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Effects of language gap interference for English as a second language students in solving physics problems

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Abstract

Physics is an essential subject in most fields of Science and Engineering which cannot be mastered simply by watching lectures or solving problems at the end of each chapter: students must fully engage in solving these problems. This often requires problem visualisation, which presents quite a challenge for some, especially for students who are studying Physics in a second language because their understanding of the question can be influenced by the gaps in their understanding of the language used. The focus of this study is to investigate the role the language used in the wording of Physics problems plays in students’ ability to understand the question and accurately visualise the scenario that would be needed to extract the required information. 220 undergraduate students and 80 preparatory students volunteered to participate in this study. Students were asked to read two sets of Physics problems and to draw the scenario or image described in the text. The first set used the more advanced English that is commonly found in Physics textbooks and which includes passive voice and homonyms, while the other uses active voice and more simplified English. The results of the study highlight the fact that ESL students’ struggle with certain types of advanced English used in Physics such as the passive voice, showing that they are more capable of translating text into images when active voice is used.

Keywords: physics language interference; mental image; physics education; science education; STEM.

Introduction

In order to accurately understand and solve Physics problems, students need to be able to visualise the scenario described; but what happens when the language gap for students who speak English as a second language interferes with understanding? When teaching students in their second language it is sometimes difficult to determine whether their difficulties in solving Physics problems are due to a lack of understanding or due to their language gaps. This is particularly apparent when teaching Physics because the questions used to assess their understanding require students to be able to understand and visualise a scenario in order to formulate the equation necessary to solve the problem. The ability to generate and manipulate mental images associated with words and phrases is essential to our ability to process language (Clark and Paivio, 1991; Nielsen Hibbing and Rankin-Erickson, 2003). This visualisation skill, the aspect of cognition often referred to as visual working memory, is essential for reading comprehension and construction of meaning, particularly for texts that contain high levels of image content (Kozhenikov, Hegarty and Mayer, 2002; Just et al., 2004; Kozhenikov and Thornton, 2006; Kozhenikov, Motes and Hegarty, 2007; Kozhevnikov, Blazhenkova and Becker, 2010). Visualisation is thus found to be critical for successful communication in technical applications such as computerised natural language processing and scientific visualisations (Gordin and Pea, 1995; Nayak et al., 2015). The interference of language gaps, especially for English language learners can cause difficulty in fully understanding a question, in particular when passive voice, homonyms, or easily mistaken words are used in the description.

The need for visualisation is necessary to some degree in many school subjects including Mathematics, however subjects like Biology, require more memorisation or are shaped by context (Hinojosa, 2015). A typical Biology question might ask students to draw the parts of the digestive system, label them, and explain what they do. This type of question is fairly straightforward and easy to accomplish if the students have studied, because it just requires memorisation. Physics, on the other hand, requires not only a certain amount of memorisation, such as remembering Newton's third law, but also requires students to apply what they have learnt in order to solve problems (Ornek, Robenson and Haugan, 2007; Yousuf and Chaveznava, 2015; Safataj and Amiryousefi, 2016; Ellis and Kopel, 2022; Engineering Plus). The students often know the meaning of a system in equilibrium from their Physics classes, but they are not often able to apply that knowledge in order to draw the forces acting on an object when that image is described to them in a few lines of English text.

Sometimes, students may be fluent in decoding words but still struggle to comprehend what they read due to an inability to create mental images (Nielsen Hibbing and Rankin-Erickson, 2003). This difficulty becomes especially apparent in the Physics classroom as students encounter complex problems that require visualisation in order to produce a solution. Often in Physics, a diagram or a figure is given and students must imagine and draw additional elements in order to solve the problem. Visualisation plays a central role in the conceptualisation process of Physics and other Science subjects (Gordin and Pea, 1995; Nielsen Hibbing and Rankin-Erickson, 2003; Kozhevnikov and Thornton, 2006; Nayak et al., 2015; Mustafa et al., 2016) but if students cannot understand what the words in the question are explaining they will not be able to build the image in their mind. Solving Physics problems requires a good amount of effort in terms of creating a mental image of the situation that has been described in the question. Many errors, if not most, in a Physics assessment can be traced back to mistakes made when determining which equation to use and where to put each piece of information. In many instances, the difficulties in solving problems correctly can be related to either having difficulty visualising the question’s scenario or missing conceptual information during reading (Gordin and Pea, 1995, Nayak et al., 2015; Mustafa et al., 2016). Difficult problems in Physics are multistep problems and the path from known information to unknown quantity is often not immediately obvious. The problem can become like a jigsaw puzzle; the assembly of all the pieces into the whole can only occur after careful inspection, analysis, and perhaps some wrong turns (Gordin and Pea, 1995; Kozhevnikov and Thornton, 2006; Nayak et al., 2015; Mustafa et al., 2016; Physics Classroom, 2019).

For the vast majority of students in the United Arab Emirates (UAE), English is their second language and their secondary education does not adequately prepare them for university Science courses. One reason for this is that Physics classrooms in public schools in the UAE use Arabic as the medium of instruction, so when they go to university, which uses English, they are not familiar with many terms and phrases used in Physics in English (MOE, 2021). For example, if a Physics question mentions an inclined plane, many students will think it is referring to an aeroplane instead of a flat surface as they are not familiar with the other use of this word. This is because there are different tiers of vocabulary. Language learners first learn common vocabulary used in everyday conversation, then the second tier which is words that are not typically used in everyday conversation, then the third tier which is words that are specific to a content area such as STEM content (Haynes and Zacarian, 2010). The teaching approach followed in many of their primary and secondary schools follows a more traditional model, where students are not required to search for information outside the classroom; instead, they must rely on simply memorising the information given by their teachers or the textbook (Celik, Onder and Silay, 2011). This practice has an adverse effect on students' understanding and learning in Physics because the principles of Physics cannot be truly understood by memorisation. Teaching methods that focus on memorisation for any subject can affect students' ability and motivation in learning Physics and can directly impact their achievement in the Physics classroom.

According to recent studies, UAE students tend to avoid Physics learning and many of them choose not to pursue Physics at the university level (Celik, Onder and Silay, 2011). Findings of this nature are also reported by other researchers who point out that students' Physics achievements are negatively affected by low interest in classroom activities (Celik, Onder and Silay, 2011). It is possible that this behaviour towards Physics is not wholly related to the subject itself, the way the subject is being taught, or the challenges of visualisation, but instead may be more related to the way Physics textbooks, homework problems, and assessments are commonly written. It is possible that Physics authors and teachers use a writing style that is confusing to students contributing to poor reading comprehension, low achievement in assessments, and high levels of frustration. This frustration could be a major contributing factor to a student's belief that Physics is a difficult subject, which could be avoided. Physics courses tend to have a high failure rate and are sometimes reported as having a lower than desired or expected achievement of learners (Nayak et al., 2015). Many students struggle with Physics in both the secondary and the university level and in life applications. Therefore, many withdraw from or perform poorly in the foundation programme or the first-year general Physics courses (Gordin and Pea, 1995; Kind, Jones and Barmby, 2007; Ali and Rubani, 2008). In Khalifa University (KU), more than one third of students get a grade of 79.5% or below in the Preparatory Physics subject, with 72.5% being the passing grade, and results are similar in the mandatory introductory undergraduate level Physics courses (mechanics and electromagnetism). Students normally describe their interest towards a course by expressing likes or dislikes of the subject (McLeod, 1992; Papanastasiou and Papanastasiou, 2004; Berg, 2005; Hussein, 2006; Kind, Jones and Barmby, 2007; Belge-Can and Boz, 2012; Fikret, 2012).

The low interest in enrolling in Physics suggests that there is a negative association with Physics classes. A positive view towards Physics indicates that students are confident in learning Physics and that they enjoy the learning process. It is believed this point of view has an effect on achievement in Physics; the more positive the students view, the better their achievement (Papanastasiou and Papanastasiou, 2004; Kind, Jones and Barmby 2007; Ali and Rubani, 2008; Harris et al., 2018).

The focus of this study is to investigate the role that the language used in the wording of Physics problems has in students' ability to understand the problem and accurately visualise the scenario that would be needed to solve the problem.

Methodology

Participants

This study was conducted at Khalifa University in Abu Dhabi, United Arab Emirates during the 2020-2021 academic year. The participants of this study were a group of Khalifa University undergraduate students. English is the second language for all the students involved in this study and they have varying degrees of language ability and familiarity. Participating students were from two levels: 220 students from the freshman Physics course, and 80 students from the Science, Technology, Engineering and Mathematics (STEM) course in the preparatory programme, which is a pre-enrolment course for students who have recently graduated from high school and need some additional instruction before they meet the required level for enrolment in freshman courses at the university. There were 204 female students and 96 male students. Each of these students had taken Physics courses in high school, and were in either the preparatory programme STEM courses, and/or the undergraduate level Physics courses. All participants of this study volunteered to participate and were invited based on their score in the Physics subject in their high school course, which was a B- or better.

Ethical approval

All participants signed the research consent form used at Khalifa University, with information about the purpose of the study and the intention of using the data in publication. This study went through all the principles outlined in Khalifa University's ethical policy and received approval from the ethics committee.

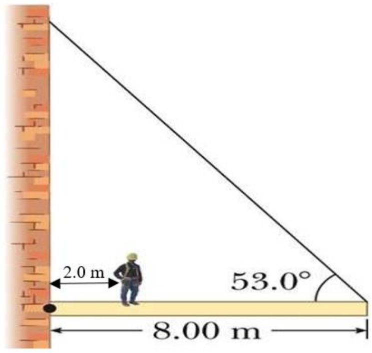
Materials

Students were divided into two groups: each group included 110 freshmen students and 40 preparatory students. Each group was given six mechanics Physics problems covering a variety of topics including forces, motion, 2D projectile motion and equilibrium. It is important to mention that neither of the groups saw the questions given to the other group. In this study, the six problems were taken from a fundamental Physics textbook, which we do not use in our courses, and were written in plain English text using passive voice. These questions were then analysed for passive voice and possibly confusing language and were simplified and written in active voice. For example, the original form of one of the questions used passive voice and stated, 'a 1kg box is launched from a spring'. This question was re-worded using active voice to say, 'a spring launches a 1kg box'. Some words that may have been confusing were clarified. For example, one question referred to a 'worker standing on a beam', but beam has more than one meaning in English, so the word 'wooden' was added to emphasise the fact that this was not a beam of light, but rather a solid beam that a person could stand on. Students in each group were given a selection of these Physics problems, three of which were in their original form and three problems which had been modified and simplified with active voice and word choices.

Student responses

For both groups, all students' answers were compared to the answer key to determine the degree to which students were able to understand the text, visualise the situation, and produce an accurate diagram. The accuracy of their answer was evaluated based on showing the major physics/concepts details in their sketch. For the example provided above, the main items considered for the marking scheme were: a horizontal beam, a pin connecting the beam with the wall, the worker standing in an acceptable location (2.0 m) compared to the total length (8.0 m) of the beam, and the cable at the other end of the beam connected with the wall. The ideal drawing is illustrated in Figure 1.

Figure 1. The ideal sketch of the problem (Serway and Jewett, 2013).



Results

A marking scheme was designed for determining accuracy in the students' sketches. As described above, in this marking scheme, each question was evaluated out of four marks and students' sketches were compared to what should be included in the ideal sketch. For example, sketches may have four elements that need to be present and in the appropriate location.

The responses to the original version of the problems were separated from the responses to the modified problems to be able to compare the effect that the modifications had on the students' ability to visualise the problems.

Figures 2 and 3 depict two examples of students' sketches of the question.

Figure 2. Example of a students' visualisation for the problem.

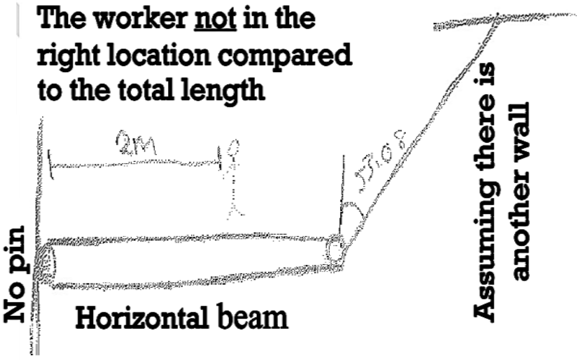
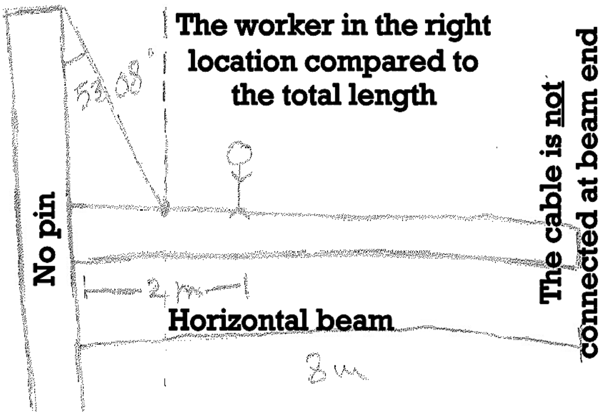


Figure 3. Example of a students' visualisation for the problem.



This study used ANOVA which is a statistical test used to compare the means of two or more groups. It determines whether the differences between the means of the groups are statistically significant or if they could have occurred by chance.

We examined and compared students' performance at both the preparatory and undergraduate levels. There were 80 preparatory students and 220 UG students involved in total.

ANOVA test results for students' responses

We compared the test results of the preparatory students' responses to questions using the original language in passive voice and a modified version in active voice. Each question was worth four marks, with a possible full mark of 24. There were six questions in their original form (passive) and six modified (active) ones. We collected the average marks obtained by the two groups, and the results were 16.9375 for the active questions and 15.2625 for the passive questions, as shown in the table.

To determine if the difference in means between the two groups was significant, we conducted an ANOVA test. The ANOVA test showed that there was a significant difference in performance between students who answered active voice questions compared to those who answered passive voice questions. The F-value for this test was 5.653878, with degrees of freedom of (1,159), which exceeded the critical F-value of 3.900989. Additionally, the p-value was 0.0016, which was less than the alpha level of 0.05, indicating that the null hypothesis of no difference was rejected.

Table 1. The ANOVA analyses of the preparatory students' performance.

Anova: Single Factor						
Summary						
Groups	Count	Sum	Average	Variance		
TM Active Prep	80	1355	16.9375	20.79351		
TM Passive Prep	80	1221	15.2625	18.90491		
ANOVA						
Source of Variation	SS	df	MS	F	P-value	F_{crit}
Between Groups	112.225	1	112.225	5.653878	0.018612	3.900989
Within Groups	3136.175	158	19.84921			
Total	3248.4	159				

We used the same tool to analyse the responses of the undergraduate students answering questions written in their original form (passive) and their modified form (active). The results of this analysis were similar to those of the preparatory students and show that students scored higher when answering the modified (active) questions. The table below, shows the average score for the active questions was 18.18636, while the passive questions show an average score of 16.46364.

There is a significant difference in the responses to active questions compared to those of passive questions. The F-value for this test was 19.02432, with degrees of freedom of (1,439), which exceeded the critical F-value of 3.862777. Furthermore, the p-value was 1.6109x10-5, which was less than the alpha level of 0.05, indicating that the null hypothesis of no difference was rejected.

Table 1. The ANOVA analyses of the undergraduate students' performance.

Anova: Single Factor						
SUMMARY						
Groups	Count	Sum	Average	Variance		
TM Active UG	220	4001	18.18636	14.28018		
TM Passive UG	220	3622	16.46364	20.03977		
ANOVA						
Source of Variation	SS	df	MS	F	P-value	F_{crit}
Between Groups	326.4568	1	326.4568	19.02432	1.6109×10^{-5}	3.862777
Within Groups	7516.068	438	17.15997			
Total	7842.525	439				

Table 3. Average accuracy score of each original (passive) question for undergraduate and preparatory.

	Average Accuracy Score Original Questions	
Question No.	Undergraduate	Preparatory
1	80.0%	71.0%
2	77.0%	69.0%
3	55.0%	25.0%
4	80.0%	73.0%
5	48.0%	28.0%
6	65.0%	54.0%

Table 4. Accuracy percentage score of each modified (active) question for undergraduate and preparatory.

	Average Accuracy Score Modified Questions	
Question No.	Undergraduate	Preparatory
1	88.0%	80.0%
2	87.0%	73.0%
3	73.0%	67.0%
4	90.0%	83.0%
5	60.0%	47.0%
6	78.0%	66.0%

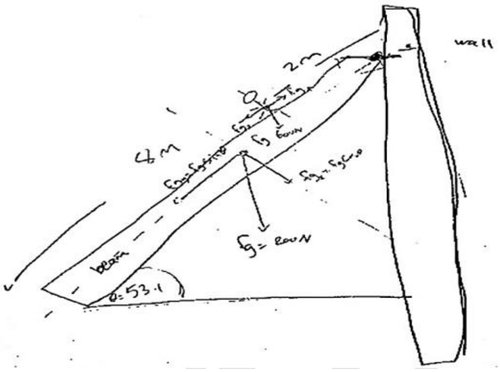
Tables 3 and 4 show that when we compare the results of each question for the two groups, we can see that the preparatory students benefited from the modified questions more than the undergraduate students. The responses to the problems using passive voice showed an average accuracy of 67.5%±5.61% for undergraduate students and 53.33%±8.92% for preparatory students. For the responses to the problems using active voice, there was an average accuracy of 79.33%±4.7% for undergraduate students with an increase in accuracy of 11.83% and 69.33%±5.26% average for preparatory students with an increase in accuracy of 16.0%.

Based on our findings, we can conclude that questions written in 'active' voice result in more accurate visualisations for both undergraduate and preparatory students. Therefore, we recommend the use of 'active' question style in the assessment of students to improve their academic performance.

Visualisation in Physics

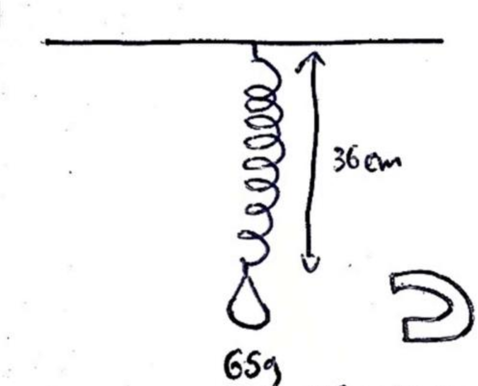
Student challenges observed in the responses in this study can be separated into two categories. In category A, students misunderstand basic Physics concepts including a misunderstanding of projectile motion of an object, a struggle to differentiate between the horizontal distance (range) and the height, an inability to correctly identify if the spring is compressed or stretched, and difficulty locating the angle of the force acting on an object. Figure 4 illustrates how a student drew the wooden beam as an inclined plane, even though the question stated that the beam was in a horizontal position with a cable connecting the end of the beam to the wall as shown in Figure 1. The student assumed the setup was an inclined plane with the cable in a horizontal position.

Figure 4. Misunderstanding the Physics concept, horizontal, angle location.



A second category of common mistakes is related to mixing similar sounding words such as string and spring. Figure 5 shows a student sketch for the problem that states ‘an iron bolt with a mass of 65g hangs from a string that is 36cm long. The top end of the string is fixed. . . . Sketch the final configuration of iron bolt, string, and magnet’.

Figure 5. Mixing the string and the spring.



The string is mentioned twice in the question but the student draws a spring instead. The student might believe the sketch is correct, but as a Physics concept, the way of handling string is different to handling a spring, due to the fact that a spring should stretch/compress whereas the string does not stretch, and this will require a different approach to solve the problem.

Figure 6 shows a student’s drawing for another problem which states: ‘a wood block with a mass m=7.0 kg is pulled up a fixed frictionless plane by a string. The plane is inclined at an angle θ=20° to the horizontal. The string that pulls on the block makes an angle ϕ=40° with the inclined plane. The tension force in the string is T = 27 N’.

Figure 6. Student drawing for ‘A wood block with a mass. . .’

As can be seen in Figure 6, the student confused the word ‘string’ with ‘spring’ and drew a spring.

Discussion

Results of this study highlight the role that language gap interference may play in students’ ability to understand Physics problems. The main issue that this study focused on is the difficulties that language comprehension present in creating a mental image for the scenario described in a question based on their basic knowledge of Physics.

The confusion of a single letter as highlighted in Figure 6 (above) creates a serious issue for solving a Physics problem. This difference of one letter would require much more complex formulas which would cause the answers to be very different. In addition, Physics is extremely hierarchical, meaning each concept builds upon the concept before. In Physics, in order to solve the multistep problem shown in Figure 6, students would need to have a firm understanding of not only the concept of conservation of energy, but also the more basic concept of motion in one dimension. In addition to understanding the concepts, they must be able to visualise the scenario in order to apply the knowledge of these concepts to determine which equations to use to get the answer without being explicitly told what to do with the information.

Language

The results show that changing the language in the questions had a greater positive impact on the ability of the preparatory students to produce the image than on the undergraduate students. This could be attributed to the fact that undergraduate students, on average, are stronger in English than the preparatory students. Therefore we would expect that language interference would play a greater role in the results of the students in the preparatory programme. The fact that all participants speak English as their second language poses a particular issue for problems given to them, which are written in an indirect way. When a person begins to learn English they will most likely be exposed mainly to sentences constructed in active voice instead of passive voice. This is because active voice is seen as much easier to understand because it is more direct and straightforward (Hinojosa, 2015; Yew and Goh, 2016). A sentence in active voice is one that follows the pattern of subject-verb-object and in which the subject of the sentence is the one doing the verb. In contrast, a sentence in passive voice would be one in which the verb is being done to the subject (Yew and Goh, 2016). Passive voice can be challenging for English language learners to master as they find it difficult to determine who is doing the action and who is receiving the action. This poses a problem for students at university level who are studying Physics, because Physics textbooks will often use passive voice. For example, a Physics textbook might say ‘the box is pushed down the plane by a spring’, but the students will have a difficult time understanding that the spring is the thing doing the pushing. Instead, they may assume that the box is pushing the plane because they are used to the active voice structure.

In this study, the Physics questions used were mostly framed in a passive voice and an attempt was made to re-write the question in an active voice to see if that small change could make them more accessible to the students. For example, the original form of one question stated, ‘a 1kg box is launched from spring’. Assuming the students understand the word launched, they may still struggle to understand that the spring is the thing that is causing the action, because in this structure, the box appears to be the subject and it may cause students to believe that the box is doing something to the spring. This question was re-worded to say, ‘a spring launches a 1kg box’. While that change is quite simple, the fact that the spring is now the subject will help students to connect the action of launching to the spring. Students enrolled in these courses certainly should understand passive voice, but they may need to be explicitly taught the difference before they are expected to understand a passage written in passive voice that is not a regular part of Physics curriculum. Another issue that had to be addressed in order to make the questions more accessible to second language learners was the issue of uncommon vocabulary. A marker of a language learner is that when confronted with a word that has more than one meaning, they will often only know the most common meaning of the word (Hinojosa, 2015; Neilson, 2016). This becomes an issue in Physics because the questions contained words like beam and plane. Students will often misunderstand the word ‘beam’ because they will have heard the word beam referring to a beam of light or a laser beam more often than referring to metal or wood. This could be due to the use of the phrase ‘high beams’ in their cars or ‘laser beam’ in video games. This misunderstanding could cause confusion because a beam of light would not be able to support any amount of weight as in the example of a ‘worker standing on a beam’. In the updated version where active voice was used, this issue was clarified by using the term ‘wooden beam’. By reducing the areas of possible confusion in the way the question is explained, the language gap interference that many students face becomes less of an issue and teachers are better able to assess students’ understanding of the actual Physics concepts instead of those results being distorted by a simple misunderstanding of the wording and word order of the questions. Students had to rely less on their language skills to understand the modified-questions because there were fewer possibilities of students getting confused.

Therefore, while many professors worry that the students’ struggle with understanding questions is due, in large part, to gaps in critical thinking skills, it cannot be said that language plays no part in their struggle with Physics. This indicates that in order to improve students’ success rate in Physics, the language gaps, in particular with students with English as their second language, must be addressed because we cannot take language completely out of teaching Physics.

Conclusion

When trying to assess students’ abilities in college-level Physics and other STEM subjects it is important to keep in mind that the language interference may be distorting the results because students could have a good command of the subject matter but would not be able to demonstrate it if they do not understand the language in the question. Physics problems often use passive voice and include words that have multiple meanings. This study has shown that both of these characteristics can overcomplicate a question. Professors of Physics and other subjects should keep this in mind when writing questions. If educators feel it is necessary for students to be able to answer questions written in passive voice or using words that have more than one meaning, these concepts and words should be explicitly taught so the results of assessments accurately measure the students understanding of the subject. We would suggest that more attention be given in a Physics classroom to how questions are worded to ensure that students are aware of the fact that the subject can come after the verb and that some words may have more than one meaning.

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Appendix

Questions used

	Original Version	Modified Version
1	In a restaurant, a customer slides his water glass across a table toward his friend. After sliding a distance S, the glass accidentally slides off the table and then strikes the floor after falling a vertical distance H and moving a horizontal distance D from the table's edge. Make a sketch showing the entire motion of the water glass.	In a restaurant, a customer slides his water glass across a table toward his friend. After the glass slides a distance (S), it accidentally slides off the table. Once it leaves the table, the glass moves horizontally while it falls until it strikes the floor. During the falling motion, the glass falls a vertical distance (H) while moving horizontally a distance (D) from the edge of the table. Make a sketch showing the entire motion of the water glass.
2	A string is used to pull a 7.0kg block up a fixed frictionless plane that is inclined at an angle θ=20° to the horizontal. The string makes an angle ϕ=40° to the plane and the string tension T = 27 N. Draw a diagram representing this situation.	A wood block with a mass m=7.0kg is pulled up a fixed frictionless plane by a string. The plane is inclined at an angle θ=20° to the horizontal. The string that pulls on the block makes an angle ϕ=40° with the inclined plane. The tension force in the string is T = 27 N. Draw a diagram representing this situation.
3	An 8.00 m length, uniform, horizontal 200 N beam is connected with a wall by a pin. The far end of the beam is supported by a cable making an angle Ө= 53.1° with the beam. A 600 N worker stands on the beam, 2.00 m	A wooden beam that has a length of 8.00 m and a weight of 200 N is connected to a wall. It is located high above the ground. The beam is connected to the wall with a pin on one end. The other end of the beam is held up by a cable that makes an angle Ө = 53.1o with the beam. A worker who

	from the wall. Draw the scenario and locate and label all the forces.	weighs 600 N stands on the beam a distance of 2.00 m away from the wall. Draw the scenario and locate and label all the forces.
4	A 1.0 kg ball, initially 2.0 m above the ground, is launched horizontally using a spring with constant 135 N/m, initially compressed 25cm. Draw a diagram that includes the vertical and horizontal distances the ball travels before it hits the ground.	There is a table which is 2.0 m tall. On this table there is a spring with a constant equal to 135 N/m that has been compressed 25cm. The spring is used to launch a 1.0kg ball horizontally off the edge of the table. Draw a diagram that includes the vertical and horizontal distances the ball travels before it hits the ground.
5	A 65g iron bolt hangs from a 36cm string. The string's top end is fixed. Without touching it, a magnet causes the bolt to move horizontally 28cm from the previously vertical line of the string. Finally, the magnet is to the right of the stationary bolt and at the same vertical level. Sketch the final configuration of iron bolt, string, and magnet.	An iron bolt with a mass of 65g hangs from a string that is 36cm long. The top end of the string is fixed. To the right of the bolt is a powerful magnet. Without touching it, the magnet attracts the bolt so that it is displaced horizontally 28cm to the right from the previously vertical line of the string. The bolt in the final configuration is stationary and at the same level as the magnet. Sketch the final configuration of iron bolt, string, and magnet.
6	A 2.0 kg block on a rough incline (Ɵ = 37^{o}) is connected to an initially unstretched spring (k= 100 N/m) that is mounted at the top of the incline. When the block is released from rest, it moves down the incline and the spring stretches. The block moves 20 cm down the incline before it again is at rest. Draw the scenario, showing the incline, block, and spring. Indicate	There is a rough incline that makes an angle Ɵ = 37^{o} with the horizontal. A wood block with a mass of 2.0 kg is situated on the incline. The block is connected to a spring that has a constant k = 100 N/m. The spring is initially unstretched. The spring is mounted at the top of the incline. When the block is released from rest, it starts to move down the incline and causes the spring to become stretched. The block moves 20 cm down the incline before it is

	the initial and final positions of the block.	again at rest. Draw the scenario, showing the incline, block, and spring. Indicate the initial and final positions of the block.

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