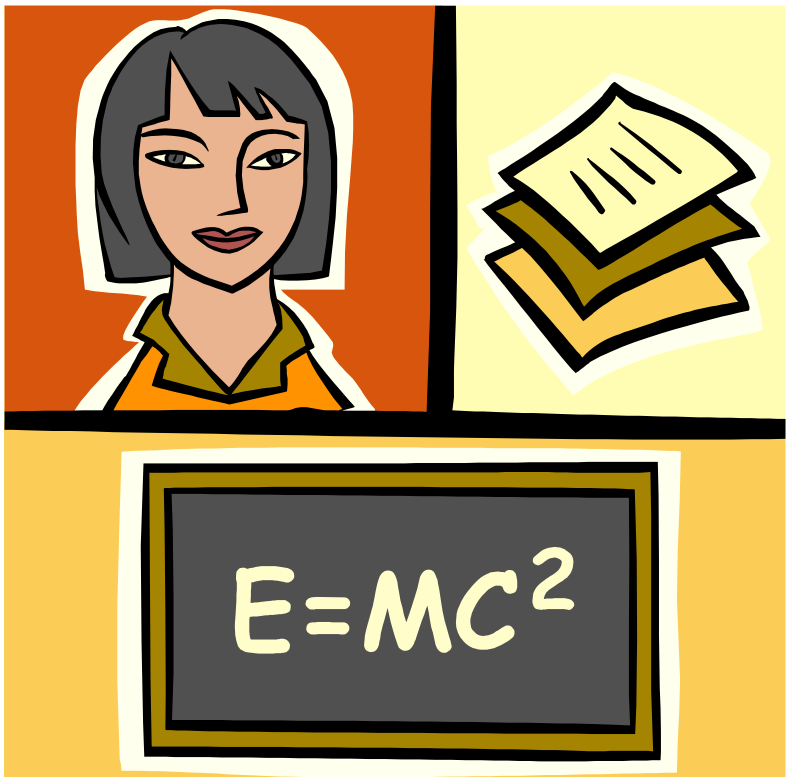
Examining Teacher Expectations about Physics Homework



Physics Honors Thesis

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Dedicated to Tony Barker

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Abstract

There are many different ways by which students learn physics and develop beliefs about physics. These range from exams to lectures, from labs to homework. Teachers have beliefs about the ideal content for each of these media to contain, as well as beliefs about what they typically do contain. The purpose of my thesis, therefore, is to examine in detail, a small but vital way that this information is conveyed from teacher to student: Homework. First, I design a survey to be administered to teachers of introductory university classes. This survey is designed to acquire data about teachers' expectations and beliefs about their homework content. Next, I administer the survey and simultaneously conduct an interview with each professor in my study. Then, I acquire homework sets from the teachers' classes. I rate these homework sets along the same dimensions the teachers were asked to rate them. Finally, I compare the ratings and analyze them for agreement.

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I. Introduction

It may come as a surprise to many teachers that despite (or perhaps even because of) their best efforts, students in introductory physics classes do not typically master basic physics concepts. Additionally, these students do not acquire their professors' attitudes and beliefs about physics itself as a discipline. Since the primary goals of most teachers are for their students to learn physics content as well as general beliefs about the nature of physics, something is going wrong. As a response to this problem, a new field has arisen within the physics community: physics education research or PER. In one particularly prominent area of PER, researchers attempt to discover the extent to which students succeed or fail to learn physics and their physics expectations. They also hope to uncover *why* students succeed or fail. Some work on developing successful teaching methods for a variety of subjects, students and environments.

There are many different ways by which students learn physics and develop beliefs about physics. These range from exams to lectures, from labs to homework. Teachers have beliefs about the ideal content for each of these media to contain, as well as beliefs about what they typically do contain. The purpose of my thesis, therefore, is to examine in detail, a small but vital way that this information is conveyed from teacher to student: Homework. First, I design a survey to be administered to teachers of introductory university classes. This survey is designed to acquire data about teachers' expectations and beliefs about their homework content. Next, I administer the survey and simultaneously conduct an interview with each professor in my study. Then, I acquire homework sets from the teachers' classes. I rate these homework sets along the same dimensions the teachers were asked to rate them. Finally, I compare the ratings and analyze them for agreement.

There are many different ways that students construct an understanding from all of the different resources offered throughout the course. Even though the way that students learn is very complicated, I have approximated the process by the following model:

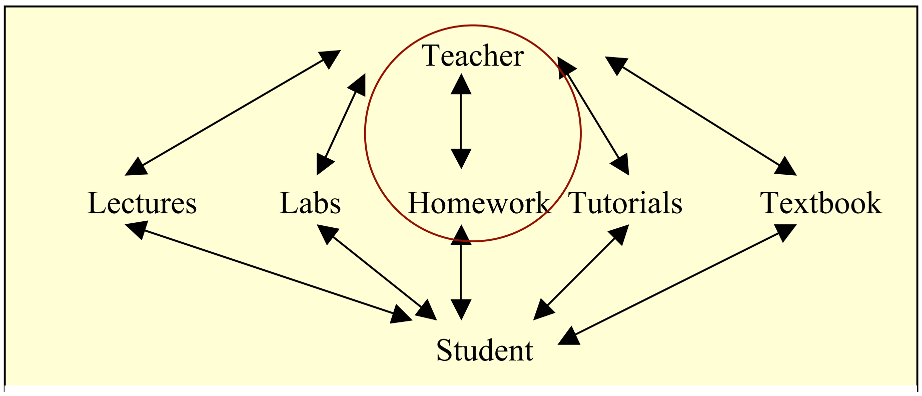

Figure 1: Diagram of Teacher / Student interaction via media

The area my research project addresses is circled in the above diagram. The purpose of my research project is to discover some of the consistencies and discrepancies between teacher and student expectations. Particularly, I focus within the medium of homework and examine the coordination and discontinuity between the teacher's ideal beliefs about homework content and their actual homework practices.

Future work on this subject would be to correlate these findings with other areas of learning as well as students' expectations about homework content. Then it would be possible to discover where the consistencies and discrepancies exist between the actual homework content and student beliefs about homework content as well as between their beliefs about homework content and their beliefs about physics in general. Also, some very important future work would be to repeat this process of interviews, surveys and analysis for other methods of learning, such as labs, lectures and tutorials, etc. An interesting avenue for further work would also be to discover how the location of consistencies and discrepancies correlates with the teachers' knowledge of physics education research.

II. Background

1. Goals and Motivation for Physics Education Research

The United States leads the world in many ways. It is a major economic, military and entrepreneurial force. Therefore, it is surprising that its students perform so poorly in science and math when compared to students around the world. When advanced high school senior students from different countries were compared, the United States performed significantly worse than the others[1], leading many teachers, leaders and even politicians to ask that effort and money be spent on figuring out why the U.S. performed so low, as well as how to improve. The following chart is based on the results from a test that high school students took in 1998. They were asked a broad range of questions, requiring them to solve traditional-type physics problems as well as conceptual problems about physics.

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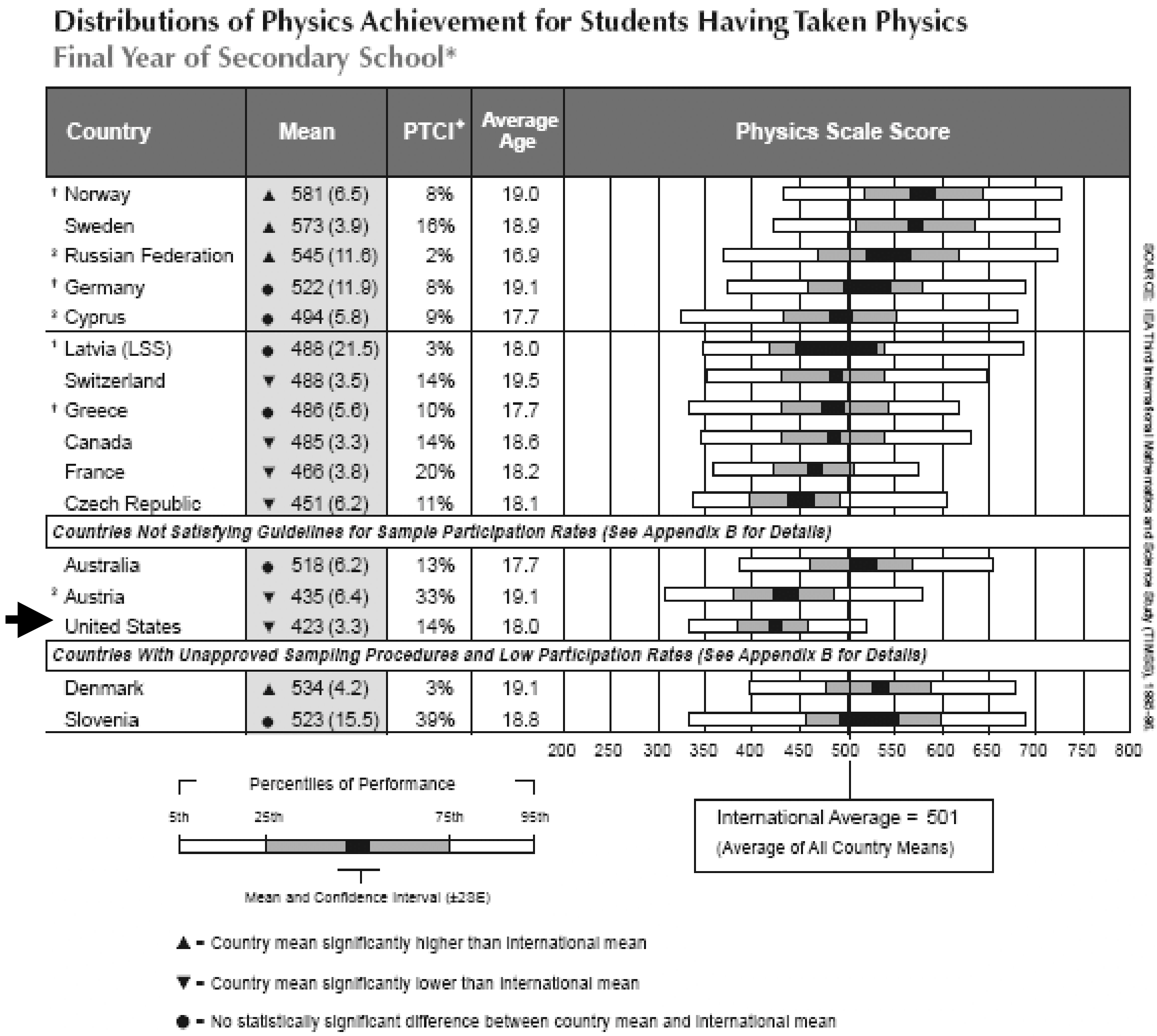
[1] http://timss.bc.edu **Mathematics and Science Achievement in the Final Year of Secondary School**. February 1998. Mullis, Martin, Beaton, Gonzalez,Kelly, and Smith (http://timss.bc.edu/timss1995i/TOC_MSC.html)



Country	Mean	PTCI*	Average Age
† Norway	▲ 581 (6.5)	8%	19.0
Sweden	▲ 573 (3.9)	16%	18.9
² Russian Federation	▲ 545 (11.6)	2%	16.9
† Germany	● 522 (11.9)	8%	19.1
² Cyprus	● 494 (5.8)	9%	17.7
¹ Latvia (LSS)	● 488 (21.5)	3%	18.0
Switzerland	▼ 488 (3.5)	14%	19.5
† Greece	● 486 (5.6)	10%	17.7
Canada	▼ 485 (3.3)	14%	18.6
France	▼ 466 (3.8)	20%	18.2
Czech Republic	▼ 451 (6.2)	11%	18.1
Countries Not Satisfying Guidelines for Sample Participation Rates (See Appendix B for Details)			
Australia	● 518 (6.2)	13%	17.7
² Austria	▼ 435 (6.4)	33%	19.1
United States	▼ 423 (3.3)	14%	18.0
Countries With Unapproved Sampling Procedures and Low Participation Rates (See Appendix B for Details)			
Denmark	▲ 534 (4.2)	3%	19.1
Slovenia	● 523 (15.5)	39%	18.8

Figure 2: Comparison of High school physics achievement between countries

These results were problematic for policy-makers in the U.S. Many emphasized the importance of physics education, and it was in 2000 that, "The [National] Commission [on Mathematics and Science Teaching for the 21st Century] is convinced that the future well-being of our nation and people depends not just on how well we educate our children generally, but on how well we educate them in mathematics and science specifically."[2] Congress agreed and even passed a law demanding that U.S. students perform better in the future.[3]

The American Physical Society further supported the field, stating, "In recent years, physics education research has emerged as a topic of research within physics departments . . . The APS applauds and supports the acceptance in physics departments of research in physics education."[4]

2. Physics Concepts

As teachers and researchers in physics realized that their students were not acquiring basic underlying physics concepts, they designed tests to quantify the extent to which their students' knowledge was insufficient. These are termed 'concept tests' and there are a lot of them. A frequently used and cited example of these is the Force Concept Inventory, or FCI[5]. Through a series of multiple choice questions, it attempts to gauge students' understanding of the concepts most teachers agree students should have mastered by the end of an introductory mechanics course. A sample question of the FCI is as follows[6]:

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2 Before It's Too Late (Glen Commission)- September 2000.

3 *"By the Year 2000, United States students will be first in the world in mathematics and science achievement"* Goals 2000: Educate America Act. Pub. Law 103-227 passed: 4/26/96

4 American Physical Society: Statement on Research in Physics Education (1999)

5 Hestenes, Wells, and Swackhamer, "Force Concept Inventory," Physics Teacher 30 141-158 (1992).

6 Hestenes, Wells, and Swackhamer, "Force Concept Inventory." Physics Teacher, v. 30 141-158, (1992).

Imagine a head-on collision between a large truck and a small compact car. During the collision:

(A) The truck exerts a greater amount of force on the car than the car exerts on the truck.

(B) The car exerts a greater amount of force on the truck than the truck exerts on the car.

(C) Neither exerts a force on the other; the car gets smashed simply because it gets in the way of the truck.

(D) The truck exerts a force on the car but the car does not exert a force on the truck.

(E) The truck exerts the same amount of force on the car as the car exerts on the truck.

Force Concept Inventory (1992)

Figure 3: Sample question from the Force Concept Inventory

Students who have merely mastered the equation-matching or a ‘plug and chug’ approach will not be able to answer this question because it relies on an understanding of the underlying concepts about force. Further, this question can show when a student does not even utilize concepts of forces to answer force-related physics questions, (for instance when he or she chooses answer ‘C’). Answer C is a good example of a ‘research-based distractor,’ which is a common, implicitly held belief of students. These researched-based distractors are discovered by researchers in physics education who use interviews observations and surveys of students to ascertain their beliefs. Often-times physics teachers do not think to provide C as an answer, and are incredulous to learn that many students, who can answer quantitative problems about forces, hold this view, demonstrating that they have failed to learn even the most basic concepts about forces.

This and other concept tests have been used to measure students’ success at physics. The results from these tests can then be quantitatively compared between classes, schools, and countries, as in the previously discussed TIMSS study.

The students' poor performance on these concept tests combined with teachers', scientists', and politicians' desire to improve led to many educational reforms, especially in lecture styles and the design of lab experiments. These interventions are based on promoting conceptual development. One example of such a change is the use of Personal Response Systems, or 'clickers,' in large lectures. These 'clickers' are connected via infrared signal to a computer which can immediately tally students' answers to a question asked during lecture. This gives teachers instantaneous feedback about the level of understanding of their students. They can cater their lectures in real time to the needs of the class. Also, students are often asked to discuss their answers with their peers before they punch in their answers. In this way, they are also participating in a form of peer instruction.[7] Another popular change was to introduce tutorials.[8] A tutorial is a way of leading students in a Socratic, reasoned way through a complex, conceptual problem. It is usually done in addition to lecture.

These kinds of changes have resulted in higher student performance on concept tests such as the FCI. The following graph shows the gain (how much students' conceptual understanding improve over the course of the semester) both in traditional classes without research based changes (black) and in interactive engagement (IE) classes

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[7] E. Mazur, Peer Instruction: A User's Manual (Englewood Cliffs, NJ: Prentice-Hall, 1997). http://www.columbia.edu/cu/gsapp/BT/RESEARCH/mazur.html

[8] McDermott, Lillian, Department of Physics, University of WA, Seattle

which incorporate research based changes ranging from peer instruction to tutorials to wholesale course reform (grey).[9]

$$\langle g \rangle = \text{gain} = \frac{\text{Post-class score} - \text{Pre-class score}}{100\% - \text{Pre-class score}\%}$$

For example, suppose a student scores a 40% before he takes the class and an 80% on the same test after taking the class. His gain would be:

$$\langle g \rangle = \frac{80\% - 40\%}{100\% - 40\%} = .66$$

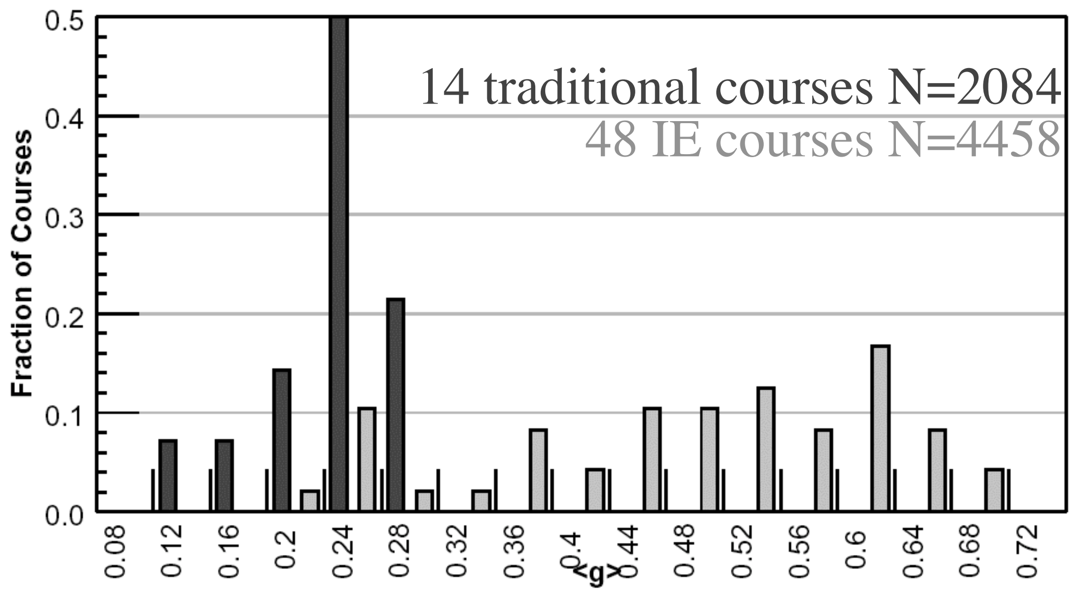

Figure 4: Comparison of gain between traditional and interactive engagement classes

Notice that most students do not score nearly as high as our example above. The average gain for a traditional class is only .23. With the interactive engagement, the average is close to .5. Not only is the average gain higher in classes utilizing IE, but

[9] Hake, R.R. "Interactive-engagement vs. traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses," Am. J. Phys. 66, 64-74 (1998). http://www.physics.indiana.edu/~sdi/ajpv3i.pdf

additionally, almost every student performs higher than almost all of the students in traditional classes.

3. Physics Expectations

Sometimes teachers, even in reform courses, assume that if their students are performing well on conceptual tests, their general beliefs about physics must be correct as well. For instance, some teachers assume that students who can correctly answer conceptual questions about circuits also believe that physics is a coherent, conceptual field about the everyday real world. These teachers assume that beliefs about physics 'come along for the ride' with knowledge of conceptual physics content. In reality, many students who can answer conceptual physics questions do not always believe that physics is a coherent, conceptual field about the everyday world. Worse, their beliefs about physics typically deteriorate over the course of the semester. In other words, if a student enters a class believing that physics is about the real world, most likely, she will leave the class with only a weak belief that physics is about the real world. One reason this deterioration is problematic is because my data suggest that conveying these beliefs is one of their main goals in the course. For example, in an interview I conducted, one teacher claimed his primary goal was for students to "understand that physics explains the world around them."[10] Teachers want their students to share their beliefs about the intrinsic nature of physics. Another reason this deterioration is troublesome is that preliminary data[11] show that student beliefs about physics are correlated with retention. In other words, students that believe physics is a coherent, conceptual study of the real

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[10] Teacher A, see appendix
[11] Adams, Finkelstien, Wieman, forthcoming.

world are more likely to go on in physics than those who do not have those beliefs. It is important to note that this is merely a correlation, not causation.

Maryland Physics Expectations Survey

One of the most common tools used to ascertain student beliefs is a survey called the Maryland Physics Expectations Survey (MPEX).[12] The survey has 34 statements about the nature of physics. Students are asked to choose a number, 1 through 5, depending on whether they agree or disagree with the statement. 1 is "strongly disagree," 2 is "disagree," three is "neutral," four is "agree," and five is "strongly agree." The 'expert view' was derived by giving the survey to physics teachers. The teachers' answer is the 'expert' answer. Answers of 4 and 5 are grouped together as "agree" and answers of 1 and 2 are grouped together as "disagree." If the student agrees with the expert view, her answer is considered favorable. If she disagrees, her answer is considered unfavorable. For example, one of the MPEX statements is: "Physical laws have little relation to what I experience in the real world." The expert answer is 'disagree.' (Presumably this is because physical laws *do* relate to what a person experiences in the real world.) Therefore, if a student answers with a 4 or a 5, her answer is unfavorable, (because she *disagrees* with the expert) whereas if she answers with a 1 or a 2 her answer is favorable (because she *agrees* with the expert). The MPEX is designed to ascertain students' beliefs and expectations along six dimensions of physics.

The first dimension is independence. These statements ask the student if physics should be learned independently with the student taking responsibility for his or her own

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[12] Redish, Saul and Steinberg, "Student Expectations in introductory physics,"*Maryland Physics Expectations Survey* University of Maryland Physics Education Research Group. American Journal of Physics 66 212-224, (1998). http://www.physics.umd.edu/perg/expects/mpex.htm. (See Appendix C1)

understanding, or if physics should be learned without evaluation by taking what the teacher and text book say as given. The first answer is considered favorable.

The second dimension is coherence. These statements ask the student if physics should be considered as a connected, consistent framework or if physics can be treated as separated facts or ‘pieces’. Again, the first is the favorable answer.

The third dimension is concepts. These statements ask the student if physics stresses the understanding of the underlying ideas and concepts or if studying physics means focusing on memorizing and using formulas. The first response is favorable.

The fourth dimension is the reality link. These statements ask students if they believe ideas learned in physics are relevant and useful in a wide variety of real contexts or if they believe ideas learned in physics are unrelated to experiences outside the class-room. The first beliefs are favorable.

The fifth dimension is math link. These statements ask if students consider mathematics as a convenient way of representing physical phenomena or if they view the physics and the math independently with no relationship between them. Again, the first answer is favorable.

The sixth dimension is effort. These statements ask if the student makes the effort to use information available and tries to make sense of it or if the student does not attempt to use available information effectively. The first answer is the favorable one.

If a student agrees with the expert view on every single statement, then her expectations would be entered at the top left corner of the following graph,[13] at the point (100%, 0%). If she disagrees with the expert view on every single statement, her expectations would be entered as (0%, 100%). If she is neutral on every statement, her

[13] Redish, 1998.

expectations would be entered as (0%, 0%) because she has neither favorable nor unfavorable expectations. The arrows represent the average beliefs before and after the course. With the minor exception of the 'concepts' category, all of the expectations deteriorate between the beginning of the class and the end. In the category of 'math' they drop by as much as 10%.

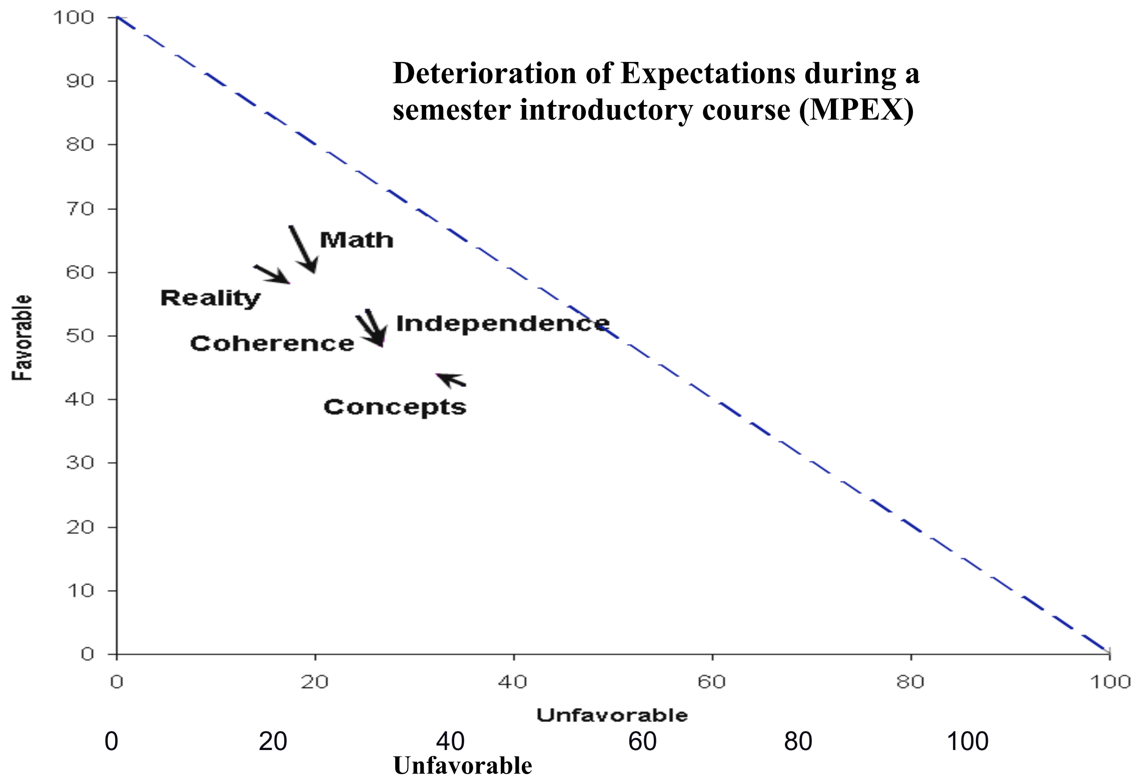


Figure 5: Pre to Post-class changes in expectations

Colorado Learning Attitudes about Science Survey

Researchers at the University of Colorado, Boulder have built on the MPEX and other instruments to develop the Colorado Learning Attitudes about Science Survey or CLASS. It is a similar survey designed to ascertain students' attitudes and expectations about physics. Comparable results have been obtained with the CLASS that also demonstrate students' expectation regression during an introductory course. Results from the CLASS can be seen in the table below.[14] Data taken before the semester of introductory physics are "Pre," while data taken after the semester are "Post." As can be seen, there is a significant drop in expectations over the course of the semester. In other words, the students agreed with almost 70% of statements asserting that physics is about the real world *before* they took the course. After the course and all of its lectures, exams, labs and homework, these same students agreed with only 52% of the same statements asserting that physics is about the real world. The following data is from an introductory course at the University of Northern Colorado.

Category	***CLASS Pre Favorable%***	***CLASS Post Favorable %***
reality (world)	69.5 (4.5%)	52
reality (personal)	66 (4%)	42.5
independence	61 (3%)	49
coherence	58.5 (3%)	58
concepts	59 (3%)	47.5
math	73.5 (3.5%)	59.5
effort	40 (2.5%)	32.5

Figure 6: Sample Pre to Post-class changes in expectations for U.N.C. intro class

As I mentioned before, preliminary data show that students whose views are correlated with the expert views are much more likely to go on in physics[15]. The following table shows the percent favorable responses to CLASS category, Reality Personal View, (what I've been calling 'Student Reality' link) issued at the beginning of term for a variety of different types of courses:

[14] Adams, Finkelstein, Wieman, Forthcoming.
[15] Adams, Finkelstien, Wieman, forthcoming.

University Environment	**Favorable Pre-Test Score (%) (uncertainty; n)**
UNC Calc-based Physics I (FCI 0.35) (mostly majors)	**71 (5%, n=41)**
CU Calc-based Physics I (FCI 0.6) (mostly engineers)	**63 (2%, n=174)**
UNC Alg-based Physics I (FCI 0.13) (who stayed enrolled) **Students who started**	**61 (5%, n=36)** **49 (4%, n=78)**
CU Non-Science Major Physics I	**44 (4%, n=77)**
CU Non-Science Major Physics II	**61 (n=34)**

Figure 7: Expectation data for a variety of classes in one expectation dimension

In the above graph, notice that for the UNC Algebra-based Physics I class the students who stayed enrolled and went on to complete the course had significantly higher (61% as opposed to 49%) *pre* expectations. In other words, this result is not due to any expectations they learned by staying in the course. Similarly, the students that chose to go on to the Non-Science Major Physics II had higher expectations for how much physics related to their lives than the general population of those entering the Non-Science Major Physics I class.[16]

III. My Project

There are many ways these expectations are taught, both explicitly and implicitly. Teachers convey these through what they test on exams, what they say in lecture, what they ask their students to do in labs, which text books they assign and in which homework problems they assign. In order to keep my project down to a manageable size, I had to pick one of these areas to examine in detail.

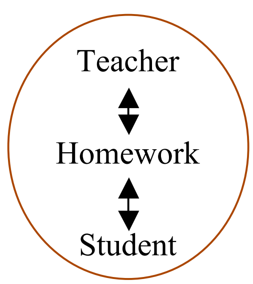
[16] Please note that this only establishes a correlation, not a causal relationship between expectations and physics retention.

I decided to focus on homework. My reasons for choosing homework are threefold. First, most teachers use homework scores as a significant part of the class grade. For example, one of the teachers I surveyed has the following statement on his course website: **With this system, the most important requirement for getting a good grade is to do all the assignments!** (Bold emphasis original.) Second, students spend a large amount of time working on homework and teachers spend a large amount of time finding and grading assignments homework. This time should be time well-spent. Finally, and most importantly, many teachers believe that it is by 'doing problems' that students learn about physics and how real physics is done.

1. Hypothesis

As observed in the data above, not only is there a discrepancy between expert and student expectations about physics, but that discrepancy widens as student expectations regress during the course. Therefore, since homework is a major part of what physics students are required to do, it is reasonable to look for evidence of that discrepancy somewhere within homework.

The model I use to describe how teachers convey expectations to students through homework is a magnified subset of the model shown in the introduction:



The diagram below contains the details I am going to examine. The arrows represent connections between the different elements and the lines through them are possible discrepancies or breakdown points.

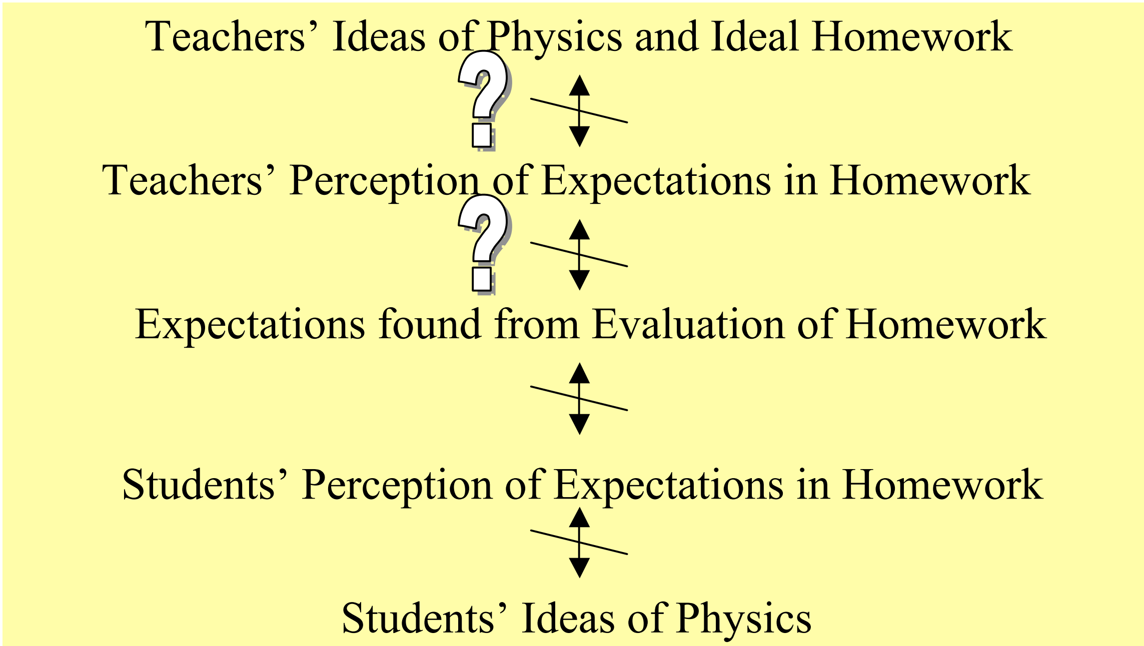


Figure 8: Model of interaction between teachers and students within homework

My hypothesis is that a breakdown can be observed between teachers' ideas of physics / ideal homework content and actual homework content. (These possible locations are indicated by the question marks.) My thesis will investigate the extent and characteristics of this breakdown.

In order to keep my project a manageable size, I limit it in two ways. First, my research only considers the top three categories, between teacher expectations and perceptions of homework and homework content. It is not within the scope of this project to consider the students' categories. I will suggest how this could be done at the end of the thesis in the section on further work. Next, I will choose three out of the six MPEX dimensions of expectations presented above to examine. Based on the CLASS, I will divide the reality link into two categories, which I will discuss below, leaving me with four expectation dimensions to analyze in the homework. Specifically, I will examine coherence, concepts and two aspects of reality link (real world and student world).

2. Methods and Tools

The first step in my project was to design a survey to ascertain teacher beliefs about the content of their homework as well as the relative importance faculty place on homework. I asked teachers to list the top five goals for their class. I also asked what percentage of learning they believe occurs during a number of different activities: during lectures, while doing homework, while reading the textbook, while preparing for exams, during recitations or labs, or somewhere else. Using the MPEX and CLASS as guides, I first formulated a preliminary survey[17] with eleven statements concerning the expectation dimensions. Teachers are asked to indicate whether they agree, disagree or are neutral with respect to the statements. They are asked to give a number (just as before, 1 is strongly disagree, 3 is neutral, and 5 is strongly agree) for each of the various statements. Designing a survey that could accurately capture teachers' expectations proved to be much more difficult than I had anticipated.

One problem I had with the first survey was that many of the statements did not present a dimension clearly enough to accurately categorize a teacher's beliefs. For instance, one statement reads: "The overall coherence of physics is often explicit in homework." Many teachers found it difficult to rate their agreement because it wasn't clear what would constitute "explicit coherence." This statement was taken out of the second version of the survey.

[17] See Appendix A1 for a copy of survey #1.

Another problem brought to my attention by Wendy Adams[18] is that the two statements about the reality link really contain two, very different ideas. The first statement says, "Homework problems frequently ask the student to consider a real world situation to which a physics principle applies." The second says, "Homework questions often ask the student to consider his or her own experience." Most teachers agree with the first statement but disagree with the second. This is because, as one teacher said, "all of physics is about the real world," independently of whether or not students are asked to consider their experience. To address this problem, as was done in the CLASS, I divided the category of reality link into two categories: real world link and student world link. I will discuss further problems with the real world link below. Another problematic expectation dimension in the first survey attempted to gauge teachers' expectations about effort. This was very difficult to measure because teachers were unwilling to make general statements about how effort affected the students' success in their class. For instance, one of the questions I asked on the first survey is: If students do not do well on homework assignments it is generally because they are not putting in as much time and effort as I have recommended. Many teachers said that this was highly student-dependent. Some noted that a student may be putting in plenty of time and effort, but in the 'wrong ways' (not in groups, or just re-reading the text book). They pointed out that doing poorly on the homework could be attributed to a number of different factors, and so did not feel comfortable generalizing enough to assign a number. I got similar reactions to the other question about effort, so I decided to throw out the effort expectation dimension and focus on the others.

[18] Wendy Adams is a graduate student at CU currently doing research on student expectations with the CLASS survey.

In addition to the survey, I used teacher interviews as a tool for validating the survey, evaluating teacher expectations and confirming their goals as well as the importance they place on homework. I audio recorded the interviews and took notes so that I could reliably use the interview data.

First, the interview is used to validate the survey. If, for example, I were to hand out the surveys and collect them later, I would only have a number (1-5) for each statement. I wouldn't know that the teachers had trouble deciding what 'explicit coherence' is, etc. By interviewing them and asking them to 'think aloud' as they fill out the survey I obtain a lot of information about what they think the statements are getting at as well as whether or not they agree.

Next, I use the interview to get direct quotations, such as those of Teacher B who said, "I need to look at my homework" in order to answer the survey questions about the content of his homework. Teacher B also said, "If they [the students] look at the CAPA[19] they are being misled" about what is important.

The interviews also provide a more thorough understanding of teacher expectations. For instance, a teacher might say, "I'm putting down a four because even though I don't have very many conceptual problems in my homework assignments, the ones that are conceptual cannot be solved without a truly thorough conceptual understanding of the underlying material." This statement contains a lot more information than a number. The interviews are especially useful for designing the next version of the survey. The interviews are also useful for making sure my survey is

[19] CAPAs are computer assisted physics assignments which are assigned for homework in this teacher's class.

comprehensive enough. I ask each teacher if he thinks I've left something crucial out of the survey.

After an analysis of my preliminary survey data and the first set of interviews, I begin the design of my final survey, adding and removing several statements.[20]

For the reasons discussed above ('explicit coherence' is difficult to characterize) I remove the question about 'explicit coherence' in homework. One of the other statements I use concerning coherence in the first survey is: Students are asked to infer general principles from specific examples in the homework problem sets. Many teachers did not know how to answer this question either. Therefore, I modify both coherence questions for the next survey.

I ask the same first ten questions for general information about the importance of homework based on what percentage of learning the teacher believes occurs while doing homework. I also ask the teacher to list his top five goals for the class. The goals can be used to help ascertain teachers' ideas about physics generally and ideal homework content. Then I ask the teachers to agree or disagree with twelve statements about the importance of homework and the four expectation dimensions: coherence, concepts, real world link, and student world link.

The Final Survey

The three statements about coherence are:

1. The majority of problems in a given homework set ask about the same two or three ideas.
2. If a student does poorly on the homework in the first unit, he or she can still do well on the next unit's homework by working exclusively on the new material.
3. There is usually at least one homework question in each set about how the current material relates to other material from the course.

[20] See Appendix A2 for a copy of Survey #2.

Notice that the first and third of these statements are positive, while the second is negative. In other words, if a teacher strongly believes his homework is coherent, he will answer with a 5 for the first statement, a 1 for the second statement and a 5 for the third statement. Therefore, when rating whether or not a teacher believes his homework is coherent, it is necessary to exchange or reverse the values for all of the negative statements. So the teacher described above would have a 'coherence score' of: 5 5 5. Stated more precisely, an agreement of 1 (strong disagreement with the statement) for the second statement is really an agreement of 5 with the belief that the homework is coherent. Conversely, if a teacher has an agreement of 4 for the second statement, it needs to be reversed to a 2 in order to evaluate the teacher's belief about whether or not his homework is coherent.

The two statements about concepts are:

- Most homework problems can be solved by carefully looking over the given equations to find the right one.
- In order to solve my homework problems students must understand the underlying concepts.

For this expectation, the first statement is negative and the second is positive in the sense discussed above.

The two statements about the world reality link are:

- Homework problems frequently ask the student to consider a real world situation to which a physics principle applies.
- Most of the 'real world' homework problems I assign are 'idealized' or 'abstracted' to simplify the complexities of the real world.

The first statement is positive, the second is negative.

The two statements about the student reality link are:

- Homework questions often ask the student to consider his or her own experience.
- The material I cover in my homework relates to the students' everyday lives.

These are both positive statements.

The three statements about the importance of homework are:

- All of the material (concepts, formulas, etc.) I expect my students to know on an exam is covered at some point on the homework.
- If a student does poorly on the homework, he or she will most likely do poorly overall in the class.
- If students want to know what I think it is important for them to learn, they can look at the homework problems I assign.

These statements are all positive.

The final tool I utilize is a rubric by which to evaluate homework content.[21] Since I want to look for correlations and breakdowns between teacher perceptions of homework content and actual homework content, I need a way to evaluate the actual homework content. One might wonder why I think my evaluation of actual homework content is more objective than the teacher perception of homework ascertained by the survey. First of all, the teachers' perceptions ascertained on the survey are done without looking at the homework (some teachers had not looked at their homework sets for several semesters). Ideally, I want to evaluate the homework sets in such a way that if the teacher were to evaluate the homework with me, he would agree with my ratings. I developed a rubric by which to objectively evaluate the homework for every teacher. The following table is the rubric for the expectation dimension of concepts. The number on the left is the degree to which the question is conceptual. 1 is the lowest and 5 is the highest.

Homework Concept Rubric:

[21] See Appendix A3 for a copy of the rubric used.

1 HW question can be solved by pattern-matching or manipulating one equation.
2 HW question can be solved by manipulating fewer than three equations.
3 Some knowledge of what symbol(s) in equation represent is helpful in solving question.
4 Knowledge of what symbol(s) in equation represent is required to solve question.
5 HW question explicitly asks students about concepts, must be answered in terms of concepts

Figure 9: Rubric designed to evaluate homework sets along the concept expectation dimension

First I acquire homework sets from every teacher I survey and interview. I then select three representative sets: the second assignment, the fifth or sixth assignment and the tenth or twelfth assignment. By choosing these assignments I don't have to worry about a 'pretest' or 'concluding' assignment which may skew the evaluations. Then I look at each problem and evaluate them along the same expectation dimensions I ask about in the survey.

3. Data: Teacher Surveys and Interviews

Now I am ready to use these developed tools to collect data. The data from the preliminary survey are as follows:

Statement #	4	5	6	7	8	9	10	11	12	13	14	15
Category	E	I	C	R	I	N	N	C	I	C	E	R
Teacher A	4	5	5	5	5	5	4	3	4	2	3	4
Teacher B	4	4	3	4	4	4	2	3	4	4	4	2
Teacher C	4	3	3	4	4	5	4	4	4	5	4	3
Teacher D	4	2	2	4	3	3	2	3	4	2	3	2

Figure 10: Preliminary Data for Survey #1, by teacher and by category

E = Effort C = Coherence N = Concepts
I = Importance R = Reality

1 Strongly Disagree 3 Neutral 5 Strongly Agree

Notice that this survey asks about effort, which is absent from the next survey. This is because it would be too difficult to try to evaluate the homework problems for whether students were constructing their own ideas or taking information as given. This kind of dimension would be much easier to evaluate in the context of a lecture or lab. Also, this first survey does not differentiate between the two different kinds of reality links discussed earlier. The raw data from the revised survey are as follows:

Category:	Imp	Coh	RW	Coh	Imp	SW	Con	Coh	Imp	SW	Con	RW
Statement #	4	5	6	7	8	9	10	11	12	13	14	15
Teacher A	5	5	5	2	5	4	1	3	5	5	5	5
Teacher B	4	4	3	2	5	2	2	4	3	2	4	5
Teacher C	4	4	4	2	3	4	2	4	4	4	5	5
Teacher D	2	4	4	2	3	2	4	3	4	3	3	4
Teacher E	5	4	2	4	5	1	5	2	5	1	2	5

Figure 11: Preliminary Data for Survey #2, by teacher and by category

Imp = Importance RW = Real World Con = Concepts
Coh = Coherence SW = Student World

The first question on the survey is for the teacher to list his top five goals for his class. The table below shows sample data from one of the teachers interviewed. Complete data from the preliminary questions about the teacher's goals for the class are listed in Appendix B3.

Goals	Teacher C
1	Think scientifically
2	Develop new ways of "seeing" the universe
3	Develop qualitative and quantitative reasoning
4	Develop skills of explaining your thoughts
5	Critical thinking

Figure 12: Preliminary Data for Survey #1 Goals for sample Teacher C.

The data from the same question on the second survey are listed in Appendix C3. The table below shows the same teacher's answer to the same questions one semester later. Notice that Teacher C does not list content or physics as a goal on the first survey but does in the second. Despite these changes, his answers are very similar.

Goals	Teacher C
1	Learning Environment
2	Physical reasoning
3	Explain to peers
4	Quantitative Reasoning
5	Physics

Figure 13: Preliminary Data for Survey #2 Goals for sample Teacher C.

Although most goals were found in more than one teacher's list, this goal appeared only once, as goal #5 of Teacher E:

Goals	Teacher E
5	A necessary filter

Figure 14: Data for Survey #2 Goals for sample Teacher E.

The second question on the survey asks the teachers to estimate how much of student learning occurs via different media. The data from the first teacher interviews for sample Teacher A and B (complete data in Appendix B4) about what percentage of learning occurs in these areas are as follows:

	% OF LEARNING OCCURS				Labs &
	lectures	homework	text book	exam prep	recitations
Teacher A	15%	75%	5%	5%	N/A
Teacher B	30%	20%	10%	10%	30%

Figure 15: Data for Survey #1 Percentage of Learning for Teachers A and B.

The data from the second teacher interviews about the same question for the same teachers are as follows: (complete data in Appendix C4)

	% OF LEARNING OCCURS				labs &	
	lectures	homework	text book	exam prep	recitations	other
Teacher A	25%	60%	2%	8%	5%	0%
Teacher B	25%	30%	12.5%	12.5%	20%	0%

Figure 16: Data for Survey #2 Percentage of Learning for Teachers A and B.

4. Analysis: Teacher Surveys and Interviews

In the previous section about the tools I use (survey and interviews) I explain how the evaluation of the interviews helps me to make changes to the survey. Happily, I did not get very many complaints about my second survey. Teachers generally understood the statements on the survey and felt comfortable agreeing or disagreeing with them.

The notable exception to this is statement #15: “Most of the ‘real world’ homework problems I assign are ‘idealized’ or ‘abstracted’ to simplify the complexities of the real world.” This statement was intended to be a negative statement about the real world link. In other words, I was hoping that teachers who believed that their homework problems were about the real world would answer with a disagreement. Unfortunately, this statement cued a methodological answer rather than a content answer. What I mean is that teachers viewed this statement as about the *methods* by which students solved the problems. They recognized that many of their homework problems were designed to teach students how to use abstraction in order to solve complex problems. Their homework problems still may have had real world content, such as a bicycle, instead of abstracted content, such as a generic “object”. This confusion clearly presents itself in my interviews. Teacher C, when answering statement #15 about whether his homework was abstracted, said, “Absolutely. That’s what physics is all about.”

The misunderstanding about statement #15 is corroborated by the data themselves as I will show below.

Reversing Data

In the second survey, statements 7, 10 and 15 are 'negative' statements (where an agreement constitutes a disagreement with the expert expectation). Therefore, the data must be reversed for these statements (by exchanging 1 and 5 as well as 2 and 4). Arranging the reversed data for survey #2, by category, we have:

Category	Imp			Coh			RW		SW		Con	
Statement	4	8	12	5	7	11	6	15	9	13	10	14
Teacher A	5	5	5	5	4	3	5	1	4	5	5	5
Teacher B	4	5	3	4	4	4	3	1	2	2	4	4
Teacher C	4	3	4	4	4	4	4	1	4	4	4	5
Teacher D	3	3	4	4	4	3	4	2	2	3	2	3
Teacher E	5	5	5	4	2	2	2	1	1	1	1	2

Figure 17: Reversed Data for Survey #2 to account for 'negative statements.'

Graphically, by category, the data are below. The first graph is 'importance' and contains data about how important homework is. The numbers (1-5) on the left of the graph represent the possible agreement (5 = strong agreement, etc.) The letters along the bottom represent the different teachers (A – E).

Importance:

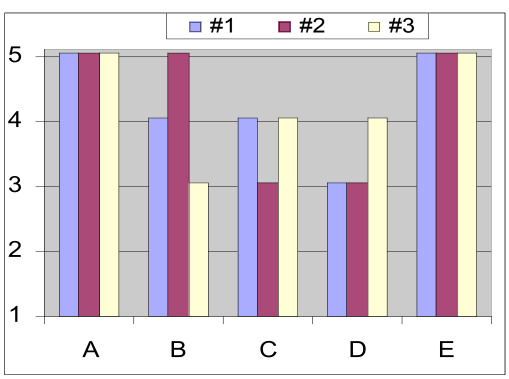
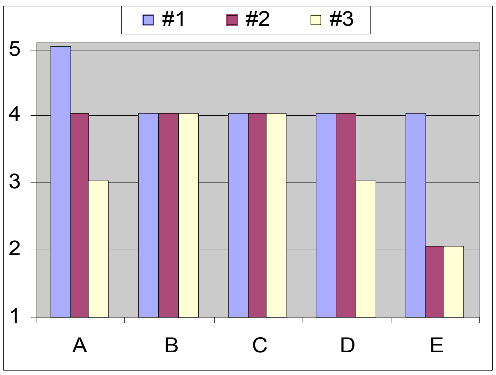


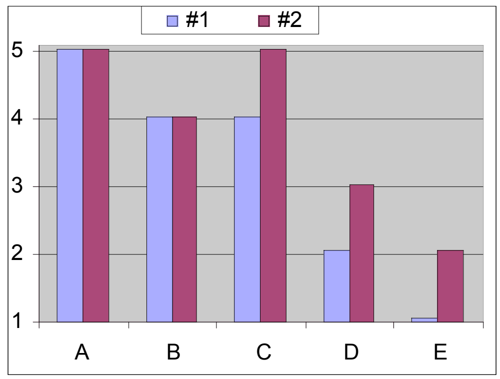
Figure 18: Graph of Importance of Homework for three questions for each teacher

The next four graphs show the data on the four different expectation dimensions my research project analyzed. If the graph has two bars, it means that the survey asked the teacher to agree or disagree with two statements about that category. Similarly, if it has three bars, there were three statements with which the teacher was asked to agree or disagree. Again, the numbers on the left represent the level of agreement (1 – 5) while the letters across the bottom represent the different teachers surveyed.

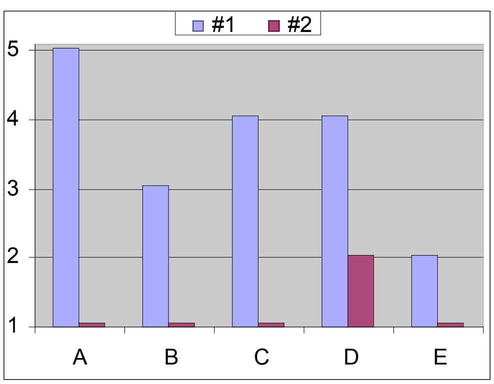
Coherence:



Concepts:



World Reality:



Student Reality:

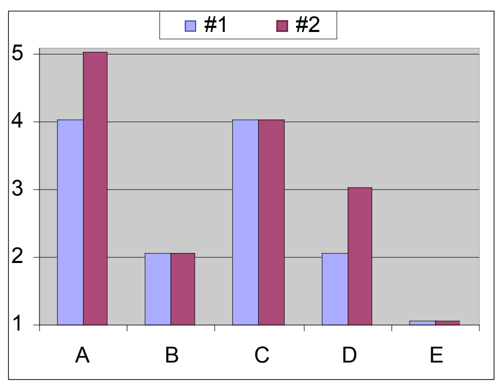


Figure 19: Graphs of teacher perception of 4 Expectation Dimensions in Homework

The data in these graphs offer another check for the validity of my survey. First, there should be general agreement for the statements of any given category. For example, a teacher who strongly agrees with the statement: "*If a student does poorly on the homework in the first unit, he or she can still do well on the next unit's homework by working exclusively on the new material*" should also strongly agree with the statement:

"*There is usually at least one homework question in each set about how the current material relates to other material from the course*." If questions from one homework set ask about how the material relates to other material, a student cannot focus exclusively on the new material and do well. If, on the other hand, there is significant disagreement, it is probably because the teacher doesn't think the statement is about what I intended it to be about.

This is, in fact, what happened for the statements about the real world link. The graph for the world reality link is as follows:

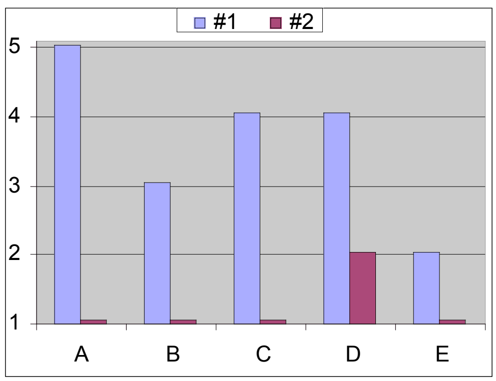


Figure 20: Graph of teacher perception of Real World Expectation Dimension in HW

Clearly, teachers think the two statements are asking something very different. Most teachers strongly disagreed with the second statement while agreeing, in some cases, with the first. It is important to note that there is no correlation for any teacher between bar #1 and #2. Therefore, I know that the two statements

- Homework problems frequently ask the student to consider a real world situation to which a physics principle applies.

and

- Most of the 'real world' homework problems I assign are 'idealized' or 'abstracted' to simplify the complexities of the real world.

are not about the same expectation. As I discussed above, the second statement is intended to be a negative statement about the real world. A negative answer is taken to mean that physics problems *are* about the real world. However, as I noted above, most teachers said that all physics problems are abstracted, and furthermore, that's how it ought to be. Therefore, I discard the second statement and use only the first statement to determine the teachers' beliefs about the real world link in their homework. This category on the survey will not be as robust as if I had two statements, but I can still obtain data with the other statement about the real world link.

For the other three expectation dimensions, excluding importance (which is used to ascertain the overall importance of homework rather than beliefs and attitudes expressed *within* the homework), I average the results. For example, since teacher B agreed with a '4' for both questions on concepts, his average value is a '4' for concepts.

5. Data: Homework

Next I took data on the homework sets of the teachers. I did this by selecting three representative homework sets. Then I evaluated every question of these homework sets for its real world link, its student world link and its concepts. Then I evaluated each of the three homework sets for its overall coherence. I evaluated them according to the homework rubric I developed in collaboration with Professor Finkelstein.[22]

I will demonstrate the method I used for evaluating the homework for one sample class: Teacher B's class. I used the same method for evaluating the homework in every class, so I will skip the method and report the results for the other classes.

[22] See Appendix A3

First, I selected three representative homework sets. For example: #2, #6, and #11. Then, I evaluated every question of these three homework sets for Real World Link, Student World Link and Concepts according to the rubric discussed above:

HW2	WR	SR	CON
#1	3	3	2
#2	3	3	3
#3	3	4	3
#4	3	3	2
#5	2	2	5
#6	2	2	3
#7	1	1	2
#8	1	1	3

HW 6	WR	SR	CON
#1	3	4	3
#2	3	3	5
#3	2	1	3
#4	4	4	3
#5	3	3	3
#6	4	4	4

HW 11	WR	SR	CON
#1	3	3	3
#2	2	2	4
#3	2	2	3
#4	2	2	4
#5	3	3	3
#6	4	3	4
#7	3	3	5

Figure 21: Table of three Expectation Dimensions in each problem of 3 sets of HW

Then I evaluated each set for coherence:

Coherence
HW 2: 3.00
HW 6: 3.00
HW 11: 4.00

Figure 21: Table of Coherence Expectation Dimensions in each 3 sets of HW

The evaluations for each of the other homework questions for the different teachers can be viewed in Appendix D5.

6. Analysis: Homework

After I had these values, I averaged the homework values for the four expectation dimensions. For example, for calculating the average for student reality, I added up all of the values and divided by the total number of homework questions. I did not average in stages; first by questions in the homework set, then between the sets themselves. This is because each homework question is worth the same number of points. Assignment #2 has eight questions and is therefore worth eight points, whereas assignment #6 has six questions and is therefore only worth six points. Since each question has the same weight, it should be averaged with equal weight. Therefore, we are left with the following table of average values:

Homework Summary					
Teacher	A	B	C	D	F
WR	4.73	2.67	2.76	2.9	2.48
SR	4.4	2.67	2.44	2.05	1.52
CON	4.73	3.33	2.92	2.85	2
COH	4.33	3.33	3.67	4	3.67

Figure 22: Table Summarizing 4 expectation dimensions in HW for each teacher

Graphically, we have the same homework summary:

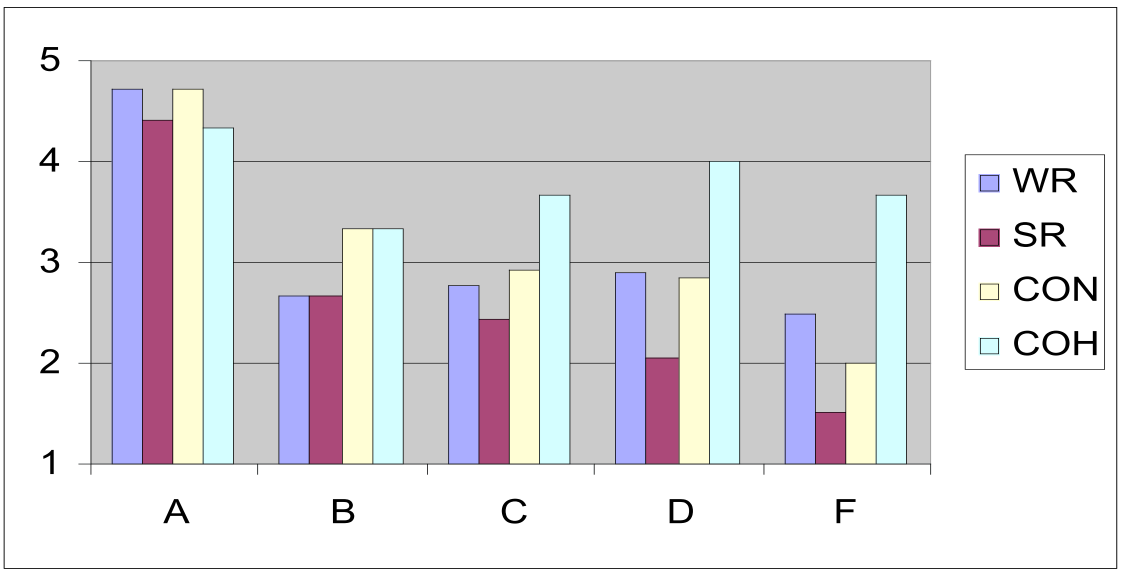


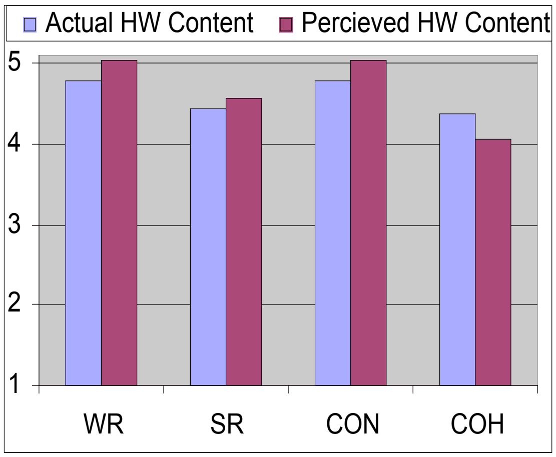
Figure 23: Graph Summarizing 4 expectation dimensions in HW for each teacher

Discussion

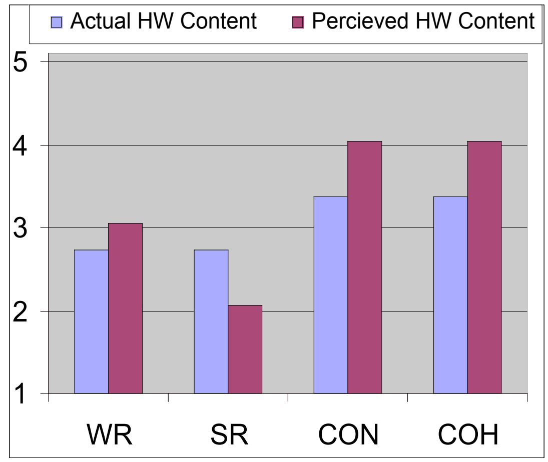
a. Comparative Analysis: Teacher Perceptions and Homework

Now, with these values, I am ready to proceed to an analysis where I compare the teachers' perceptions of the actual homework content with evaluations of the actual homework content along these expectation dimensions and look for evidence of any discontinuities. The first bar in the following graphs represents the actual homework content and the second bar represents the teachers' perception of their homework.

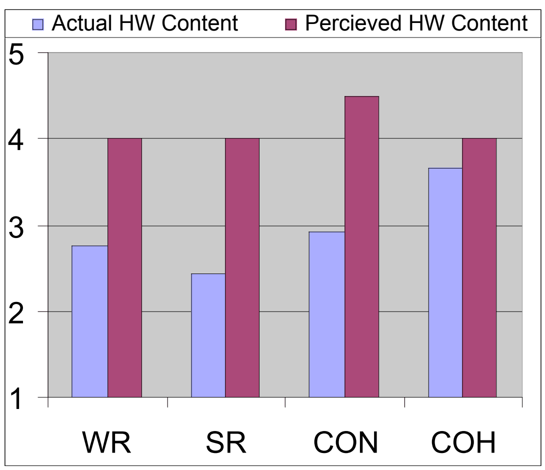
TEACHER A:



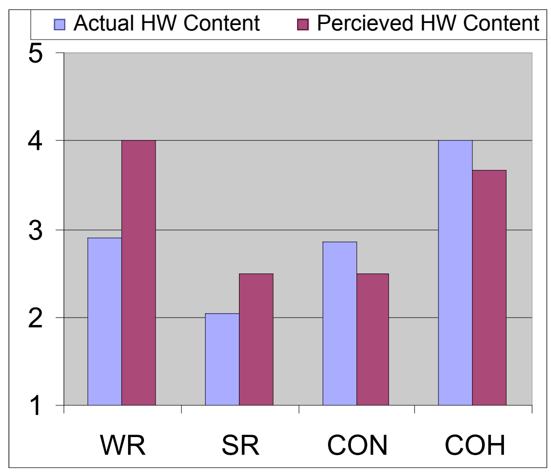
TEACHER B:



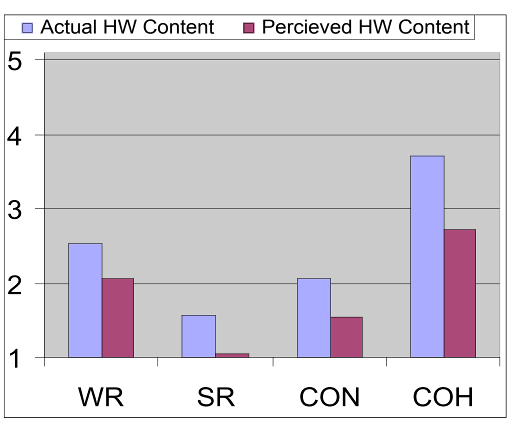
TEACHER C:



TEACHER D:



Teacher E:



The first discrepancy I will look for is between teachers' perception of expectations in homework and actual expectations in homework. Teacher A has the most consistency between his perceptions of his HW and the HW itself. The most the two values disagree is .27, less than a third of a point. The second most consistent teacher is Teacher B whose largest discrepancy is .67, two thirds of a point.

Next, we have Teacher D and Teacher E. Both of these teachers have strong agreement for three out of four categories, but a sizeable discrepancy between their perceptions of their homework and their homework content in one dimension. For Teacher D, it is the World Reality Link and for Teacher E, it is Coherence. Not only are these large discrepancies (roughly 1 whole point), but the two values are split across #3. Remember that 3 is neutral, so above a three is an agreement and below, a disagreement. Therefore Teacher D agreed that his homework is about the real world, but the evaluation of the homework disagrees. Similarly, Teacher E disagreed that his homework was coherent, but the evaluation of the homework agrees with the statement that the homework is coherent.

Teacher C, the least consistent, has a large discrepancy for three out of four expectation dimensions: World Reality, Student Reality and Concepts. This teacher perceived his homework to contain much more of the expectations than it actually did. He overestimated these three categories by 1.24, 1.56, and 1.58, respectively. This discrepancy means that he agreed that his homework was about the real world, about his students' world and required conceptual understanding. However, his homework, when evaluated, does not contain as many real world, student world and conceptual problems as he believed.

b. Comparative Analysis: Teacher Perceptions and Teacher Goals

For the teachers whose perceptions of their homework were consistent with the researchers' analysis, it may be fruitful to also look at their goals for consistencies and discrepancies with their perceptions of their homework. For instance, Teacher E has consistent perceptions with homework content for world reality, student reality and concepts; each of which is low (between 1 and 2.5). There are a few possible explanations for this. First, if he holds these expectations as important goals of the class, then either he does not think homework is the place to teach these ideas, or he does think that homework is the place to teach the ideas. If the latter is the case, then we have discovered a breakdown between his ideal physics homework content and his perception of the homework content. This is clearly the case for Teacher B who has consistent perceptions of homework with homework content, said 30% of student learning occurred while doing homework, and who exclaimed during the interview that he did all of these reforms in his lectures and tutorials, but, "no, I don't do any of this in the homework." His frustration indicated his awareness of the breakdown between his ideals and his perceptions.

Returning to Teacher E, recall that he has consistent but low values for perceptions and content of homework. Teacher E's goals are the following:

GOALS	Teacher E
1	Confidence in the force of reasons
2	skills and career paths
3	create good citizens -informed and inquisitive
4	grasp of concepts
5	a necessary filter

Figure 24: Table of Goals for Teacher E

Therefore, if this teacher is concerned with career skills, creating good citizens and providing a filter, he may not be as concerned with students learning (the expectation) that physics is a conceptual field about their world and the real world. Interestingly, his fourth goal is "a grasp of the concepts". This can mean one of two things: either a breakdown exists between his ideals and his perceptions, or he means something different by 'concept' than do others.

There is another possibility for Teacher E that I will mention here. Teacher E thinks that only 15% of student learning occurs during homework. Therefore, he may not emphasize expectations he wants his students to learn in the homework because he believes that more student learning happens in other places.

Teacher A, as a comparison, has extremely high consistency between his perceptions of his homework and his homework content. To compare these results to his goals, we have:

GOALS	Teacher A
1	World around them understand and explain by physics
2	reasoning ability applying principles
3	quantitative problem solving and understand its value
4	appreciate and value physics
5	understand and apply specific content

Figure 25: Table of Goals for Teacher A

Clearly, Teacher A believes that ideally, students will learn about the world around them (goal #1). Teacher A had very high values for world and student reality links (4.73, 4.4) in the homework and believed that those were very high (5, 4.5). Therefore, we should see that Teacher A believes homework is an important media since he has changed it to contain such a high amount of the real and student world expectations. In fact, this is exactly what we see. Teacher A thinks that 60% of student learning occurs while doing homework. Therefore, he not only has consistency between his perceptions of homework and his homework, he also has consistency between his ideal homework content and his perception of homework content. Therefore, in my model:

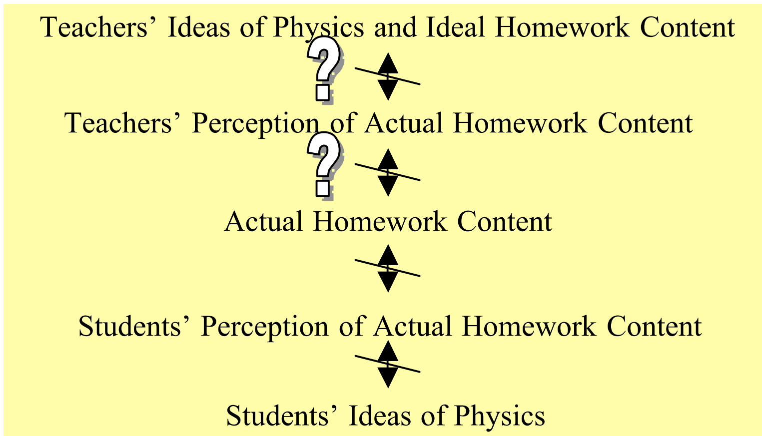


Figure 8: Model of interaction between teachers and students within homework

The breakdown for Teacher A does not happen at the first *or* second question mark. Therefore, if the students are not completing the class with more favorable expectations than they had before the class, then the breakdown will be happening somewhere else. There is a slight breakdown at the second question mark for Teacher B, but the largest breakdown for him is at the first question mark between what he wants to teach in the homework and what he thinks is in the homework. For Teachers D and E, there is a non-trivial breakdown at the second question mark. At the first question mark, Teacher D has some breakdown while Teacher E has very little. Teacher C has a large breakdown at the second question mark between his perceptions of the homework and the actual homework content.

c. Comparative Analysis: Familiarity with Physics Education Research

It is interesting to look at which of Teachers A-E has studied or is familiar with physics education research. Based on the teachers' self-reported familiarity as well as the interviews, I was able to characterize the five teachers according to their familiarity with PER. Teacher A is highly aware of physics education research and is actively engaged in research-based reform. Teacher B is also highly aware of physics education research and is engaged, though not as actively as Teacher A in reform. These teachers can be categorized as "Fully" aware of PER. Teachers C and D both have some knowledge of the field of PER and are moderately engaged in some reform. They can be categorized as, "Moderately" aware of PER. Teacher E has just begun looking at results from PER and is interested in beginning some moderate reforms. He can be categorized as "Lowly" aware of PER.

Significantly, the teaching practices of these teachers can also be characterized along a parallel axis. Teachers A and B are "Reform" teachers, actively engaging in research-based changes to their classes. Teachers C and D are "Transitional" teachers who have made some significant changes to their classes. Teacher E teaches traditionally and has made very few changes to his class. We can categorize him as "Traditional".

Teacher	**Awareness of PER**	**Extent of Reform in Class**
A	Fully Aware of PER	Reform
B	Fully Aware of PER	Reform
C	Moderately Aware of PER	Transitional
D	Moderately Aware of PER	Transitional
E	Lowly Aware of PER	Traditional

Figure 26: Table of Characterizations of Teachers

These preliminary characterizations allow us to notice that the two most consistent teachers, as measured by accurate perception of homework, are fully aware of PER and actively engaged in sizeable reform of their classes. The next most consistent teachers were the traditional and the second transitional teachers. The least consistent teacher was moderately aware of PER and was transitional. This could indicate a variety of causal factors which my study is unable to differentiate between. For instance, transitional teachers may be less consistent because their goals change more rapidly than their practices. Or, they may overestimate the extent to which expectations are present, still implicitly believing that expectations 'come along for the ride' with content. These are very interesting questions and would be worth pursuing.

IV. Future Work

There are a lot of areas for further research. It would be very interesting to correlate these findings with data on student expectations. For instance, do students of Teacher A have higher or lower expectations than those of Teacher C? Than Teacher E? That research would complete the vertical analysis according to my theoretical model (fig. 8). To extend the research horizontally in the same model, it would be interesting to look at teacher perceptions of labs, lectures, exams, etc., then compare those perceptions with independent evaluations of these media. It would also be very interesting to quantify the awareness of PER and teaching styles more quantitatively. I presented just a very basic outline of what it might look like in the previous section.

Another area for interesting future work is to acquire more statistically robust data. Now that I have validated the second survey (with the exception of question #15) the survey could be more widely distributed to teachers without a corresponding interview. This way, a much larger amount of data could be collected and correlated to actual homework content.

V. Conclusion

My honors thesis was to pick a problem in physics education research, research it and acquire and analyze data. I chose to examine teacher goals, teacher beliefs about expectations in their homework as well as the actual expectations in their homework. In this paper I have presented background material in Physics Education Research. I have motivated the problems of concepts and expectations not getting taught to intro-level undergraduates. I then presented my project. I presented the conceptual space and theoretical models with which I was working. I demonstrated the tools I developed to inquire into this topic. I developed a survey, conducted interviews and evaluated homework sets according to the rubric I largely designed. I acquired data and analyzed it. Overall, it was a terrific experience because I was able to pick the problem I wanted to look into and I was able to design the most of the tools I used to inquire into these issues. I obtained many interesting conclusions about characterizing where breakdown occurs between teachers and their students and their homework.

Appendix A1: Survey #1

Questions

1. Please list (in order) your top five goals for this class.
    a.
    b.
    c.
    d.
    e.

2. Out of the following, what percentage of learning occurs:
    a.) During lectures ______
    b.) While doing homework ______
    c.) While reading text book ______
    d.) While preparing for exams ______
    e.) During recitations / labs ______
    f.) Other ______________ ______
3. I write or design ______% of homework problems assigned in my class.

Please answer the following questions according to the scale:
1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree

4. If students do not do well on homework assignments it is generally because they are not putting in as much time and effort as I have recommended.
5. Everything I expect my students to know on an exam is covered at some point on the homework.
6. The overall coherence of physics is often explicit in homework.
7. Homework problems frequently ask the student to consider a real world situation to which a physics principle applies.
8. If a student does poorly on the homework, he or she will most likely do poorly overall in the class.
9. Most homework problems can be solved by carefully looking over the given equations to find the right one.
10. Students are asked to infer general principles from specific examples in the homework problem sets.
11. If a student does poorly on the homework in the first unit, he or she can still do fine in the next unit by working harder exclusively on the new material.
12. Students know what I think it is important for them to learn because of the homework problems I assign.
13. There are multiple approaches or ways to solve the homework problems I assign.

14. If a student is having trouble, I encourage him or her to try harder on the homework.
15. Homework questions often ask the student to consider his or her own experience.

Appendix A2: Survey #2

Questions

1. Please list (in order) your top five goals for this class.
    a.
    b.
    c.
    d.
    e.
2. Out of the following, what percentage of learning occurs:
    a. During lectures ______
    b. While doing homework ______
    c. While reading text book ______
    d. While preparing for exams ______
    e. During recitations / labs ______
    f. Other _____________ ______

Please answer the following questions according to the scale:
1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree

3. I am familiar with physics education research that has been done on courses similar to mine.
4. All of the material (concepts, formulas, etc.) I expect my students to know on an exam is covered at some point on the homework.
5. The majority of problems in a given homework set ask about the same two or three ideas.
6. Homework problems frequently ask the student to consider a real world situation to which a physics principle applies.
7. If a student does poorly on the homework in the first unit, he or she can still do well on the next unit's homework by working exclusively on the new material.
8. If a student does poorly on the homework, he or she will most likely do poorly overall in the class.
9. Homework questions often ask the student to consider his or her own experience.
10. Most homework problems can be solved by carefully looking over the given equations to find the right one.
11. There is usually at least one homework question in each set about how the current material relates to other material from the course.
12. If students want to know what I think it is important for them to learn, they can look at the homework problems I assign.
13. The material I cover in my homework relates to the students' everyday lives.
14. In order to solve my homework problems students must understand the underlying concepts.

15. Most of the ‘real world’ homework problems I assign are ‘idealized’ or ‘abstracted’ to simplify the complexities of the real world.

Please use this space to write any crucial information left out of the survey.

Appendix A3: Homework Evaluation \Rubric

Grading Rubric:

Coherence

1 HW set contains six or more different ideas or concepts
2 HW set contains five different ideas or concepts
3 HW set contains four different ideas or concepts
4 HW set contains three different ideas or concepts
5 HW set contains one or two different ideas or concepts
(Add one to this score if at least one question explicitly relates this material to previous material.)
(Subtract one from this score if no question explicitly relates this material to previous material.)

Concepts

1 HW question can be solved by pattern-matching or manipulating one equation.
2 HW question can be solved by manipulating fewer than three equations.
3 Some knowledge of what symbol(s) in equation represent is helpful in solving question.
4 Knowledge of what symbol(s) in equation represent is required to solve question.
5 HW question explicitly asks students about concepts, must be answered in terms of concepts

World Reality

1 No link to real world, question is purely abstracted
2 Has recognizable features that could be construed as real world
3 Real world features are used, but abstraction is expected
4 Real world features are used, but abstraction is sufficient to answer question
5 Real world features and objects are used; knowledge of real world is required to answer question

Student Reality

1 No link to student's life
2 Has recognizable features that could be construed in terms of student's life
3 Features from student's life are used, but abstraction is expected
4 Features from student's life are used, but abstraction is sufficient
5 Features from student's life are required to answer question

Appendix B1: Survey #1 Data

Statement #	4	5	6	7	8	9	10	11	12	13	14	15
Category	E	I	C	R	I	N	N	C	I	C	E	R
Teacher A	4	5	5	5	5	5	4	3	4	2	3	4
Teacher B	4	4	3	4	4	4	2	3	4	4	4	2
Teacher C	4	3	3	4	4	5	4	4	4	5	4	3
Teacher D	4	2	2	4	3	3	2	3	4	2	3	2

Appendix B2: Reversed Survey #1 Data

Person	E	E	I	I	I	C	C	C	R	R	N	N
Teacher A	4	3	5	5	4	5	3	2	5	4	5	4
Teacher C	4	3	2	3	4	2	3	2	4	2	3	2
Teacher D	4	4	3	4	4	3	4	5	4	3	5	4
Teacher B	4	4	4	4	4	3	3	4	4	2	4	2

Appendix B3: Interview #1 Data: Goals:

Goals	Teacher A	Goals	Teacher C
1	Be able to physics in everyday life	1	Think scientifically
2	"Expert" attitudes about physics	2	Develop new ways of "seeing" the universe
3	Logical problem solving approaches	3	Develop qualitative and quantitative reasoning
4	Understand numbers can be useful	4	Develop skills of explaining your thoughts
5	Gain appreciation of physics	5	Critical thinking
Goals	Teacher B	Goals	Teacher D
1	Content (conservation laws)	1	Importance of Physics
2	Qualitative understanding	2	Learn how basic things work
3	Articulate / Evaluate	3	Problem solving skills
4	Coherence	4	Understand how science develops

5	Enjoy physics	5	

Appendix B4: Interview #1 Data: % of Learning Occurs:

	lectures	homework	text book	exam prep	recitations
Teacher A	15%	75%	5%	5%	N/A
Teacher B	30%	20%	10%	10%	30%
Teacher C	20%	30%	10%	20%	20%
Teacher D	30%	30%	20%	10%	10%

Appendix C1: Survey #2 Data:

Category:	PER	Imp	Coh	RW	Coh	Imp	SW	Con	Coh	Imp	SW	Con	RW
Question #	3	4	5	6	7	8	9	10	11	12	13	14	15
Teacher A	5	5	5	5	2	5	4	1	3	5	5	5	5
Teacher B	5	4	4	3	2	5	2	2	4	3	2	4	5
Teacher C	4	4	4	4	2	3	4	2	4	4	4	5	5
Teacher D	4	2	4	4	2	3	2	4	3	4	3	3	4
Teacher F	4	5	4	2	4	5	1	5	2	5	1	2	5

Appendix C2: Reversed Survey #2 Data

(Negative Agreement has been Reversed)

Category:	PER	Imp	Coh	RW	Coh	Imp	SW	Con	Coh	Imp	SW	Con	RW
Question #	3	4	5	6	7	8	9	10	11	12	13	14	15
Teacher A	5	5	5	5	4	5	4	5	3	5	5	5	1
Teacher B	5	4	4	3	4	5	2	4	4	3	2	4	1
Teacher C	4	4	4	4	4	3	4	4	4	4	4	5	1
Teacher D	4	2	4	4	4	3	2	2	3	4	3	3	2
Teacher F	4	5	4	2	2	5	1	1	2	5	1	2	1

Appendix C3: Interview Data: Goals

GOALS	Teacher A
1	World around them understand and explain by physics
2	reasoning ability applying principles
3	quantitative problem solving and understand its value
4	appreciate and value physics
5	understand and apply specific content
GOALS	**Teacher B**
1	Content Knowledge -conceptual, factual, formal
2	Problem solving skills
3	Improved ability to "talk physics" -includes scientific argument
4	Reality Link -physics is about the world
5	Self checking: improved ability to know what they know, sense making
GOALS	**Teacher C**
1	Learning Environment
2	Physical reasoning
3	Explain to peers
4	Quantitative Reasoning
5	Physics
GOALS	**Teacher D**
1	Appreciate importance of physics in society
2	how using abstract concepts describes real events
3	appreciation on scientific method
4	ability to understand basic E&M (e.g. how a microwave works)
5	
GOALS	**Teacher F**
1	Confidence in the force of reasons
2	skills and career paths
3	create good citizens -informed and inquisitive
4	grasp of concepts
5	a necessary filter

Appendix C4: Interview Data: Importance of Media

	% OF LEARNING OCCURS lectures	Homework	text book	exam prep	labs & recitations	other
Teacher A	25%	60%	2%	8%	5%	0%
Teacher B	25%	30%	12.5%	12.5%	20%	0%
Teacher C	30%	30%	10%	10%	20%	0%
Teacher D	20%	20%	20%	20%	3%	17%
Teacher E	25%	15%	10%	30%	20%	0%

Appendix D5: Homework Data

Teacher A	WR	SR	CON	COH
HW set 2	5	5	5	
	5	5	5	
	5	5	5	
	5	5	5	
	5	5	5	4
HW set 7	5	3	5	
	4	4	5	
	4	4	4	
	4	4	4	4
HW set 12	5	4	5	
	5	5	5	
	5	4	5	
	4	3	3	
	5	5	5	
	5	5	5	5
Averages:	4.73	4.4	4.73	4.33

Teacher B	WR	SR	CON	COH
HW set 2	3	3	2	
	3	3	3	
	3	4	3	
	3	3	2	
	2	2	5	
	2	2	3	
	1	1	2	
	1	1	3	3
HW set 6	3	4	3	
	3	3	5	
	2	1	3	
	4	4	3	
	3	3	3	
	4	4	4	3
HW set 11	3	3	3	
	2	2	4	
	2	2	3	
	2	2	4	
	3	3	3	
	4	3	4	

	3	3	5	4
Averages:	2.67	2.67	3.33	3.33

Teacher C	WR	SR	CON	COH
HW set 2	2	3	4	
	2	2	3	
	2	2	3	
	2	2	3	
	2	2	3	
	2	2	4	
	2	2	2	
	2	2	3	
	3	3	4	4
HW set 6	4	3	2	
	3	3	2	
	3	2	2	
	3	2	3	
	3	2	2	
	3	2	2	4
HW set 11	4	2	1	
	3	3	3	
	3	3	4	
	3	3	4	
	3	2	3	
	2	2	2	
	2	2	3	
	3	2	3	
	4	4	4	
	4	4	4	3
Averages:	2.76	2.44	2.92	3.67

Teacher D	WR	SR	CON	COH
HW set 2	3	2	3	
	2	2	3	
	2	1	1	
	2	1	3	
	3	1	5	
	3	1	5	
	3	2	4	4
HW set 6	2	2	1	
	3	1	2	
	3	2	3	
	3	2	2	
	2	2	4	4
HW set 11	3	1	1	
	3	3	2	
	4	3	4	
	4	3	4	
	3	4	3	
	3	2	1	
	3	3	3	
	4	3	3	4
Averages:	2.9	2.05	2.85	4

Teacher E	WR	SR	CON	COH
HW set 2	3	1	1	
	1	1	1	
	2	1	2	
	2	2	2	
	2	1	1	
	2	1	3	
	2	1	2	
	2	1	2	
	3	2	2	3.00
HW set 7	3	2	1	
	2	1	2	
	4	2	3	
	3	1	2	
	2	1	2	
	3	1	2	
	2	1	2	
	2	1	3	
	2	1	2	4.00
	3	3	3	
	3	2	2	
	4	3	2	
	3	2	2	
	2	2	1	
	2	1	2	
	3	2	2	
	2	1	2	
	3	3	3	4.00
Averages:	2.48	1.52	2	3.67

Student Expectations in University Physics:
The Maryland Physics Expectations Survey

Here are 34 statements which may or may not describe your beliefs about this course. You are asked to rat each statement by circling a number between 1 and 5 where the numbers mean the following:

1: Strongly Disagree	2: Disagree	3: Neutral	4: Agree	5: Strongly Agree

Answer the questions by circling the number that best expresses your feeling. Work quickly. Don't over-elaborate the meaning of each statement. They are meant to be taken as straightforward and simple. If you don't understand a statement, leave it blank. If you understand, but have no strong opinion, circle 3. If an item combines two statements and you disagree with either one, choose 1 or 2.

1	All I need to do to understand most of the basic ideas in this course is just read the text, work most of the problems, and/or pay close attention in class.	1 2 3 4 5
2	All I learn from a derivation or proof of a formula is that the formula obtained is valid and that it is OK to use it in problems.	1 2 3 4 5
3	I go over my class notes carefully to prepare for tests in this course.	1 2 3 4 5
4	"Problem solving" in physics basically means matching problems with facts or equations and then substituting values to get a number.	1 2 3 4 5
5	Learning physics made me change some of my ideas about how the physical world works.	1 2 3 4 5
6	I spend a lot of time figuring out and understanding at least some of the derivations or proofs given either in class or in the text.	1 2 3 4 5
7	I read the text in detail and work through many of the examples given there.	1 2 3 4 5
8	In this course, I do not expect to understand equations in an intuitive sense; they must just be taken as givens.	1 2 3 4 5
9	The best way for me to learn physics is by solving many problems rather than by carefully analyzing a few in detail.	1 2 3 4 5
10	Physical laws have little relation to what I experience in the real world.	1 2 3 4 5
11	A good understanding of physics is necessary for me to achieve my career goals. A good grade in this course is not enough.	1 2 3 4 5
12	Knowledge in physics consists of many pieces of information each of which applies primarily to a specific situation.	1 2 3 4 5
13	My grade in this course is primarily determined by how familiar I am with the material. Insight or creativity has little to do with it.	1 2 3 4 5
14	Learning physics is a matter of acquiring knowledge that is specifically located in the laws, principles, and equations given in class and/or in the textbook.	1 2 3 4 5
15	In doing a physics problem, if my calculation gives a result that differs significantly from what I expect, I'd have to trust the calculation.	1 2 3 4 5

16	The derivations or proofs of equations in class or in the text has little to do with solving problems or with the skills I need to succeed in this course.	1 2 3 4 5
17	Only very few specially qualified people are capable of really understanding physics.	1 2 3 4 5
18	To understand physics, I sometimes think about my personal experiences and relate them to the topic being analyzed.	1 2 3 4 5
19	The most crucial thing in solving a physics problem is finding the right equation to use.	1 2 3 4 5
20	If I don't remember a particular equation needed for a problem in an exam there's nothing much I can do (legally!) to come up with it.	1 2 3 4 5
21	If I came up with two different approaches to a problem and they gave different answers, I would not worry about it; I would just choose the answer that seemed most reasonable. (Assume the answer is not in the back of the book.)	1 2 3 4 5
22	Physics is related to the real world and it sometimes helps to think about the connection, but it is rarely essential for what I have to do in this course.	1 2 3 4 5
23	The main skill I get out of this course is learning how to solve physics problems.	1 2 3 4 5
24	The results of an exam don't give me any useful guidance to improve my understanding of the course material. All the learning associated with an exam is in the studying I do before it takes place.	1 2 3 4 5
25	Learning physics helps me understand situations in my everyday life.	1 2 3 4 5
26	When I solve most exam or homework problems, I explicitly think about the concepts that underlie the problem.	1 2 3 4 5
27	"Understanding" physics basically means being able to recall something you've read or been shown.	1 2 3 4 5
28	Spending a lot of time (half an hour or more) working on a problem is a waste of time. If I don't make progress quickly, I'd be better off asking someone who knows more than I do.	1 2 3 4 5
29	A significant problem in this course is being able to memorize all the information I need to know.	1 2 3 4 5
30	The main skill I get out of this course is to learn how to reason logically about the physical world.	1 2 3 4 5
31	I use the mistakes I make on homework and on exam problems as clues to what I need to do to understand the material better.	1 2 3 4 5
32	To be able to use an equation in a problem (particularly in a problem that I haven't seen before), I need to know more than what each term in the equation represents.	1 2 3 4 5
33	It is possible to pass this course (get a "C" or better) without understanding physics very well.	1 2 3 4 5
34	Learning physics requires that I substantially rethink, restructure, and reorganize the information that I am given in class and/or in the text.	1 2 3 4 5

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