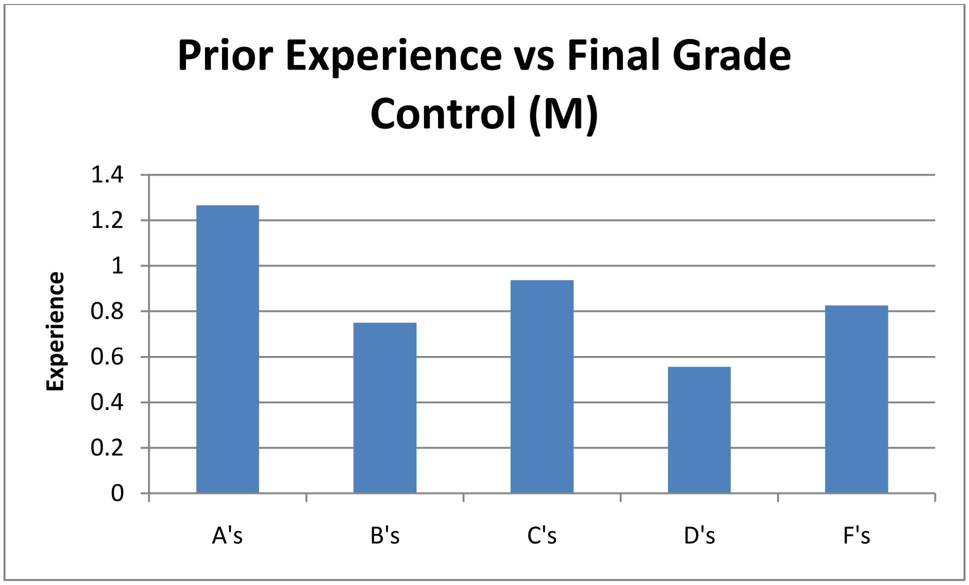


Figure 7. Grade distribution for prior experience.

Prior preparation shows a flat distribution in figure 7 and no trend is seen between prior preparation and the final grade in this control group. There is a slight elevation in the average prior preparation of students who received A's, but there is no overall trend.

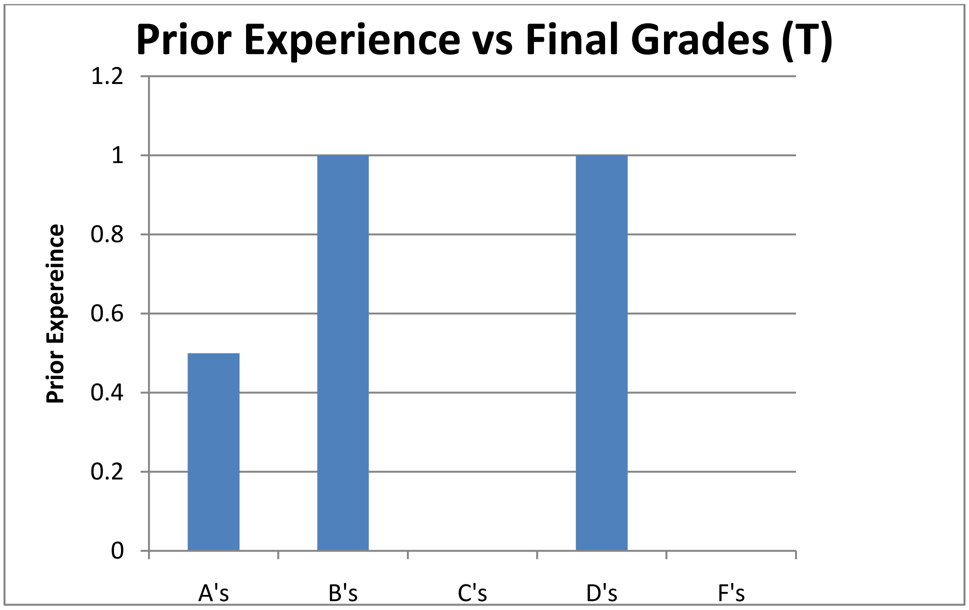


Figure 8. Grade distribution for prior experience.

In the treatment group, compared in figure 8, of eight students, 5 of the 8 students with low prior experience were successful and 3 of the 8 students with low prior experience were unsuccessful.

Learner Level

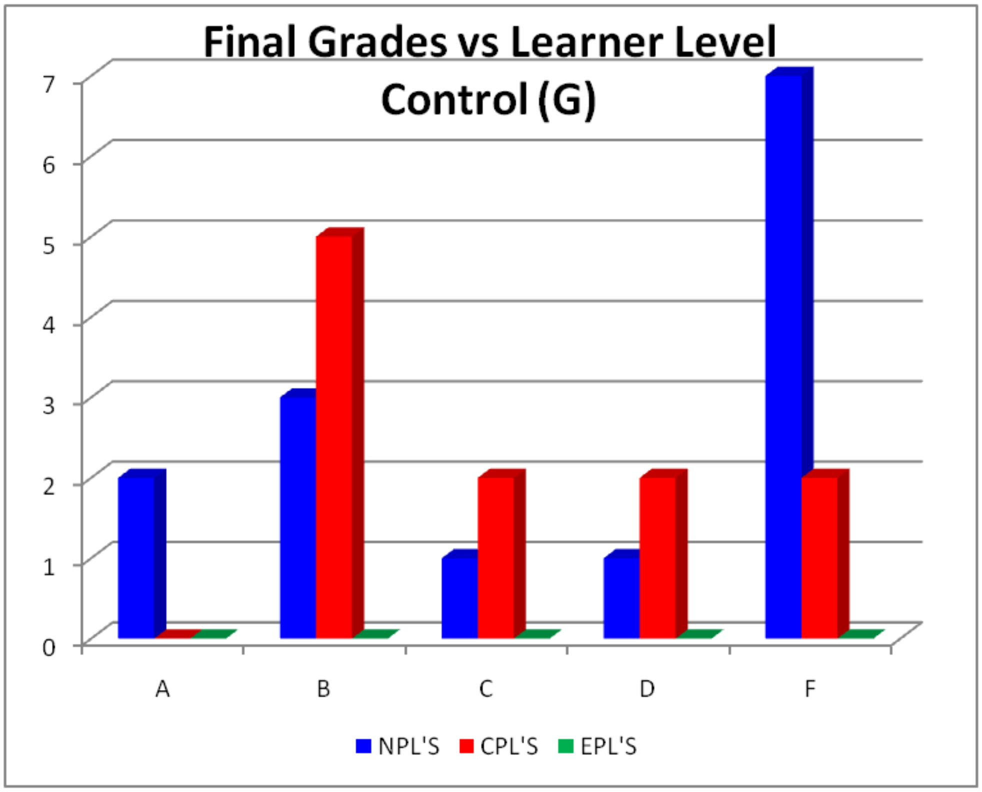


Figure 9. Grade distribution for learner levels.

In figure 9, a comparison is made between final grades and learner levels of Novice Physics Learners (NPL's) Continuing Physics Learners (CPL's) and Experienced Physics Learners (EPL's). One expects students classified by a combination of low confidence and low prior experience to have low final grades. From this graph, there is a possible trend of Novice Physics Learners scoring the most F's.

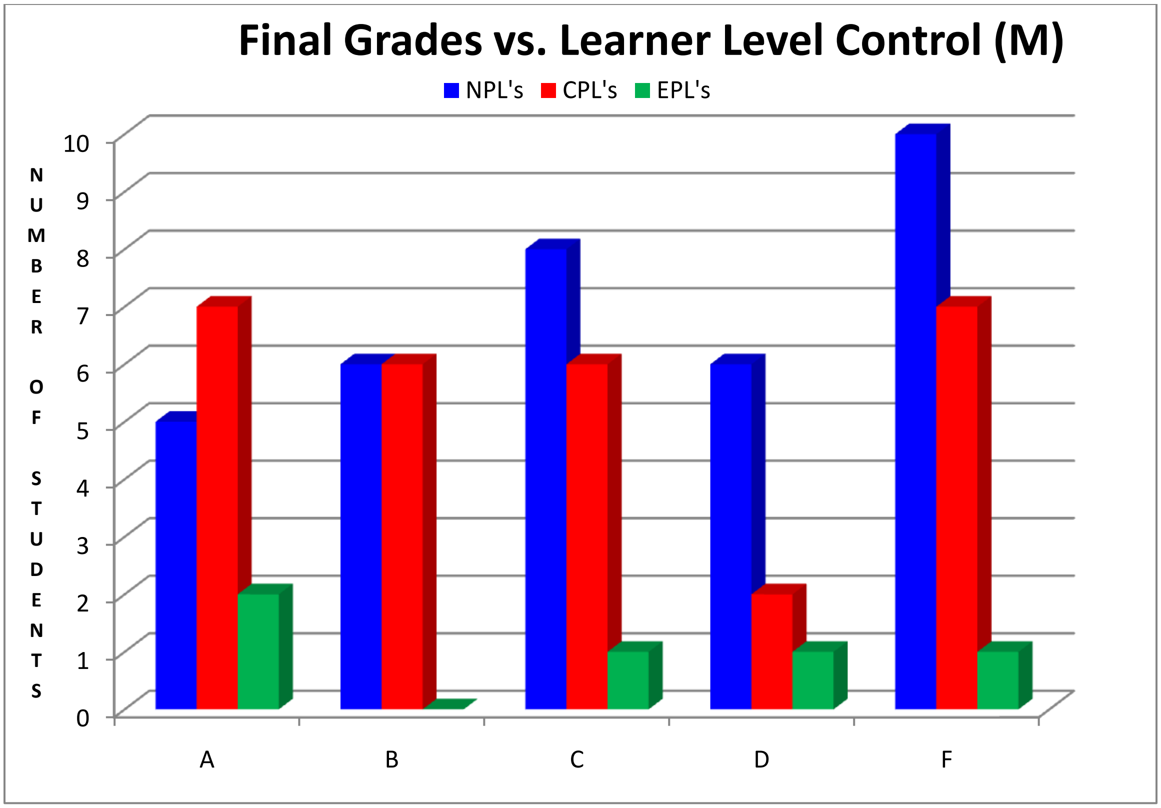


Figure 10. Grade distribution for learner levels.

In figure 10, the control group of 89 students is distributed into the tri-modal classification. One expects novice learners to score lowest. The most common grade was F for the NPL's.

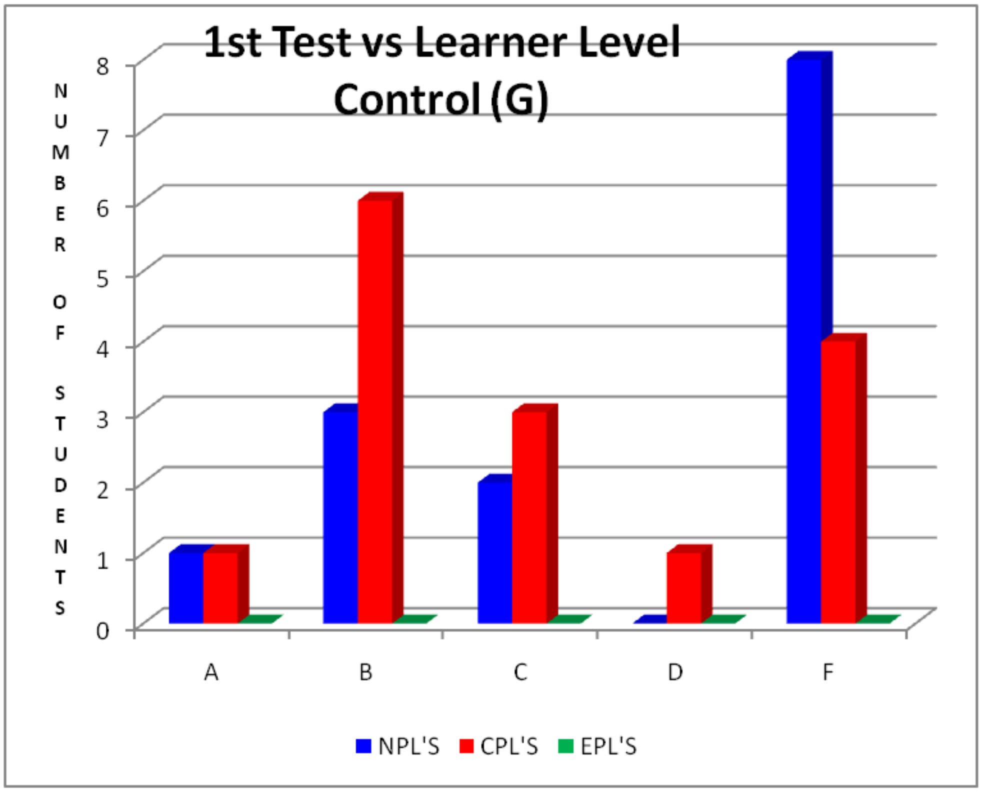


Figure 11. Grade distribution for learner levels.

In figure 11, showing the learner level distribution after the 1st test, where intuitively we expect for NPL's to have the lowest grades. An expectation of prior experience's impact on the 1st test is not obvious. NPL's have the most F's.

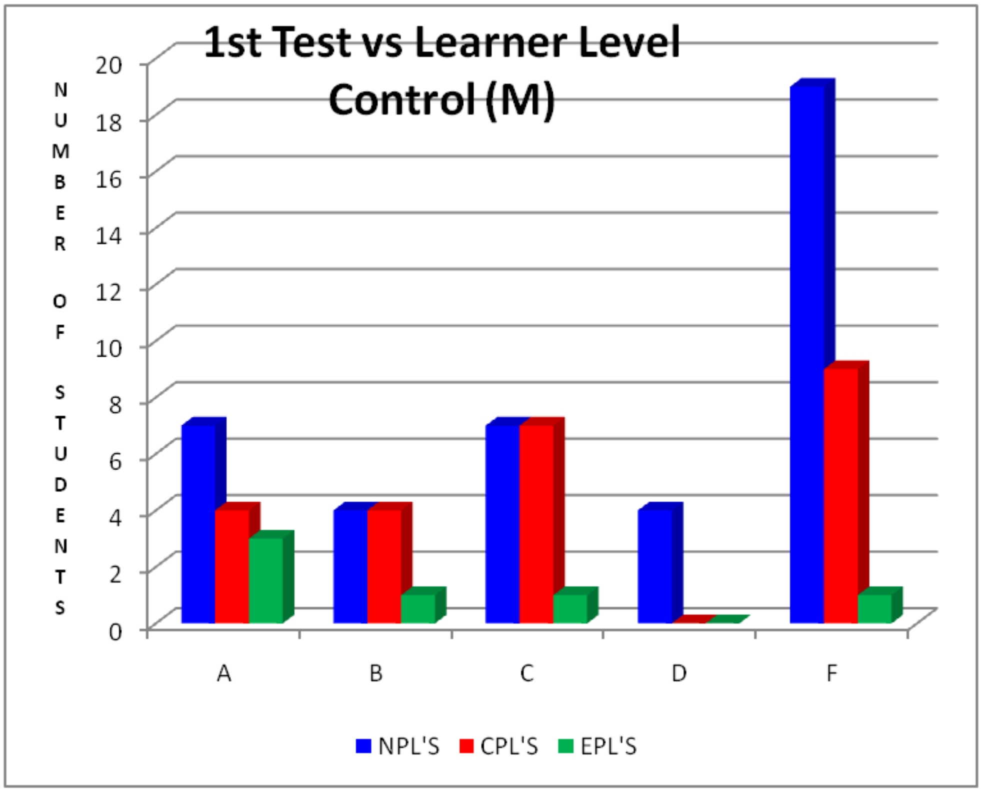


Figure 12. Grade distribution for learner levels.

The larger control group is distributed across the tri-modal classification in this graph. A trend seen in the prior graph is shown here also. One sees our expectation of NPL's getting the most F's again. Since this trend is seen in both groups there is a possible generalization that could be suggested.

Treatment Group

Self-Efficacy Results

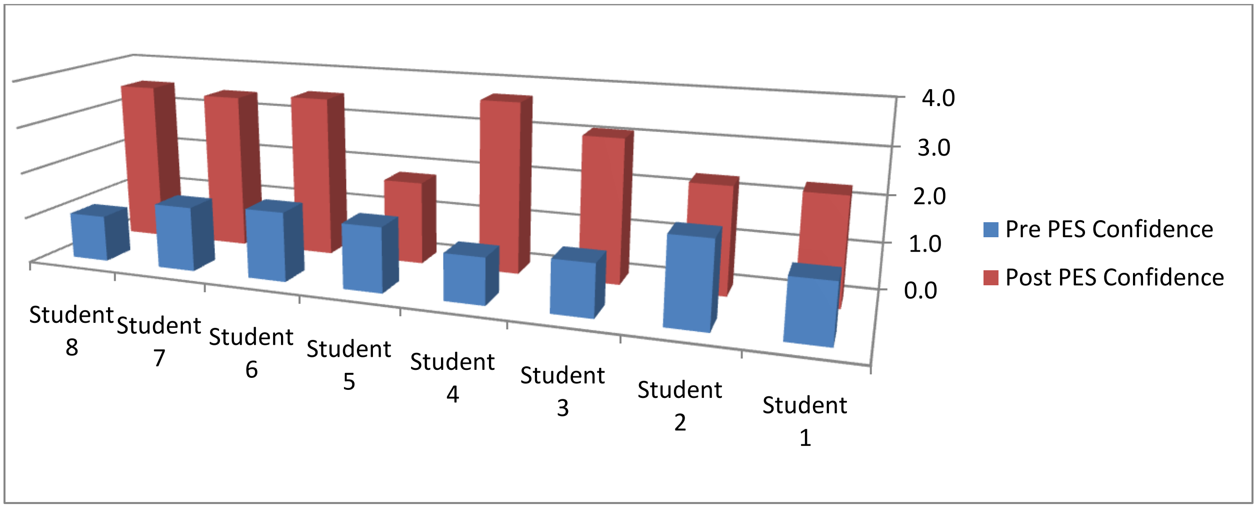


Figure 13. Average confidence level.

In figure 13, a comparison is made between the Pre-Physics Experience Survey and the Post Experience Survey. One expects confidence levels to rise after attending the 7-week course supplemental. One sees that all students have a rising trend in confidence.

Force Concept Inventory (FCI) Results

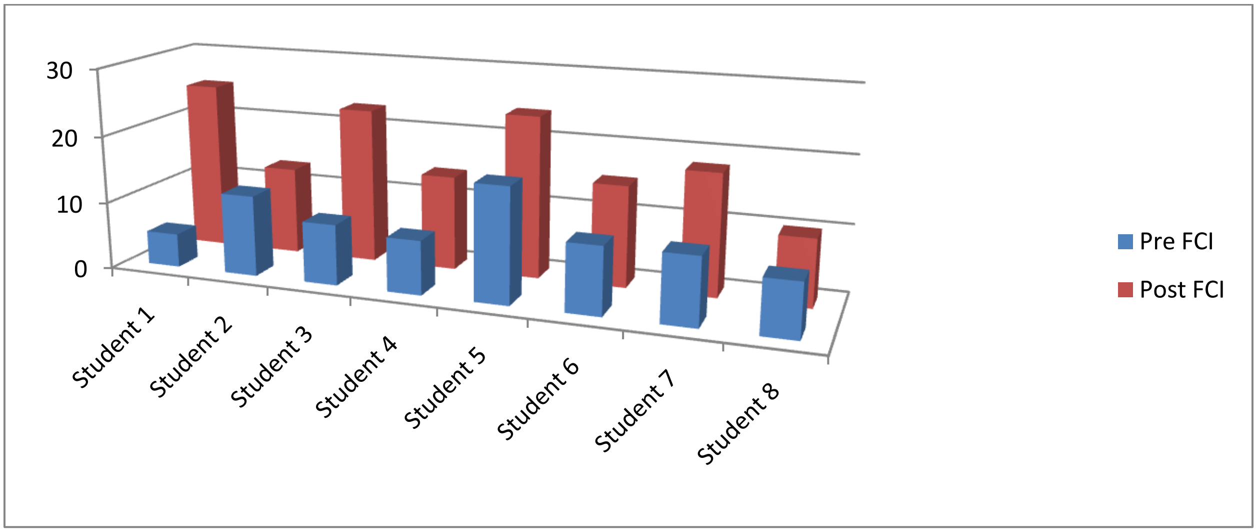


Figure 14. Treatment Group Distribution.

In figure 14, a comparison is made between the Pre-Force Concept Inventory and the Post-Force Concept Inventory of the treatment group of students. Scores improved across the graph as we expected.

Discussion

Lessons Learned

Professors have limited contact time and are using their time efficiently to prepare students for higher level courses. But the student's perception is quite different. Students try to minimize work and rationalize themselves into a form of denial, especially novice and continuing physics learners. This denial is exposed after the first exam, and by mid-term, a sink or swim mentality pervades due to a drop deadline imposed by the university. The course supplement was designed to raise novice physics learners to the level of experienced physics learners in the first midterm period. It was thought that acclimating students to the rigors of physics would attack the problem of adjustment to test anxiety in introductory physics. Since the goal of any test is to measure knowledge content, a recommendation is allowing a test practice time allotment for every hour of instruction.

Lack of experience is a factor that leads to longer adjustment time to physics pedagogy. Preliminary data does not support this hypothesis. It was also thought that test anxiety contributes to a low self-efficacy factor. Through exit interviews of our treatment group, students repeatedly asked for more practice time, rather than problem solving exposition. This request indicated the action of an adjusted hypothesis in the second semester, since the course supplement would attack the problem of test anxiety through test practice sessions. The teacher working as an expert team member during these 2^{nd} hour practice sessions built morale and self-efficacy by supervisory group work. This is a possible role for not only graduate assistants but also undergraduate learning assistants

A second hypothesis of the two variables of prior preparation and self-efficacy varying independently was not supported by the data. Other researchers have shown that self-efficacy and prior preparation does not predict exam or course grades and this study verified that result.

Intuitively, the physics coursework environment needs less adaptation if students have formal prior preparation which allows them to perceive they can master problem solving skills and perform well on the first mid-term exam. Most instructors in our department provide one free drop grade to take this factor into account. Students perceive themselves in a high self-efficacy mode but are deceived and can only find out if they really know the material under testing environments. Practice testing provides this environment by variations on several themes of problem solving.

When using the 1st test to indicate mastery of content knowledge a fallacy of not isolating testing variables occurs. Test anxiety and lack of correct preparation skills causes students to earn grades that do not reflect their knowledge content. The lead-up to midterm exams is crucial in understanding adaptability of students to the physics classroom and success rates. Confidence levels are either accurate or illusory during this period. Recommendations on eliminating these variables will begin with restructuring the asynchronous laboratories.

Implications

Overconfidence, under-confidence, and healthy confidence

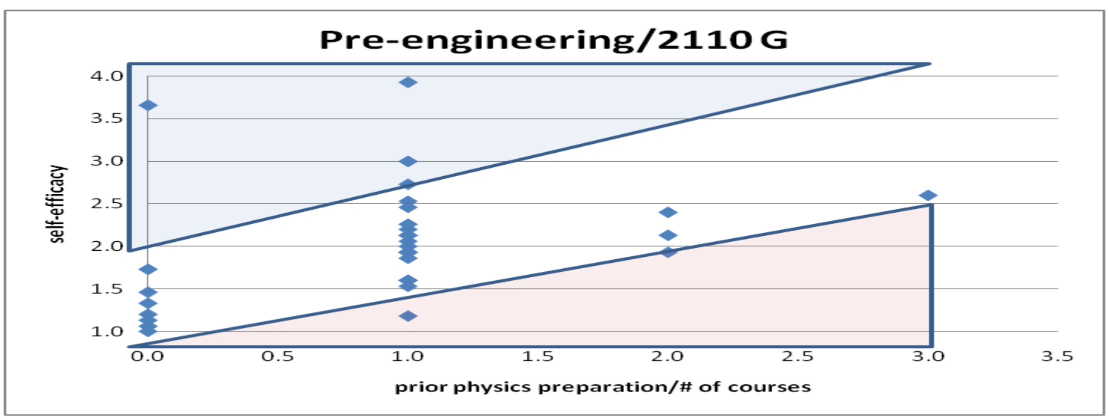


Figure 15. Scatter plot for self-efficacy versus prior preparation.

What is a healthy amount of confidence based on prior experience/preparation? For zero prior courses a student should score a confidence level that ranges from an average value of 1.0 to 2.0.Since five of the 15 questions in the PES could address a knowledge of these topics that are taught in both calculus and physics we factor this in by: (5 * 4.0 + 10

* 1.0) / 15 = 2.0 for upper limit to average For the most experienced students with three prior courses in experience, confidence levels should range from 2.5 to 4.0 which are the top 50%. It is unlikely students who have failed three prior courses would attempt taking the course again. Using the lower points {0, 1 and 3, 2.5} a lower line was constructed to be y = (5/6) x + 1.0 or (Confidence) = (5/6) (Experience) + 1.0. Similarly, the upper limit line from {0, 2 to 3, 4} yields a line of y = (2/3) x + 2.0 or Conf = (2/3) Exp + 1.0. Using these boundaries on the prior graph shows three approximate regions of overconfidence, healthy confidence and under-confidence.

Limitations

A larger statistical sample eliminate conflicts in external validity (generalizing across populations) and construct validity (theoretical argument and assessment of correspondence between samples and constructs) from the results currently documented. Scientists are bound by constructs which must meet falsifiability criteria in concert with our data. Quasi-experimentation is falsificationist in that it requires experimenters to identify a causal claim and then to generate and examine plausible alternative explanations that might falsify the claim (Campbell. 1963). The conflict addressed here in construct validity is that there is no accountability for our constructs unless we have a larger statistical sampling. Our external validity is also in questioned due to our small statistical sampling but we can generalize across our student populations some aspects that are historically self-evident: our introductory students at the U of M consistently have low success rates ranging from 39-54% that can be seen in data given by the Office of Institutional Research and a response is needed through physics teaching. Our results show a scant pattern of progress and although this progress cannot be generalized, movement into favorability is seen.

Future Work

Success rates will improve with interactive teaching and synchronous laboratories and with this pilot study we can build a practice test atmosphere in the laboratories by giving students the opportunity to do laboratory problem solving with learning assistants and graduate assistants. If self-efficacy and prior experience are found to be dependent and are coupled, then a learner classification system suggested can be accurately constructed. With student input through interviews, this classification system could possibly be used to compose a success matrix that could be generalized to upper level courses.

Conclusion

This thesis, based on a study of the first semester introductory physics course, explores a course supplement approach to intervention. The hypothesis that introductory students with low experience are adversely impacted by professors who skim over basic skills in introductory physics courses who want to emphasize higher problem solving skills and to cover required course materials was not verified by this pilot study. Experience remains a significant factor, especially when self-efficacy and prior preparation are coupled as was done in the Physics Experience Survey. Only if other factors such as course specific test preparation study skills are recognized with experience, will this study be enhanced.

In this pilot study, a classification system to measure learning has been constructed and an instructional tool of the course supplement has been employed to raise success levels. All of these components of the project design allow the issue of success rates to be confronted. In order to be more efficacious, future studies will employ practice problem solving sessions to deplete the unwanted factor of test anxiety.

The targeted intervention of a course supplement was successful in raising FCI results for 62.5% of our treatment group. Their exit interviews indicated that problem practice sessions were the most helpful part of our intervention. After receiving this request, in the spring of 2011, the course was facilitated differently, while still maintaining Initial Review Board guidelines, where in the 1st hour it was taught conceptually and interactively and the 2nd hour was instructed as a supervised group problem solving session. Time constraints are a factor to consider from this restructuring.

Our results show a scant pattern of progress and although this progress cannot be externally validated, movement into favorability is evident. This intervention addresses the barriers students experience in introductory physics courses. Even though, reading comprehension, mathematics and test preparation skills are taught in the course supplement, another issue must be addressed: is the 1st exam testing knowledge content or simply measuring test anxiety? Our study shows most introductory students are novice physics learners, a group prone to test anxiety. Since the co-requisite of Calculus I for PHYS 2110 is required for all students, coordinating with the Department of Mathematics would help to place students into the intervention before allowing them to build negative self-efficacy.

The project design had start-up flaws that must be addressed in order to take accurate statistical samples. These flaws included inaccurate initial testing of students, inflexible scheduling of students, and student polling glitches that prevented accurate data collection.

The project design would be improved by using more student interviews for success matrix models. Another recommendation is using part of scheduled time periods of course laboratories, as problem solving practice sessions. Scheduling conflicts are alleviated by implementing this recommendation.

Novice Physics Learners are our targeted group for this study even though all students are allowed to participate. Favorable results are seen in the comparison of learner levels with final and 1st exam grades. They show that NPL’s usually scored the most F’s. This insight shows that this outreach was correctly directed at the NPL group. Focusing on this group while welcoming CPL’s and EPL’s can point our attention to other avenues of instruction while constructing a success matrix for introductory physics students.

References

Adams, W.K., Perkins, K.K., Podolefsky, N., Dubson, M., Finkelstein, N.D., & Wieman, C.E. (2006). A new instrument for measuring student beliefs about physics and learning physics: The Colorado Learning about Science Survey. *Physical Review Special Topics: Physics Education Research, 2*, 21-25. doi:10.1103/PhysRevSTPER.2.010101

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory.* Upper Saddle River, NJ: Prentice-Hall.

Bandura, A. (1988). Perceived self-efficacy: Exercise of control through self-belief. *Annual Series of European Research in Behavior Therapy, 2*, 27-59.

Bandura, A. (1991). Self-regulation of motivation through anticipatory and self-regulatory mechanisms. *Perspectives on Motivation: Nebraska Symposium on Motivation, 38,* 69-164.

Bandura, A. (1993). Perceived self-efficacy in cognitive development and functioning. *Educational Psychologist, 28*(2), 117-148.

Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York, NY: Freeman.

Bandura, A., Martinez-Pons, M., Zimmerman, B. (1986). Self Motivation for Academic Attainment: The role of self efficacy beliefs and personal goal setting. *American Educational Research Journal, 29*(3), 663–676.

Bandura, A., & Schunk, D. H. (1981). Cultivating competence, self-efficacy, and intrinsic interest through proximal self-motivation. *Journal of Personality and Social Psychology, 41*, 586-598.

Barnes, R. (2002). Successful Study for Degrees (2nd ed.) London: Routledge.

Boylan, H. R., & Saxon, D. P. (2001). *An evaluation of developmental education in Texas public colleges and universities*. Boone, NC: National Center for Developmental Education.

Briggs, D. C. (2001). The effect of admissions test preparation: Evidence from NELS-88. *Chance*, *14*(1), 10–11.

Campbell, D. T., & Stanley, J. C. (1963). *Experimental and quasi-experimental designs for research.* Skokie, IL: Rand McNalley.

Center for Positive Practices. (2005). Self-Efficacy. Retrieved from www.positivepractices.com/Efficacy/ Self-Efficacy

Cohen, A.M., & Brawer. F.B. (2003). *The American community college* (4th ed.). San Francisco, CA: Jossey-Bass.

Grubb, N. V., Worthen, H., Byrd, B., Webb, E., Badway, N., & Case, C. (1999). *Honored but invisible: An inside look at teaching in community colleges*. New York, NY: Routledge.

Kintsch, W., & Greeno, J.G. (1985). Understanding and Solving Word Arithmetic Problems, *Psychological Review*, *92*(1985), 109-129.

Koch, Adina; Eckstein, Shulamith, G. (1995) Skills Needed for Reading Comprehension of Physics Texts and Their Relation to Problem-Solving Ability. *Journal of Research in Science Teaching*, *32*(6) 613-628.

Mullins, Wayne (2010). Physics Experience Survey.

Pajares, F. (1996a). Self-efficacy beliefs and mathematical problem solving of gifted students. *Contemporary Educational Psychology*, *21*(4), 325-344.

Pajares, F. (1996b). Self-efficacy beliefs in achievement settings. *Review of Educational Research, 66*, 543-578.

Pajares, F. & Graham, L. (1999). Self-efficacy, motivation constructs, and mathematics performance of entering middle school students. *Contemporary Educational Psychology*, 24(2), 124-139.

Pajares, M. F . (1992). Teachers' beliefs and educational research: cleaning up a messy construct. *Review of Educational Research*, 62(3), 307-332

Saul J.M., Steinberg R.N., M.C., Wittmann, M.C., & Redish (1996) Student difficulties with math in physics: Why can't students apply what they learn in math class? *AAPT Announcer, 26*(2), 70.

Schunk, D. H. (1995, April 18-22, 1995*). Learning Goals and Self-Evaluation: Effects on Children's Cognitive Skill Acquisition*. Paper presented at the American Educational Research Association, San Francisco, CA.

Shadish, W.R., Cook, T.D., & Campbell, D.T. (2002). *Experimental and quasi-experimental designs for generalized causal inference*. New York, NY: Houghton Mifflin Company.

Shaw, K., A. (2003). The Development of a Physics Self-Efficacy Instrument for Use in the Introductory Classroom. In J.Marx, S.Franklin, K.Cummings, (Eds.), *Physics Education Research: Vol. 720*. *AIP Conference Proceedings,* (pp.137-140). Madison,WI. doi/10.1002

Spann, M. G. Jr. (2000). *Remediation: A must for the 21" century learning society* (Policy Paper CC004). Retrieved:www.act.org/research/reports/

pdfACT_RR2005-2.pdf

Spencer, B. (2010, February 3). Astronomy class uses 'Hair' to enliven physics. *The Daily Helmsman,* pp. 1, 8.

Sytsma, S. *The basics of experimental design (A quick and nontechnical guide)*. (2009). Retrieved from: http://www.sytsma.com/phad530/expdesig.html.

Van Heuvelen, A. (1991) Learning to think like a physicist: A review of research based instructional strategies. *American Journal of Physics, 59,* 891-897.

University of Memphis, Office of Institutional Research. (2010). *Grade Distribution Generator* [Data file: Fall 2007-Fall 2010]. Retrieved from: https://oirs.memphis.edu/admindata2/GradeDistTableGenerator/GradeDistTG.html

Appendix A

Physics Experience Survey

University of Memphis

Introductory Physics Study

Course Number: Circle: 2010 or 2110   Days and Time of Meet: ________

Course Instructor: ______________ Name: ____________________________

Hours completed so far: ________Class Standing: Circle: FR SO JR SR

Prior Experience Survey

Purpose of Survey

The University of Memphis is taking steps to increase success rates in PHYS 2110 and PHYS 2010. In order to help students most effectively, we are asking students about their prior experiences in learning physics. You can help us to get a better understanding of this factor by taking time to answer a few simple questions. We will be tracking your progress in this course throughout this semester.

Students will be given a code which will ensure anonymity.

Section A: High School Physics Experience

Please check all that apply to you.

□ I did not have any physics courses in high school.
If you check this box move on to section B.

□ I have credit for one physics course on my high school transcript but we did very little physics because:

____

____

□ I had IB Physics in high school.
(circle either 1 year or 2 years)

□ I had AP Physics B in high school.
Please indicate the results of your AP exam score by circling below (optional information):

1 2 3 4 5 I did not take exam. I do not know score.

□ I had AP Physics C Mechanics in high school.
Please indicate the results of your AP exam score by circling below (optional):

1 2 3 4 5 I did not take exam. I do not know score.

□ I had AP Calculus in high school. (AB or BC please circle one)
Please indicate the results of your AP exam score by circling below (optional):

1 2 3 4 5 I did not take exam. I do not know score.

□ If you had difficulty learning physics in these courses, please describe what may have been the most dominant factor.

____

☐ Please explain other courses or exams that directly exposed you to physics:

Section B: Post - High School Physics Experience

Many students have gained some preparation for college physics in places other than high school. Listed below are some alternate resources for gaining exposure to basic physics. If you have no previous experiences then check the last box and move on to the next section. For the remaining students in this class please check all that apply to your personal experiences:

☐ I had no exposure to physics after high school. **If you check this box move on to section C.**

☐ This is not my first time to be enrolled in an ***introductory college physics*** course.

☐ I have already taken an ***engineering statics*** course.

☐ I have already taken an ***engineering dynamics*** course.

☐ I learned some physics while serving in the military.

☐ A family relative/friend of the family has tutored me in basic physics.

☐ Other (Please explain briefly)

Section C: **Personal Rating Survey**

We may be able to identify those who are at the greatest risk and who need the most help in future courses with a personal rating survey. The following questions will ask you to evaluate your exposure to and command of some basic areas of introductory physics.
Rate yourself on each of the following on a 1 to 4 scale where:

1 indicates "I am not at all familiar with the topic in this item.".

2 indicates "I have seen this before but I need to study this again from scratch."

3 indicates "I have seen this before but a brief review will be necessary".

4 indicates "I have seen this before and can help explain it to others".

1. How would you rate your ability to add two vectors? (That is, breaking vectors into x-components and y-components to combine.)
   1 **2** **3** **4**

2. How would you rate your ability to add two vectors using the Law of Sines or Law of Cosines?
   1 **2** **3** **4**

3. How would you rate your ability to analyze uniformly accelerated motion using one or more of the kinematics equations for objects in free-fall?

1 2 3 4

4. How would you rate your ability to analyze projectile motion for an object launched horizontally?
   1 2 3 4

5. How would you rate your ability to analyze projectile motion for an object launched at an angle above or below the horizontal?
   1 2 3 4

6. How would you rate your ability to draw a free-body diagram for an object at rest?
   1 2 3 4

7. How would you rate your ability to draw a free-body diagram for a small object sliding at constant speed along a level surface?
   1 2 3 4

8. How would you rate your ability to draw a free-body diagram for a small object sliding at constant speed along a level surface?
   1 2 3 4

9. How would you rate your ability to draw a free-body diagram for a small object sliding up or down an inclined plane?
   1 2 3 4

10. How would you rate your ability to apply the equation "F = ma" for a small object sliding up or down an inclined plane with friction involved?
    1 2 3 4

11. How would you rate your ability to apply the equation "F = ma" for a small object moving along a horizontal circle at constant speed?
    1 2 3 4

12. How would you rate your ability to apply the equation "F = ma" for two small objects connected by a string that is partially wrapped over a pulley?
    1 2 3 4

13. How would you rate your ability to analyze the motion of an object moving vertically using Conservation of Energy?
1 2 3 4

14. How would you rate your ability to analyze the final motion of two objects that collide and stick together using Conservation of Momentum?
1 2 3 4

15. How would you rate your ability to analyze the final motion of two objects that experience a head-on elastic collision using Conservation of Momentum and Conservation of Energy?
1 2 3 4

16. How would you rate your ability to analyze the motion of an object with non-constant mass, such as a rocket burning fuel?
1 2 3 4

Section D: Some Additional Help

For my thesis project, I am hoping to identify students who have little experience studying physics and would benefit from a supplemental, hands-on, preparatory class. My goal is to meet with students in this group for two hours per week from 1:00 to 3:00 on Wednesdays. These sessions are designed to help students compensate for a lack of prior experience and to emphasize test preparation skills. If you feel that you could benefit from this supplemental experience please indicate below with a check to the appropriate box:

☐ I am not interested in participating in your thesis project.

- ☐ I am interested in hearing more about your thesis project but do not want to commit to participation at this time.
- ☐ I am interested in hearing more about your thesis project and do want to commit to participation at this time.

To contact me for more information you can e-mail me at rwfoster@memphis.edu

Appendix B

Problem Solving Assessment

Formulae and Relations Sheet

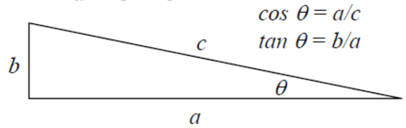
Equations

$\vec{x} = \vec{x}_i + \vec{v}_i t + \frac{1}{2}\vec{a}t^2$ $\vec{v} = \vec{v}_i + \vec{a}t$	$\}$ if $\vec{a}$ is constant	$K = \frac{1}{2}mv^2$
$F_{grav} = mg$		$U_{grav} = mgh$
$F_{spring} = kx$		$U_{spring} = \frac{1}{2}kx^2$
$f_k = \mu_k N$		$W = F_{ave}\, d$
$f_s \leq \mu_s N$	$\vec{P} = m\vec{v}$	$E = K + U$
$\sum \vec{F}_{ext} = m\vec{a}$	$\vec{P} = \vec{P}_i$ if $\sum \vec{F}_{ext} = 0$	$E = E_i + W_{ext}$

Trigonometric Relations

$a^2 + b^2 = c^2$

$sin\ \theta = b/c$
$cos\ \theta = a/c$
$tan\ \theta = b/a$



$\theta =$	0°	30°	45°	60°	90°
$sin\ \theta =$	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	1
$cos\ \theta =$	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0
$tan\ \theta =$	0	$\frac{1}{\sqrt{3}}$	1	$\sqrt{3}$	undefined

Glossary

Variable	*Description/elaboration*
a	acceleration of the object
d	distance along direction of motion
E	total mechanical energy of the system
f	forces as a result of friction
F	force
h	height with respect to a horizontal reference line
k	spring constant
K	kinetic energy
m	mass
N	normal force
P	momentum
t	time
U	potential energy
v	velocity
W	work
x	position with respect to a reference point
μ	coefficient of friction

Modifiers	*Description/elaboration*
$\rightarrow$	indicates a vector quantity
ave	indicates the average value of a variable to which it is attached
ext	variable to which it is attached must pertain to something outside ("external" to) the relevant system
grav	variable to which it is attached is associated with gravity
i	refers to the initial value of the variable to which it is attached
k	variable to which it is attached pertains to situations where object moves relative to surface ("kinetic")
s	variable to which it is attached pertains to situations where object is stationary relative to surface ("static")
spring	variable to which it is attached is associated with springs

Name:________________________

Problem-Solving Survey

---

(1) Have you ever taken physics before this course? Yes No

If *Yes*, at what level? (Circle all that apply) High School High School AP College

If you have taken college-level physics, what course (s) have you taken? ________________________

(2) What is the highest mathematics course you have successfully completed? ____________________

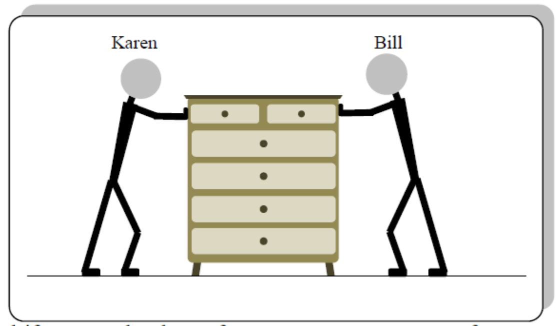
(3) What is your class year: Freshman Sophomore Junior Senior

(4) What is (are) your major(s)?

Things to know about this survey…

- *You have 40 minutes to answer the questions on this survey.*
- *You may not use a calculator to solve any part of any problem. If need be, leave any numerical answer in a convenient (yet sensibly simplified) form, such as* ⅞ *or* $\sqrt{8.3}$.
- *In additional to the formulas and relations on the "*Formulae and Relations*" sheet, you may use any of which you are aware.*
- *Perform any calculations you require in the space below each problem; you will be submitting all of the sheets at the end of the survey period.* ***NOTICE:*** *You must write your final answer in the appropriate box*

1. Karen and Bill are rearranging furniture in their house, but they don't always agree on where all the items should go. At one instant, Karen pushes a large chest of drawers (mass of 20 kg) horizontally to the right with a force of 35 N, while Bill pushes horizontally to the left with a force of 45 N. The chest is on a slippery marble floor, so it slides with essentially no friction. (Karen and Bill are both wearing rubber-soled shoes, so they get good traction.) What is the magnitude of the acceleration of the chest?



Remember: If you need to use g use g=10 m/s^2 and if you need values of *sine*, *cosine*, or *tangent* of an angle use the exact values found on the *Formulae and Relations Sheet*.

Use this space to work on the above problem.

Write your answer in the box below.

2. Samuel drops a 2 kg ball from some height above the surface of a table. The ball starts from rest and loses 36 Joules of gravitational potential energy before reaching the table's surface. What is the speed of the ball just before it hits the table?
Remember: If you need to use g use g=10 m/s^2 and if you need values of *sine*, *cosine*, or *tangent* of an angle use the exact values found on the *Formulae and Relations Sheet*.

Use this space to work on the above problem.

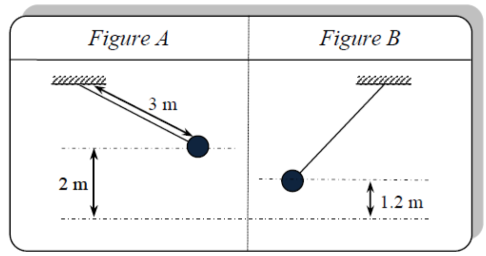
Write your answer in the box below.

3. A Volkswagen Bug (mass = 1000 kg) is traveling down the street at 8 m/s during an ice storm. The Bug approaches an SUV (mass = 3000 kg) that is stopped and unable to move due to the ice. The driver of the Bug applies the brakes, but the car just slides forward without slowing down. The two vehicles collide and stick together. How fast is the SUV moving immediately after the collision?
Remember: If you need to use *g* use *g*=10 m/s^2 and if you need values of *sine*, *cosine*, or *tangent* of an angle use the exact values found on the *Formulae and Relations Sheet*.

Use this space to work on the above problem.

Write your answer in the box below.

4. You release a ball from rest attached to a string as shown in *Figure A*. The ball swings freely. What is the kinetic energy of the ball when it passes the position indicated in *Figure B*? (The string's length is 3 m. The ball's mass is 2 kg; ignore the mass of the string.)

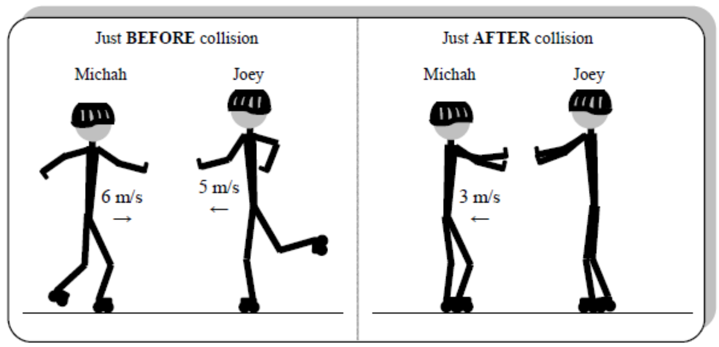


Remember: If you need to use g use g=10 m/s^2 and if you need values of *sine*, *cosine*, or *tangent* of an angle use the exact values found on the *Formulae and Relations Sheet*.

Use this space to work on the above problem.

Write your answer in the box below.

5. Michah (mass = 40 kg) is rollerskating *east* at 6 m/s when he collides with Joey (mass = 60 kg) who is rollerskating *west* at 5 m/s. As they collide, they quickly push off each other in such a way that Michah travels *west* at 3 m/s. What is Joey's speed once they push off each other?



Remember: If you need to use *g* use *g*=10 m/s^2 and if you need values of *sine*, *cosine*, or *tangent* of an angle use the exact values found on the *Formulae and Relations Sheet*.

Use this space to work on the above problem.

Write your answer in the box below.

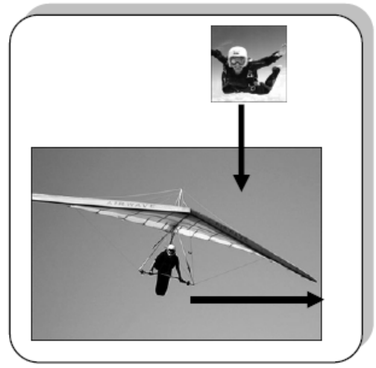
6. A 2 kg box sits at rest on a level floor. Two children push on the box at the same time. Eli pushes horizontally to the right on the box with a force of 4 N. Jamie pushes straight downward on the box with a force of 3 N. The box does not move (there is friction between the box and the floor). What is the magnitude of the upward force of the floor on the box?

   Remember: If you need to use g use g=10 m/s^2 and if you need values of *sine*, *cosine*, or *tangent* of an angle use the exact values found on the *Formulae and Relations Sheet*.

Use this space to work on the above problem.

Write your answer in the box below.

7. A skydiver is falling straight downward (prior to having deployed his parachute) when he strikes a woman in a hang glider flying horizontally to the east. The skydiver lands on the glider and grabs hold of it. Just prior to this collision, the glider had a speed of 5 m/s east and the skydiver had a speed of 10 m/s downward. What is the magnitude of the velocity of the woman and glider immediately after the collision if the skydiver holds on to it? The combined mass of the woman and glider is 120 kg and the mass of the skydiver is 80 kg.



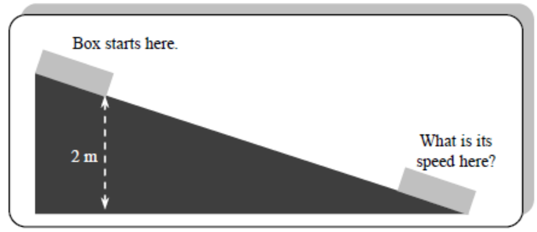
Remember: If you need to use *g* use *g*=10 m/s^2 and if you need values of *sine*, *cosine*, or *tangent* of an angle use the exact values found on the *Formulae and Relations Sheet*.

Use this space to work on the above problem.

Write your answer in the box below.

8. A 2 kg box starts from rest and slides down an incline as shown in the picture to the right. If the block loses 24 Joules of energy as it slides down the ramp, what is the speed of the box as it reaches the bottom of the ramp?

Remember: If you need to use g use g=10 m/s^2 and if you need values of *sine*, *cosine*, or *tangent* of an angle use the exact values found on the *Formulae and Relations Sheet*.

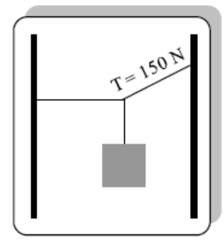


Use this space to work on the above problem.

Write your answer in the box below.

9. Regarding the figure to the right, there are three strings tied together suspending a block at rest. Determine the tension in the horizontal string if the mass of the block is 7.5 kg.

   Remember: If you need to use g use g=10 m/s^2 and if you need values of *sine*, *cosine*, or *tangent* of an angle use the exact values found on the *Formulae and Relations Sheet*.



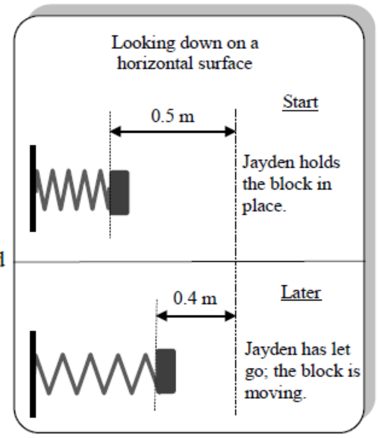
Use this space to work on the above problem.

Write your answer in the box below.

10. Jayden holds a 3 kg block pressed up against a spring on a horizontal and frictionless surface. The spring has a spring constant of 300 N/m. The spring is fixed in place, but the block is free to move. The spring is initially compressed by 0.5 m and the block is at rest. Jayden lets go of the block and it begins to move. What is the speed of the block when the spring is compressed by 0.4 m? (The block stays in contact with the spring at all times.)

Remember: If you need to use *g* use *g*=10 m/s^2 and if you need values of *sine*, *cosine*, or *tangent* of an angle use the exact values found on the *Formulae and Relations Sheet*.

.

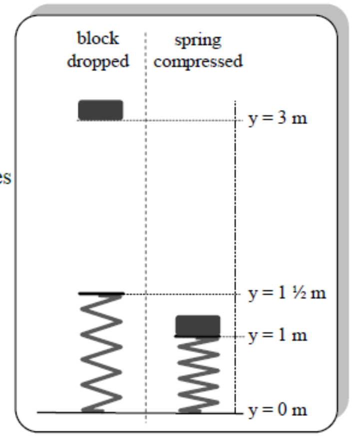


Use this space to work on the above problem.

Write your answer in the box below.

11. You drop a block from rest. The block lands on the spring (spring constant = 160 N/m) and compresses it ½ m before the block and spring momentarilty come to rest. (The spring then pushes the block upward.) What is the mass of the block?

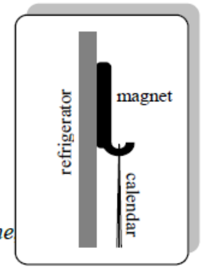
Remember: If you need to use *g* use g=10 m/s^2 and if you need values of *sine*, *cosine*, or *tangent* of an angle use the exact values found on the *Formulae and Relations Sheet*.



Use this space to work on the above problem.

Write your answer in the box below.

12. Dylan hangs a calendar on a refrigerator with a magnetic hook. Unfortunately, the magnet is too weak, so the magnet and calendar slide down the side of the refrigerator to the floor with an acceleration of magnitude 3 m/s^2. If the coefficient of sliding friction between the magnet and the refrigerator is 0.1, what is the magnitude of the total force the refrigerator exerts on the magnet? The mass of the magnet is 0.05 kg and the mass of the calendar is 0.1 kg. There is no contact between the calendar and the refrigerator.



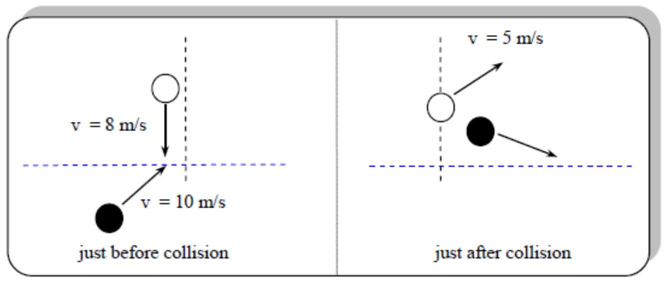
Remember: If you need to use *g* use *g*=10 m/s^2 and if you need values of *sine*, *cosine* or *tangent* of an angle use the exact values found on the *Formulae and Relations Sheet*.

Use this space to work on the above problem.

Write your answer in the box below.

13. Two pool balls, each of mass 0.2 kg, collide as shown in the figure below. Before the collision, the black ball's velocity makes an angle of 30° with the horizontal line. After the collision, the white ball's velocity makes an angle of 60° with the vertical line. What is the black ball's speed after the collision?

Remember: If you need to use *g* use *g*=10 m/s^2 and if you need values of *sine*, *cosine*, or *tangent* of an angle use the exact values found on the *Formulae and Relations Sheet*.



Use this space to work on the above problem.

Write your answer in the box below.

Appendix C

Institutional Review Board

THE UNIVERSITY OF MEMPHIS

Institutional Review Board

To: R. Wesley Foster
Physics

From: Chair, Institutional Review Board
for the Protection of Human Subjects

Subject: Preparatory Physics for Scientists and Engineers: An Interactive Supplemental Course based on the initial conditions of Physics Experience (H11-20)

Approval Date: October 29, 2010

This is to notify you of the board approval of the above referenced protocol. This project was reviewed in accordance with all applicable statutes and regulations as well as ethical principles.

Approval of this project is given with the following obligations:
1. At the end of one year from the approval date an approved renewal must be in effect to continue the project. If approval is not obtained, the human consent form is no longer valid and accrual of new subjects must stop.
2. When the project is finished or terminated, the attached form must be completed and sent to the board.
3. No change may be made in the approved protocol without board approval, except where necessary to eliminate apparent immediate hazards or threats to subjects. Such changes must be reported promptly to the board to obtain approval.
4. The stamped, approved human subjects consent form must be used. Photocopies of the form may be made.

This approval expires one year from the date above, and must be renewed prior to that date if the study is ongoing.

____

Approved

Cc: Dr. D. Franceschetti & Dr. S. Blake

University of Memphis IRB # H11-20
Approval of this form expires 10-29-11

STUDENT INFORMED CONSENT

I agree to participate in the research projects for the Preparatory Physics for Scientists and Engineers: An Interactive Supplemental Course based on the initial conditions of Physics Experience.
I understand the purpose of this work is to determine whether the form of supplemental instruction offered to the participants can make the learning of physics easier for students who have not studied physics previously. In particular the researchers will be interested in whether the supplemental instruction has a positive effect on the grades that the participants and students like them will earn in the core physics classes, **PHYS 2110 or PHYS 2010.**

As a participant, I will be asked to: 1) engage in all activities on Wednesdays; 2) attend all class sessions; 3) receive grading based on lecture and participation; 4) participate in pre-testing and post-testing . All sessions will take place on Wednesdays from 1-3 pm in MN Room 334.

I understand that there are no direct benefits to me for participating, other than the opportunity to spend additional time studying physics under an expert teacher, although the information I provide may be used to review the research activities, or to understand and/or improve future programs. My participation is completely voluntary. There are no apparent physical or psychological risks to me that are associated with participation in the present study. This is a supplemental class offered to reinforce lessons from the class and these sessions are not designed as extra credit. I understand that I may withdraw from this project at any time without penalty.

If I have any questions about the current study, I can contact Dr. Donald Franceschetti or R. Wesley Foster at 901.678.2620. If I have any questions concerning my rights as a research participant, I can contact the Institutional Review Board for the Protection of Human Subjects at (901) 678-5071.

________________________________ ________________
Signature Date

____
Researcher's Signature