The Role of Contextual Framing: Assessments, Classroom Practice, and Student Perceptions

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Abstract. Contextual framing in physics problems has been shown to generally affect student performance on assessments. This study seeks to identify some of the main influences to this effect, and to characterize how contextual framing may vary within a classroom. Students in summer introductory physics courses (algebra based and calculus based) are administered surveys that assess performance on problems that are contextually rich (more "real world") vs. contextually bland (more abstract, "laboratory" descriptions). Initially females perform worse than do males on the contextually rich versions of the assessments when performance was equal on the contextually bland versions of the test. However further assessment reveals no clear trend in this area. Students were polled on Attitudes and beliefs regarding the use of different kinds of context in the classroom, and the researcher's observations of instructor practice correlated well with students' opinions. Other roles of problem contextualization are identified, including the triggering of intuition and reasoning, albeit sometimes incorrect.

INTRODUCTION

It's safe to say that most teachers have an intuition about the importance of contextual framing in the classroom. Why else would teachers strive to provide real world examples for their students? There's something about a richly contextualized example that seems to help student interest and comprehension more than if it were delivered without real world details. If the contextual framing of a problem may help bolster student understanding, then the presence of context may actually affect student performance on assessments as well. This necessitates investigation into the use of contextualized physics problems on assessments and deepens curiosity about the exact effect of contextual framing in the classroom.

Discussion about "context" as it pertains to physics education research takes on many meanings. For efficiency and clarity, a disambiguation of the definition is in order.

When used in this paper, the word is meant to be the specific contextual framing of a particular problem or worked example. Context refers to the variation in the structure of the problem (multiple choice, free answer), the situation it depicts (a block rolling on an inclined plane, a rocket ship flying overhead, or no explanation), and the mode of presentation (via pencil and paper, computer screen, etc.).

Here, the phrase "context in the classroom" will not refer to the structural context of a class such as a "lecture environment", "recitation/lab section," rather to the explicit use of scenarios and stories established by the instructor. For example, during the course of an example problem, an instructor may explain that this problem or physical principle was first encountered during the Second World War by scientists working for the Allies. The explicit details and the example problem itself are an example of contextual framing in the classroom.

With respect to this framing, prior work has demonstrated that context can affect student performance on assessments. This paper attempts to validate some claims of existing literature and to elucidate our understanding of how context relates to student performance on assessments.

RELEVANT LITERATURE

Several studies have shown that student performance on physics assessment tools can vary significantly depending on the format of presentation. A student may perform better or worse on a particular problem compared to how they perform on the "same" problem if it is framed in a different context. Much of the research has been focused on widely used assessment tools such as the Force Concept Inventory (FCI) [1]. The results have been complicated, but all point to the dependence of student performance on problem various forms of problem context. Below is a summary of relevant studies and results.

Dancy and Beichner [2] altered the contextual framing of the FCI by administering it via computer with animations instead of using the existing pencil and paper format. Some of the animations provided information crucial to solving a particular problem, and some offered superfluous information. Out of 400 high school and college physics students participating, 135 took the animated version and 265 took the original version. Six of 30 total problems showed a significant difference between the two versions in the percent of students answering correctly. All six of these problems provided pertinent information through the animations in the animated versions. The animated version led to better performance in 3 of the 6 instances, and worse in the other three. The animated version showed higher correlation between student performance and ACT math scores, whereas the original version showed higher correlation between performance and ACT English scores.

McCullough [3] also developed an alternate version of the FCI, focusing on the perceived male gender bias in the contextual framing of the original problems. She maintained the original structure and format of each problem, but changed the setting of each problem to be as stereotypically female as possible. This included changing "questions about rockets, cannonballs, hockey and male figures" to those about "shopping, cooking, jewelry and stuffed animals." These two versions of the test were administered to 312 college students taking English, sociology or math courses. On the whole, males taking the revised version of the test performed worse than those taking the original version, but females saw no significant difference. A problem-by-problem analysis revealed no clear trend between performance differences between both versions of the test for either sex. In some problems, males performed better on the revised version (compared to males on the original) while females performed worse (than females on the original). On other problems, males performed worse on the revised version while females performed better. Some problems also saw no difference in performance between the two versions of the test.

Kohl and Finkelstein [4] studied the effects of problem representation on students' ability to correctly answer a problem. Students in undergraduate physics courses were presented with a physics problem each week at the end of recitation. Problems were given in one of four representational formats (verbal, mathematical, pictorial and graphical). Some students were forced to take a particular format (varied each week) whereas others were allowed to pick a format for that particular week before seeing the problem. Of those that were given no choice in selection, some students performed consistently across different representational formats whereas some students performed significantly better in a particular representational format. This further suggests the complex relationship between student performance and question contextual framing.

Contextual framing of the problem statement itself may have other roles in physics problems as well. Finkelstein and Podolefsky [6] describe the different meanings a certain sign (a sine wave for example) may take on depending on its context (a wave on a string, waves in the ocean, a graph of electric field strength along an axis). They proposed an Analogical Scaffolding model for how students come to gradually apply more meaning to a sign by placing it in different contexts.

In his book Teaching Physics with the Physics Suite [5], Redish establishes his "context principle," which states that the contextual framing of a particular problem may strongly affect a student's answer performance of that problem. An abstract problem, involving "Idealized laboratory-style objects" was given to students as part of an exam, and 90% of the students answered correctly. When given a similar problem presented in a "nonphysics context" using "familiar everyday objects" only 55% of those same students answered the question correctly.

QUESTIONS

Existing literature has established that context can affect student performance, but is wanting in showing what specific features impact students. This paper seeks to answer:

1. How does specific, limited variation of the contextual framing in physics problem statements affect student performance? Can a question that is framed in a real world setting positively or negatively impact performance?
2. What are students' attitudes and beliefs regarding the use of contextual framing in the physics classroom, and how are these attitudes associated with actual instructor practices?

3. Are the different sexes affected differently by changes in context, and can this be traced to any gender biasing in the questions?
4. Can some contexts trigger correct intuition and student reasoning more than others?

To address these questions, we conducted a two part study during the first and second term summer introductory physics courses at the University of Colorado. Questions 1, 3 and 4 are addressed by administering physics problems (see Appendix A) to students in these summer classes. To answer question 2, the researcher observed lectures of two different classes, both in the first summer semester, and classified instructor use of context. Student-opinion questions were added to the surveys given to the classes, in order to probe student attitudes and beliefs about the use of context in the classroom.

The study was performed in two phases. In the first phase of the study, questions 1, 2 and 3 were addressed with a survey given to students in the first summer semester. In the second phase of the study, question 4 was addressed and questions 2 and 3 were revisited, all with a survey given to students in the second summer semester.

PHASE 1

Method

In order to observe and classify the instructor's use of context in the classroom, a rubric categorizing instructor practice had to be developed. The initial field notes and observations of lectures from the two introductory physics courses were used as a guide, to suggest the forms of contextualization that were common in a classroom setting. The rubric groups classroom use of context into Contextual Incidents (CI's) which are distinct occurrences of contextual framing, having characteristics that uniquely identify them. If an instructor is lecturing on Newton's third law, then he may choose to talk about the force between the earth and the moon. This example would classify as a CI. If he continued lecturing about Newton's third law, but now explained how the law was developed historically, this too would be a CI, distinct from the first. Each CI has a unique set of attributes that distinguish it from other CI's. It may have different forms (historical, exemplary, etc.) appear at different times, and have a different duration or number of occurrences. Six unique dimensions were identified from preliminary classroom observation and are explained below.

Framing: A CI may be presented as a brief aside, as an introduction to a certain topic, as part of an example problem, as part of a derivation, as part of a demo, as any combination of these, or other.

Relation: Does the CI relate to students' everyday lives, students' interests, the historical development of a physics concept, a famous or well known historical situation, current scientific theory, or any combination of these? How so?

Relevance to material: Does the CI relate to previously covered material, material currently being covered or material not yet covered, or is it seemingly unrelated to any physics material? What material specifically?

Relation to other CI's: A CI may be linked to another CI from the same or a different lecture, or it may be nested within another contextual incident.

Frequency and duration: Does this particular CI occur more than once? What is the duration of each occurrence?

Student Behavior: How many questions are asked during the CI? Are they specifically related to the context, or to something else?

From these criteria, CI's were identified and classified for five lectures each for the algebra based and calculus based courses. The rubric used in these courses can be found in Appendix B
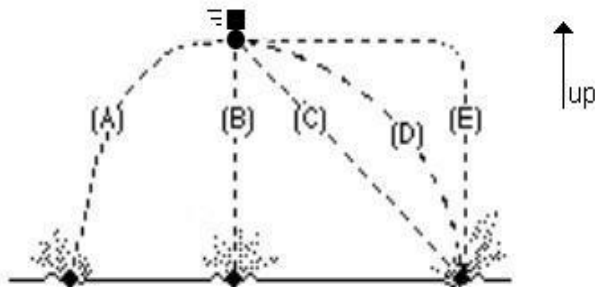
An assessment tool was also developed to evaluate student comprehension, and attitudes and beliefs. The assessment has two parts, the first containing problems that address student understanding of physics concepts. The problems were designed so that all material addressed had been previously covered in the given course. Each problem in this part has two versions, one which is very contextually bland, containing as little detail and framing as possible, the other contextually rich, placing the physics concept in a heavily detailed situation with superfluous information. One such question is shown in Figure 1.

Three problems were created, each having two versions. Half the students were given all three contextually bland versions of the problems, and the other half was given all three contextually rich versions of the problems. The problems in the first part of the assessment were all adapted from questions on the Force Concept Inventory (FCI) and the Force and

Motion Conceptual Evaluation (FMCE) [7]. The first problem had three questions, and the second and third problem had one question each for a total of five questions for this part of the assessment.

The second part of the assessment was the same for everyone. It contained 9 questions concerning the student's opinions of the instructor's use of context, and their own learning preferences as they relate to problem contextualization. These questions were adapted from questions on the Colorado Learning Attitudes about Science Survey (CLASS) [8], where students give their level of agreement with a particular statement using the Likert answer format (from strongly agree to strongly disagree),. *Strongly agree* is the "favorable" answer for all of the questions. Appendix A contains the full list of questions used for both parts of the survey.

A square moving to the right at constant speed gently drops a circle at the instant shown. Which path would the circle most closely follow after leaving the square (ignoring air resistance)? Note: The following figure is a *SIDE VIEW*.

In 2006 and 2009 North Korea conducted long range missile tests, firing rockets across the Pacific Ocean towards the United States. In both tests, the rocket appeared to malfunction and fall into the ocean. Suppose one of these rockets falls apart in the air while traveling horizontally, leaving the precious payload to fall into the ocean. As observed by a person standing on the ground and viewing the rocket as in the figure below, which path would the payload most closely follow after leaving the rocket? (ignore air resistance)
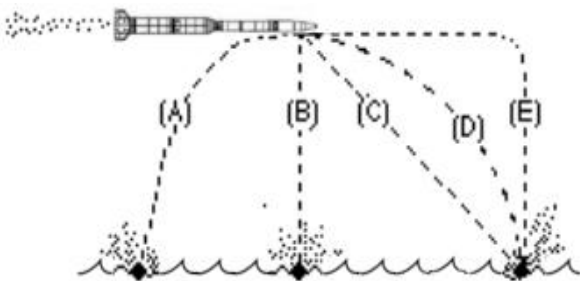
The survey was administered during the last week of class to an algebra based introductory mechanics course and a calculus based intro mechanics course. The courses occurred during the summer of 2009, each having a total duration of five weeks. The survey was given during the individual recitation sections for the algebra based course, and during lecture for the calculus based course. Participation was voluntary and did not affect a student's grade, but students were told it would be a review of some of the material from the course. In the algebra based course, of 42 students enrolled, 32 completed the survey. In the calculus based course, of 61 students enrolled, 38 completed the survey.
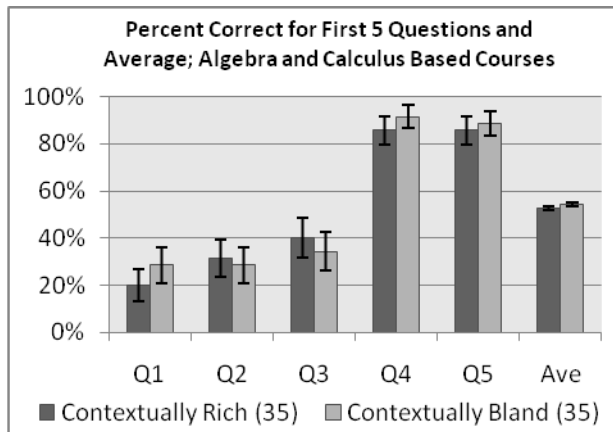
Comparing the GPA (when available) of those students who took the survey compared to those who did not take the survey shows no difference for either the algebra based class or the calculus based class. Also, comparing the GPA of students who took the contextually rich version of the test to that of the students who took the contextually bland version of the test shows no difference as well. These data suggest that the random selection process indeed generated populations that accurately represent the class as a whole. See Appendix C for more detail.

Results

Preliminary Observations

To compare differences in student responses between those who were given the contextually bland version of the survey and those who were given the contextually rich version of the survey, we compared the percent of students answering correctly for each question and the average score for each population. Scoring was determined using equal weighting for each of the five questions; each question was either correct of incorrect. Figure 2 depicts the results for each question and the average score across all five questions.

On a question by question basis, there is no statistical difference in the responses from those taking the contextually bland version compared to those taking the contextually rich version. A similar trend exists among the average scores, though the calculus based population and the population as a whole actually do exhibit a statistically significant difference, the difference itself is quite small. Error bars reflect the standard deviation of the mean assuming a binomial distribution.

Percent Correct for First 5 Questions and Average; Algebra and Calculus Based Courses

■ Contextually Rich (35)　■ Contextually Bland (35)

a few questions in the second half of the survey (where students rate level of agreement with a statement) that exhibited strong difference between males and females (See Table 1). Of females, only 33% answered in either the *agree* or *strongly agree* categories for question 9, which says "I enjoy when the instructor shows how physics was used in the past (using historical examples)." This compared to 54% of males for that same question, making a 21% gap between sexes. Question 10 reads similarly to question 9, "I learn better when the instructor shows how physics was used in the past" and showed a similar trend with 38% of males showing agreement compared to 21% of females, a 16% gap.

At first this result would seem to speak against Redish's claims that the context of a problem can significantly affect student performance. These data provide at least one instance where contextual framing of a problem (association with real world events in particular) does *not* impact performance. Apart from its differences from Redish, however, this result makes sense. The change in context was superficial, leaving the structure and physics behind each question identical. Notably, however this is not the end of the story. We will demonstrate that there is significant variation by sex that does not appear in the aggregate scores.

Differences By Sex

For females, the average performance across all questions was worse on the contextually rich version compared to the contextually bland version, in both the algebra based and calculus based courses. Males on the other hand performed better on the contextually rich version for the algebra based course, and about the same for the calculus based course.

These data might support McCullough's claim that the context used in the problems of an assessment tool may treat a particular sex preferentially, or it might indicate a difference between males and females in their ability to address richly contextualized problems. As will be seen in Phase 2, there is not such a clear-cut answer to this issue.

Seeing this result prompted the inquiry of what other differences existed between the sexes. There were

Percent Correct Between Contextually Bland and Contextually Rich Versions

■ Fem, Alg (18)　■ Fem, Calc (15)　■ Male, Alg (14)　■ Male, Calc (23)

This may suggest that some form of bias exists in the types of historical examples elicited by the instructors (who are both male), or that this reflects a difference between males and females. Both males and females answer similarly on question 11, "In this class, the instructor was good at showing how physics was used in the past," with females showing 52% agreement and males showing 59%, leaving only a 7% gap between male and female responses. This means that males and females agree on the instructor's proficiency when it comes to historical examples, but they disagree on the level of enjoyment and effectiveness in supporting learning that historical examples have. This result suggests that the difference in opinion shown in questions 9 and 10 is independent of instructor bias, meaning each sex thinks differently about the utility of using historical perspective in the classroom. This last possibility is corroborated by the results of Phase 2.

The third major source of disagreement between sexes is question 13, which says "I enjoy thinking about the physics of the world around me." Only 30% of females answered in agreement compared to 62% of males. Again, not as much of a gap exists on the associated question 14 "In this class, the instructor was good at helping me think about the physics of the world around me," (see table 1) which implies that the difference in enjoyment cannot be due entirely to instructor bias. These differences are present both in aggregate and for each of the two courses separately (See Appendix D).

Classroom Practices

The results of classification of the instructors' use of context in lecture revealed a noticeable difference between the instructor of the algebra based course and the instructor of the calculus based course. Overall, the researcher logged 16.75 Contextual Incidences per lecture on average for the calculus based course, each with an average duration of 2 minutes and 15 seconds. Compare this with only 10.25 CI's per lecture on average for the algebra based course, with an average duration of only 1 minute and 43 seconds. In total, 2 hours and 31 minutes of time in the calculus based course was occupied by CI's which is about half of the 5 total lecture hours for those four days. The algebra based course's lectures had only 1 hour and 3 minutes of time occupied by CI's which was about one sixth of the total lecture time of 6 hours and 20 minutes. Also, addition, there were 41 times where a CI either linked to or nested within another CI for the calculus based course, but only 9 times did this occur for the algebra based course. Overall, this means the students of the calculus based course were exposed to more contextual incidences which were longer and more interconnected compared to the students in the algebra based course.

So how much did students pick up on this behavior? Questions 9 and 11 are related, and both show a more favorable rating for those students in the calculus based class. Question 9, reading "I enjoy when the instructor shows how physics was used in the past (using historical examples)," received a 56% level of agreement among the calculus based class compared to only 32% agreement from the algebra based course. Similarly question 11, which states "In this class, the instructor was good at showing how physics was used in the past," received 72% agreement from the calculus based course and only 39% agreement from the algebra base course. The algebra based course had only 6 CI's with a historical element to them while the calculus based course had 17. This means that the instructor for the calculus based course not only included more CI's with a historical element, but did so more effectively (Q11) than the instructor of the algebra based course. This difference translates into a higher level of enjoyment for the students (Q9).

Question 7 shows a difference between the two courses that is not, however, clearly attributable to the researcher's observations. The question states "I learn better when the instructor relates physics to my everyday life," and 58% percent of students in the calculus based course were in agreement whereas 84% of students in the algebra based course were in agreement. This is despite the fact that students in the calculus based course had more exposure to CI's that relate to their everyday lives (39 compared to 27 for the algebra based course). It could be that higher exposure to the physics of everyday life negatively impacts the students' opinions about its helpfulness in their learning (not unlikely considering the results of the CLASS survey, which shows that instructor influence actually negatively impacts student attitudes and beliefs about science), or that the instructor in the calculus based course gave everyday life examples which did not help with the subject matter being addressed at that time. This may also be a reflection of the difference in populations that are taking the calculus based course (mostly science and engineering majors) and the algebra based course (largely pre-med and non-science majors), or those students who already understand the

material fairly well see little need for everyday life comparison. As will be noted, the results of the second phase suggest that this difference is instructor dependent.

PHASE 2

The Second phase of the study focused on readdressing differences in attitudes and beliefs between the sexes and between the two different types of courses, algebra based and calculus based. It also focused more specifically on how the perceived gender bias in a question may influence the different sexes, and how a problem's problem statement or diagram may influence student decision. In this semester, both physics courses covered introductory electricity and magnetism material, compared to the classical mechanics courses from phase 1.

Method

A survey similar to that from Phase 1 was administered to the students from these courses. Three problems were constructed, each with two versions, and each addressing a specific research question.

The first problem was based on a question from the Brief Electricity and Magnetism Assessment (BEMA) [9], and was contextually framed using what the author perceived as an overt gender bias, with one version focusing on stereotypical female and one version stereotypically male. The female version had a teddy bear and a kitten sitting in a living room which retained a charge after being petted. The male version had a pair of car seats in a mechanic's shop which retained a charge after someone entered and exited the seats. Both questions asked about the magnitude of the force between the two charged objects. If men perform better on the version with male bias, or if women perform better on the version with female bias, then this would indicate that gender bias in physics problems can significantly affect student performance.

The second problem attempted to capitalize on student intuition in one version but not the other. The question involved either current flowing into a circuit via two different resistors or people entering a major venue via two different entrances. The structure and key content was the same, but one involved a more intuitive situation than the other. If students perform better on the more intuitive problem, then this would

reveal a feasible starting point to draw upon (via Analogy [6]) when teaching students new material.

The two versions of the third problem were chosen to discern incorrect reasoning in students. Given a charge distribution, students were asked to choose the point of highest electric potential. One version contains more charges near the correct answer, and the other version contains more charges near an incorrect answer. If students think that the potential is highest where the number of charged particles is highest, then they will be prone to answer one version correctly and the other version incorrectly, indicating the flaw in logic: "more charge means higher potential." Both versions of the survey can be found in appendix E.

Along with these three content problems, students were asked to give their level of agreement with the same 9 Likert questions given in Phase 1.. The survey was given in the middle of the semester (week 3) for both the algebra based and calculus based course, but all material covered in the survey had already been covered in the class. Both classes occurred during the summer of 2009, having a total duration of five weeks. The survey was given during the individual recitation sections. Three calculus based recitations (N=65) and one algebra based recitation (N=15) participated. The students taking each version of the survey were chosen at random. Participation was voluntary and did not affect students' grades, but students were told it would be a review of electrostatics. In the algebra based course, 15 of 49 enrolled students took the survey. In the calculus based course, 65 of 80 students took the survey.

No observations of classroom practices were conducted.

Results

Biased Questions

The results of the first problem are not very clear. For the version of the problem with a female bias, 81% of males answered correctly, compared to 67% of females answering correctly. This may sound significant, but this study only included from 9 females and 26 males; this surprising result turns out to be statistically insignificant. For the version of the problem with a male bias, 85% of males answered correctly and 86% of females answered correctly. This result is surprising. At best, it shows that males and females

perform similarly on questions for problems with an overt male framing. The results of the first survey, however, pointed to the opposite conclusion, that females perform worse on highly contextualized problems. Since this comparison is being done across two different courses (phase 1 in mechanics and phase 2 in e/m), the differences in the particular populations of each class may be the cause of this discrepancy, although the two courses attract similar populations. The more likely difference is in the questions themselves. The physics material of the question in Phase 2 differs drastically from the material from the three questions in Phase 1. Also, the situation itself, the specific contextual framing, varies from question to question, which might be another source of differences.
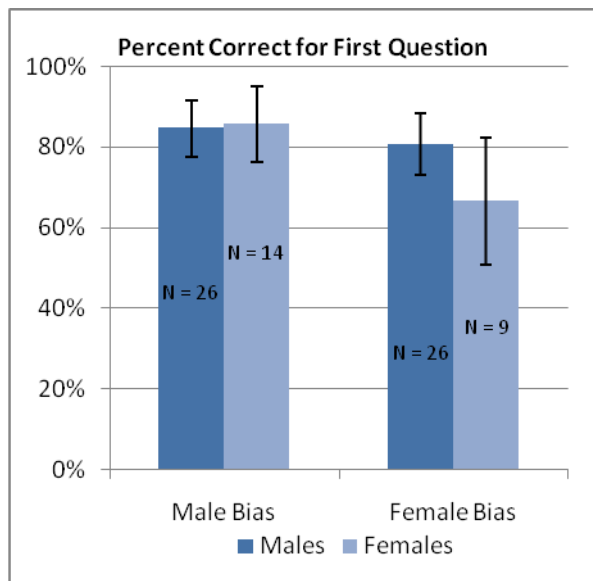
Whatever combination of factors is causing this difference in results, it overpowers any difference in responses that may be due to the overt gender biasing. The conclusion here is similar to McCullough's conclusions, that gender bias in physics problems may have a significant effect on the performance of either gender, but no clear trend emerges showing how.

The second problem, drawing on student prior experience with crowds, also showed a significant difference in the percent of students answering correctly for the two versions. Of those who were given the version concerning a current flowing through one of two resistors into a circuit, 54% answered correctly. Of those who were given the version concerning people entering a venue via two entrances, 88% answered

correctly. This outcome shows how a particular context may elicit intuitive reasoning better than another..

For the Third problem, which was designed to identify flaws in student reasoning, there was a significant difference between both versions. Of those students that took the version of the problem which had more charges near the point of highest potential, 83% answered correctly. For the version where more charges were placed away from the point of highest potential, only 45% answered correctly, with 37% choosing the answer closet to the greatest number of charges. This result indicates that many students chose an answer based on the location of the greatest number of charges, rather than the location of the highest potential. Even some students answering correctly probably did so for the wrong reasons. This result highlights the importance of explicitly assessing student reasoning, rather than assuming students come to the correct answer by correct reasoning.

Difference Of Opinion

Since the questions from student opinions portion of the survey were identical (although numbered differently) to the ones from Phase 1, some general trends seen initially can be corroborated. Questions 8 and 9 (formerly 9 and 10), which deal with students' enjoyment and learning effectiveness of historical examples, demonstrated the same gender gap as was seen in Phase 1 of the study. Question 8, "I enjoy when the instructor shows how physics was used in the past (using historical examples)," received 70% agreement from males but only 25% agreement from females. Question 9, "I learn better when the instructor shows how physics was used in the past," received 41% agreement from males but only 21% agreement from females. The persistence of this gap only strengthens the claim that females' learning and enjoyment is negatively correlated to the amount of historical perspective brought into a classroom, or at least as was manifest in these specific courses.

The gap between genders is still quite prevalent on question 12(formerly 13), which states "I enjoy thinking about the physics of the world around me." Males answered in agreement 74% of the time, whereas females only 50% of the time.

Comparing the calculus based course to the algebra based course shows that the difference seen on question 6 (formerly 7) is not as striking as it was in the first

phase. 80% for the calculus based course compared to 75% for the algebra based course means that both classes similarly feel they learn better when the instructor relates physics to their everyday life. Since the same trend is not seen here as was present in the first phase, this suggests that the difference does not exist between the populations themselves, but instead is somewhat instructor dependent. In other words, the way in which an instructor relates physics to students' everyday lives helps shape their opinion of its effectiveness towards learning.

In addition, the results for questions 8 ("I enjoy when the instructor shows how physics was used in the past (using historical examples)") and 10 ("In this class, the instructor was good at showing how physics was used in the past") are completely different compared to Phase 1, but this is expected if the key differences are instructor dependent as purported in the results of Phase 1 (where the same questions were numbers 9 and 11). Since the instructors' lectures were not observed for Phase 2, no further analysis can be done in that vein.

SUMMARY

In accordance with prior work, the significance of contextual was shown to be nontrivial. In this study, the context of a problem in some cases was able to significantly influence student responses, sometimes by triggering correct intuition, sometimes by triggering incorrect reasoning (giving false positives). The topic of sex, gender and context approached herein yielded mixed results. Initially, varied difference in contextual framing did not affect student responses, and the second study was not conclusive to its effect on the sexes. However, when disaggregating the first study by sex, there was a strong variation in performance. No clear direct influence can be attributed to the gender bias of a problem for the reason why the sexes may answer questions differently.

There were some major trends that continued through both phases of the study. Males responded more positively than females on questions regarding the usefulness and enjoyment of the instructor's use of historical examples. Males also enjoy thinking about the physics of the world around them more than females. Seeing these trends across different courses implies the difference cannot be attributed only to instructors, although they were all male. It would be

interesting to see the results of a course taught by a female instructor.

Some differences between the algebra based course and the calculus based course were traced to observed instructor practices. Students find more enjoyment in historical examples when the instructor uses them more frequently, and they tended to evaluate his use of historical examples accordingly.

APPENDIX A

Phase 1 End Of Term Survey, Contextually Bland Version, Part 1

Questions 1-3 refer to the following situation:
A frictionless cart is given a quick push so that it rolls up an inclined ramp. After it is released, it rolls up, reaches its highest point and rolls back down again.
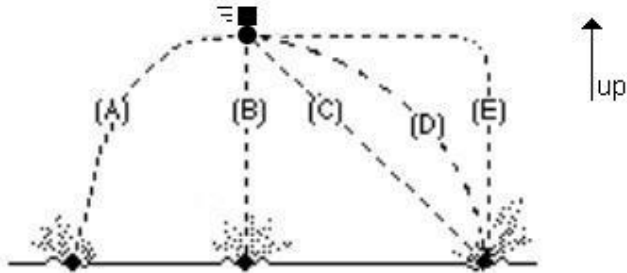

Use one of the following choices (**A** through **H**) to indicate the **net force** acting on the cart for each of the 3 cases described. Answer choice **H** if you think that none is correct.

A.	Net **constant** force **down** ramp
B.	Net **increasing** force **down** ramp
C.	Net **decreasing** force **down** ramp
D.	Net force **zero**
E.	Net **constant** force **up** ramp

F. Net **increasing** force **up** ramp
G. Net **decreasing** force **up** ramp
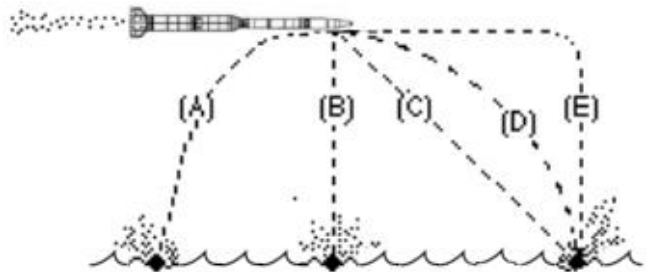**H.** None of these

1. The cart is moving up the hill after it is released. (answer A through H)
2. The cart is at its highest point. (answer A through H)
3. The cart is moving down the ramp. (answer A through H)

4. A square moving to the right at constant speed gently drops a circle at the instant shown. Which path would the circle most closely follow after leaving the square (ignoring air resistance)? Note: The following figure is a *SIDE VIEW*.

5. Cart A has a mass of 1 kg and cart B had a mass of 0.5 kg. Cart A has a spring loaded piston attached to it, and the carts are positioned as shown in the figure. When the piston in cart A is released, it pushes on cart B, and both carts move away from each other. In this situation, while the piston is in contact with cart B,
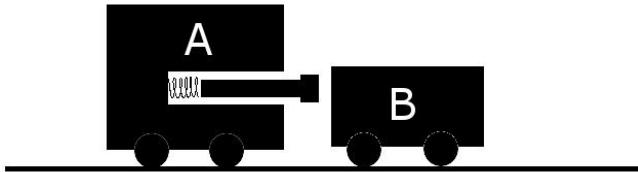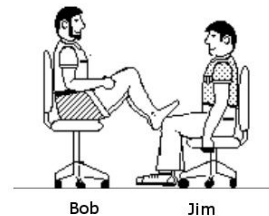

A. Neither cart exerts a force on the other.
B. Cart A exerts a force on cart B, but cart B doesn't exert any force on cart A.
C. Each cart exerts a force on the other, but cart A exerts the larger force.
D. Each cart exerts a force on the other, but cart B exerts the larger force.
E. Each cart exerts the same amount of force on the other.
F. None of these answers is correct.

Phase 1 End Of Term Survey, Contextually Rich Version, Part 1

Questions 1-3 refer to the following situation: On the second to last day of the Tour de France, riders have to climb over 5900 feet to summit Mont Ventoux. This year the race will take place on July 25th. If Lance Armstrong pulls a hamstring while riding up the hill, and can no longer push on the pedals. He rolls up, reaches a highest point, then begins to roll backwards down the hill.

Use one of the following choices (**A** through **H**) to indicate the **net force** acting on Lance for each of the 3 cases described below. Answer choice **H** if you think that none is correct.

A. Net **constant** force **down** hill
B. Net **increasing** force **down** hill
C. Net **decreasing** force **down** hill
D. Net force **zero**
E. Net **constant** force **up** hill
F. Net **increasing** force **up** hill
G. Net **decreasing** force **up** hill
H. None of these

1. Lance is moving up the hill after pulling his hamstring. (answer A through H)
2. Lance is at his highest point. (answer A through H)
3. Lance is moving backwards down the hill. (answer A through H)

4. In 2006 and 2009 North Korea conducted long range missile tests, firing rockets across the Pacific Ocean towards the United States. In both tests, the rocket appeared to malfunction and fall into the ocean. Suppose one of these rockets falls apart in the air while traveling horizontally, leaving the precious payload to fall into the ocean. As observed by a person standing on the ground and viewing the rocket as in the figure below, which path would the payload most closely follow after leaving the rocket? (ignore air resistance)

5. Two students sit in identical office chairs facing each other. Bob is heavier than Jim. Bob places his bare feet on Jim's knees, as shown in the figure above. Bob then suddenly pushes outward with his feet, causing both chairs to move. In this situation, while Bob's feet are in contact with Jim's knees,

Bob   Jim

A. Neither student exerts a force on the other.
B. Bob exerts a force on Jim, but Jim doesn't exert any force on Bob.
C. Each student exerts a force on the other, but Jim exerts the larger force.
D. Each student exerts a force on the other, but Bob exerts the larger force.
E. Each student exerts the same amount of force on the other.
F. None of these answers is correct.

Phase 1 End Of Term Survey, Part 2 (Same For Both Versions)

Here are a number of statements that may or may not describe your beliefs about learning physics. You are asked to rate each statement by selecting a number between 1 and 5 where the numbers mean the following:

A. Strongly Disagree
B. Disagree
C. Neutral
D. Agree
E. Strongly Agree

Choose one of the above five choices that best expresses your feeling about the statement. If you don't understand a statement, leave it blank. If you have no strong opinion, choose C.

6. I enjoy when the instructor relates physics to my everyday life.
7. I learn better when the instructor relates physics to my everyday life.
8. In this class, the instructor was good at relating physics to my everyday life.

9. I enjoy when the instructor shows how physics was used in the past (using historical examples).
10. I learn better when the instructor shows how physics was used in the past.
11. In this class, the instructor was good at showing how physics was used in the past.

12. I am better able to think about the physics of the world around me as a result of this class.
13. I enjoy thinking about the physics of the world around me.
14. In this class, the instructor was good at helping me think about the physics of the world around me.

APPENDIX B

Context Classification Rubric

APPENDIX C

Phase 1 GPA	Algebra Based Mechanics Course	Calculus Based Mechanics Course
Enrolled	3.06±0.60 (42)	2.94±0.76 (61)
All Surveyed	3.19±0.49 (31)	3.04±0.82 (38)
Contextually Rich	3.14±0.62 (10)	2.67±0.89 (16)
Contextually Bland	3.24±0.35 (10)	3.44±0.53 (15)

APPENDIX D

|			

APPENDIX E

Phase 2 Mid-Semester Survey, Form A, Part 1

1. You can charge up the fur of teddy bears and kittens by petting them. Suppose you place a teddy bear at one end of the living room and a kitten on the other end of the room, so that they are separated by a distance D. If the kitten and the teddy bear each have a charge +Q (after petting), then they exert a force of magnitude F on each other:

Force now is F

+Q   +Q

D
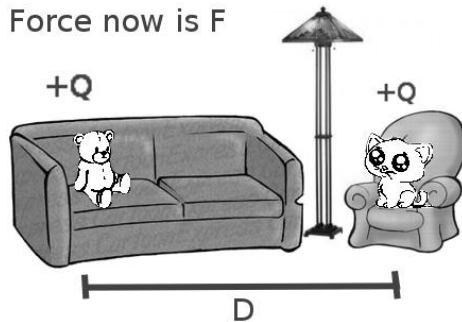
Suppose you pet the kitten again so that now it holds a charge +4Q. The original magnitude of the force between them was F, what is the magnitude of the force on the kitten now?


What is force now?

+Q   +4Q

D
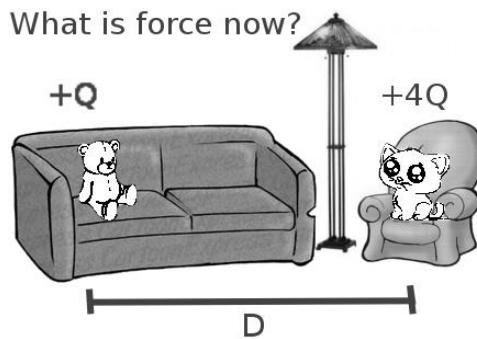
    A. 4F
    B. 5F/2
    C. 3F
    D. 2F
    E. F
    F. F/4
    G. None of these

2. An unknown circuit is connected via two resistors, R1 and R2, to two voltage sources that both maintain a voltage of $V=V_0$ where V_0 is positive. The leads on the front and side of the circuit maintain a voltage of V=0 volts. If the resistance of R1 is half that of R2, then which of the following is true about the current through each resistor?
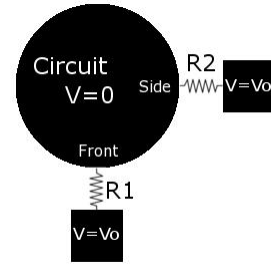
If the resistance of resistor 3 [sic] is half the resistance of resistor 4 [sic], how does the amount of current flowing through resistor 3[sic] compare to the amount flowing through resistor 4[sic]?

    A. The amount of current flowing through resistor 1 is MORE than the amount flowing through resistor 2.
    B. The amount of current flowing through resistor 1 is LESS than the amount flowing through resistor 2.
    C. Each resistor has an EQUAL amount of current flowing through it, which is not zero.
    D. No current will flow.

3. In the following figure, each "+" circle represents a positively charged particle, and each "-" circle represents a negatively charged particle. Both the "+" and "-" particles have the same magnitude (amount) of charge. Which point below has the highest electric potential (v)?
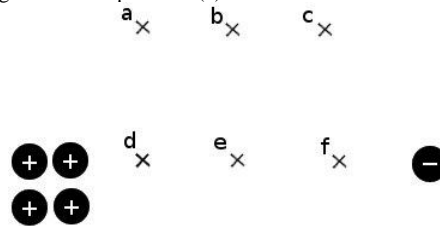

4. Please bubble in "a" for question 4 because you are using form A.

Phase 2 Mid-Semester Survey, Form B, Part 1

1. Car seats can accumulate static electricity when people exit their vehicles. Suppose there are two car seats sitting in a mechanic's shop separated by a distance D, each having a charge +Q (built up after someone exited the seat). Being charged, these seats exert a force of magnitude F on each other:


Force now is F

+Q

+Q

D
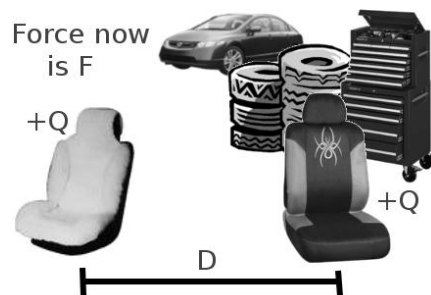
Suppose you rapidly enter and exit one of the seats again so that now it holds a charge +4Q. The original magnitude of the force between them was F, what is the magnitude of the force between the seats now?

What is force now?

+Q

+4Q

D
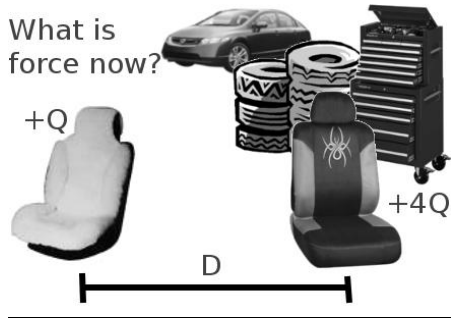
- **A.** 4F
- **B.** 5F/2
- **C.** 3F
- **D.** 2F
- **E.** F
- **F.** F/4
- **G.** None of these

2. Many public venues require tickets for admission, for example movie theaters, sporting events or concert halls. In order to enter, one has to pass through a turnstile, all while an eager crowd pushes from behind. Suppose one venue has eight turnstiles at its front entrance but only four at a side entrance and the crowd is pushing the same at both entrances. For a given time interval, how does the number of people entering the main entrance compare to the number of people entering the side entrance?

Venue
Side
Front
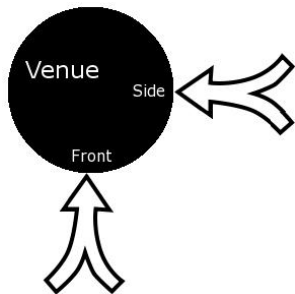
- **A.** The number of people entering the front entrance is MORE than the number entering the side entrance.
- **B.** The number of people entering the front entrance is LESS than the number entering the side entrance.
- **C.** Each entrance has an EQUAL number of people passing through it, which is not zero.
- **D.** No people will enter.

3. In the following figure, each "+" circle represents a positively charged particle, and each "-" circle represents a negatively charged particle. Both the "+" and "-" particles have the same magnitude (amount) of charge. Which point below has the highest electric potential (v)?

a ×   b ×   c ×

+   d ×   e ×   f ×   − −
                          − −
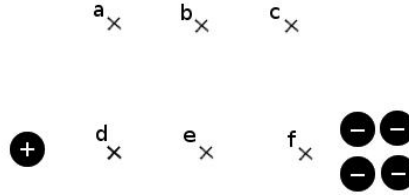
4. Please bubble in "b" for question 4 because you are using form B.

Phase 2 Mid-Semester Survey, Part 2 (same for both Forms)

Here are a number of statements that may or may not describe your beliefs about learning physics. You are asked to rate each statement by selecting a number between 1 and 5 where the numbers mean the following:

- **F.** Strongly Disagree
- **G.** Disagree
- **H.** Neutral
- **I.** Agree
- **J.** Strongly Agree

Choose one of the above five choices that best expresses your feeling about the statement. If you don't understand a statement, leave it blank. If you have no strong opinion, choose C.

5. I enjoy when the instructor relates physics to my everyday life.
6. I learn better when the instructor relates physics to my everyday life.
7. In this class, the instructor was good at relating physics to my everyday life.

8. I enjoy when the instructor shows how physics was used in the past (using historical examples).
9. I learn better when the instructor shows how physics was used in the past.
10. In this class, the instructor was good at showing how physics was used in the past.

11. I am better able to think about the physics of the world around me as a result of this class.
12. I enjoy thinking about the physics of the world around me.
13. In this class, the instructor was good at helping me think about the physics of the world around me.

REFERENCES

1. *Force Concept Inventory.* **Hestenes, David, Wells, Malcom and Swackhamer, Gregg.** March 1992, The Physics Teacher, Vol. 30, pp. 141-158.

2. *Impact of animation on assessment of conceptual understanding in physics.* **Dancy, Melissa H. and Beichner, Robert.** 1, 2006, Phys. Rev. ST Phys. Educ. Res., Vol. 2.

3. *Gender, Context, and Physics Assessment.* **McCullough, Laura.** 4, May 2004, Journal of International Women's Studies, Vol. 5.

4. *Effects of representation on students solving physics problems: A fine grained characterization.* **Kohl, Patrick B. and Finkelstein, Noah D.** 1, 2006, Phys. Rev. ST Phys. Educ. Res., Vol. 2.

5. **Redish, Edward F.** *Teaching Physics with the Physics Suite.* [ed.] Stuart Johnson. s.l. : John Wiley & Sons, 2003. p. 32.

6. *Analogical scaffolding and the learning of abstract ideas in physics: Emperical studies.* **Podolefsky, Noah S. and Finkelstein, Noah D.** 2, Septmber 2007, Phys. Rev. ST Phys. Educ. Res., Vol. 3.

7. *Assessing student learning of Newton's laws: The Force and Motion Conceptual Evaluation and the Evaluation of Active Learning Laboratory and Lecture Curricula.* **Thornton, Ronald K. and Sokoloff, David R.** 4, April 1998, Am J. Phys., Vol. 66, pp. 338-352.

8. *New instrument for measuring student beliefs about physics and learnin physics: The Colorado Learning Attitudes about Science Survey.* **Adams, W. K., et al.** 1, Jun 2006, Phys. Rev. ST Phys. Ed. Res., Vol. 2.

9. *Evaluating an electricity and magnetism assessment tool: Brief electricity and magnetism assessment.* **Ding, Lin, et al.** 1, 2006, Phys. Rev. ST Phys. Ed. Res., Vol. 2.