Hints Really Help!

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Abstract

We study the usefulness of hints in learning physics using myCyberTutor (aka: Mastering Physics), a web-based homework tutor. About 48% of the students request hints on average to a given problem with an average of one hint request per wrong answer submitted. Administering related problem pairs to two equally skilled groups in different orders we find that the group which solves a problem in a given problem-pair second requests on average 12% fewer hints than the group which solves it first. The maximum reduction (19%) in requests for hints occurs for a problem after solving its related tutorial problem. These results support the cognitive theory that feedback is a form of information that helps students in learning.

Introduction

The usefulness of feedback in learning has been demonstrated through many studies (e.g. Thorndike, 1931; Trowbridge & Cason, 1932). As a new medium of learning, the web-based tutors' role in employing hints and feedback however, is not obvious. The present study investigated students' use of hints in a controlled study in the context of Newtonian mechanics using the web-based physics tutor, myCyberTutor.

Hints in myCyberTutor are designed to guide students in the direction of the correct solution. When students request hints to a given part they are displayed on a separate window as a hint list. In the hint list only the titles of the hints are displayed which serves as a summary of what those hints concern. Students have to explicitly open the hints in order to look at the details. These details can range from comments on how to approach the problem, principles and concepts that must be considered to sub-parts where students are asked to solve a sub-problem that would be helpful in solving the main part. The main part problem is then repeated at the end of the hint list keeping with the contiguity principle (Clark & Mayer, 2003) thereby reducing the cognitive load on students.

In this paper we look at evidence of knowledge transfer through use of hints. We provide data from three related problem pairs on the use of hints by two groups of students.

The Study

The student pool involves ~ 430 students in total from the introductory mechanics course (course 8.01, fall 2003) at the Massachusetts Institute of Technology (MIT). The student population was divided into two equally skilled groups, A & B, using myCyberTutor homework scores of the first six weeks. These two groups were administered related problem-pairs in different orders. The three problem pairs fall mainly into the categories of linear momentum, torque, and universal gravitation. The six problems contain 31 main parts with 31 hints in total. The problems are related in the sense that they involve the same concepts and methods. Students were allowed eight attempts for any given main part of the problem or a sub-part within the hints. However, hints can be requested at any time to any given main part.

Results

Our major findings are:

1. On average 48% students use hints on a given problem.

2. On average one hint is requested per one wrong answer submitted.

3. About 88% of the students request hints only after submitting wrong answers (i.e. only about 12% request hints before submitting any answers).

4. On average only about 10% of the students request all the hints to a given problem.

5. When there is more than one hint for a given main part, the last hint of the hint list is requested by 26% of the students on average compared to only 2% for the first hint of the list before giving the correct solution. (It is in only one case out of seven that this observation does not hold true. However, in this case the last hint is a sub-hint (see Figure 6)). On average 13% of the students use a given hint as the last hint before giving the correct solution to a given main part of a problem.

6. For pairs of closely related problems, the group which solves either problem second requests 12% fewer hints compared to those who solve that same problem first. The maximum reduction (19%) occurs for the tutorial-related problem pair having solved the tutorial problem first.

The results are depicted in Figures 1-6 and Table 1. In the figures the proportion is the fraction of students using a particular hint as the last hint before submitting the correct solution relative to the total number of students giving the correct solution to the main part of interest. The parentheses next to the group labels indicate the order in which the problem was done (i.e. whether done first (1) or done second (2)).
In Table 1 a descriptive summary of what the hints concern is shown together with the corresponding *p*-values (one-tail tests have been performed showing the fact that the first

group clearly requests more hints compared to the second group). The same information is presented to the student when they open the hint list to a given main part. We have also investigated whether students use only this summary to arrive at the solution without explicitly opening the individual hints. We do not find evidence of this approach.

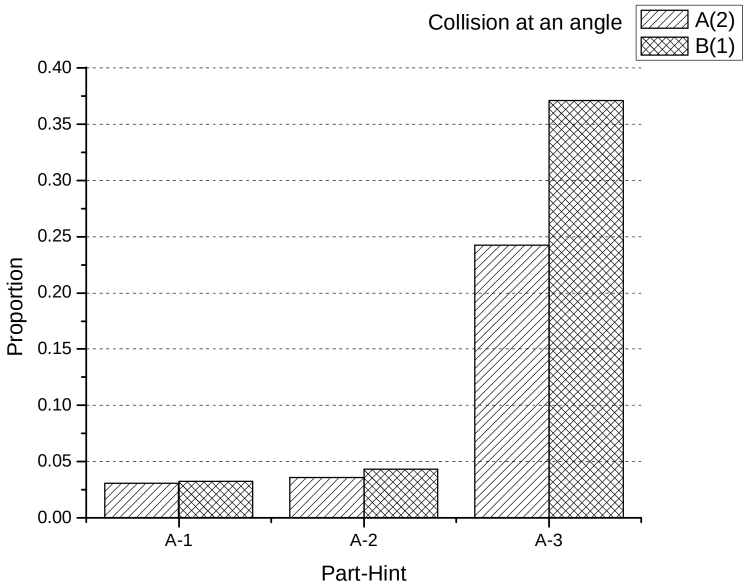

Figure 1

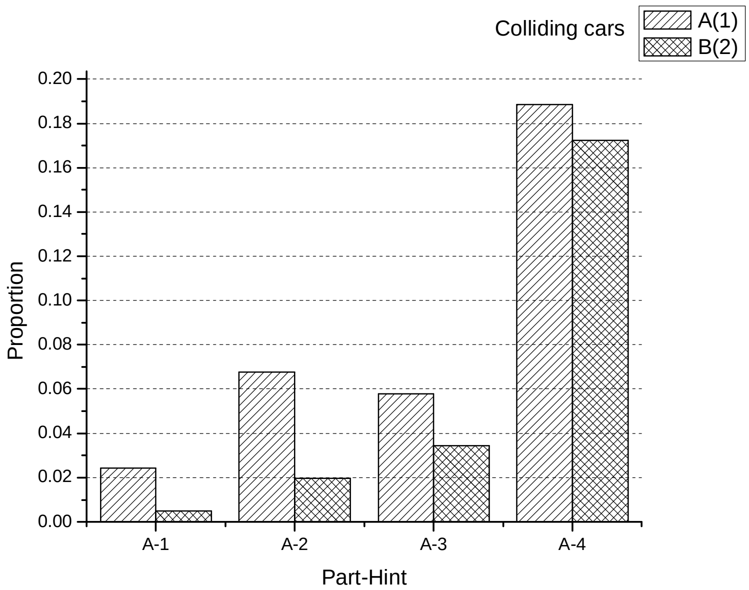

Figure 2

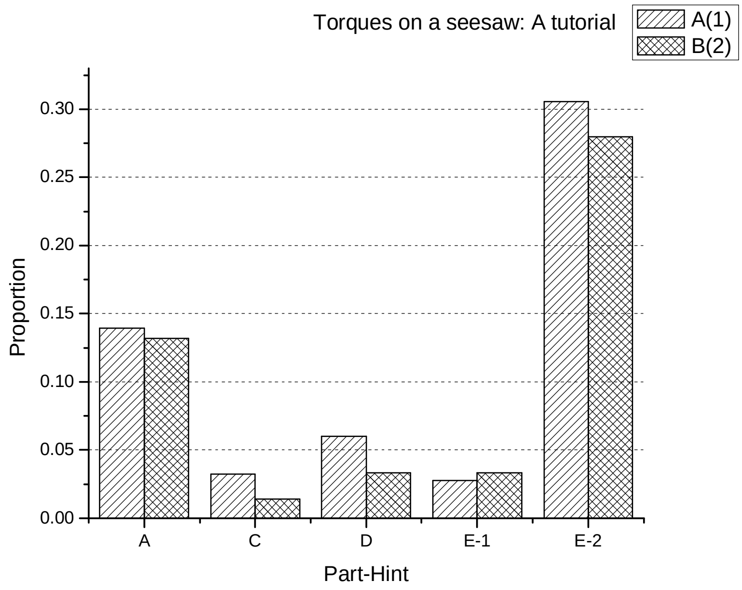

Figure 3

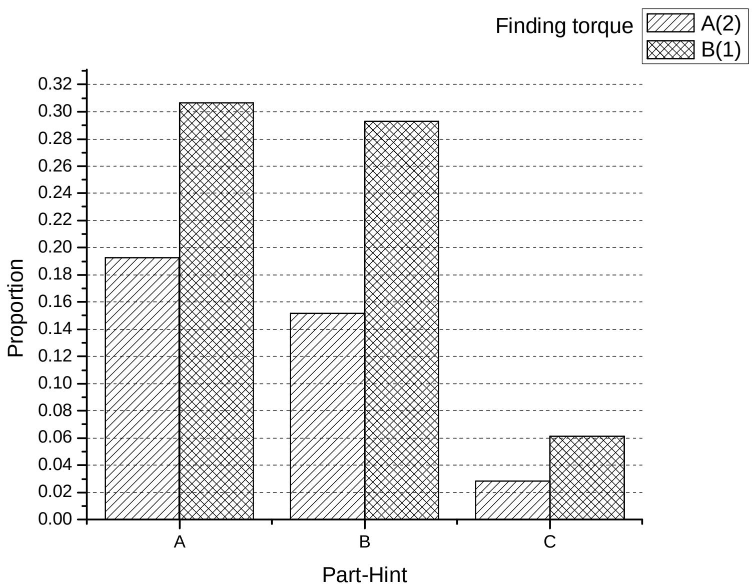

Figure 4

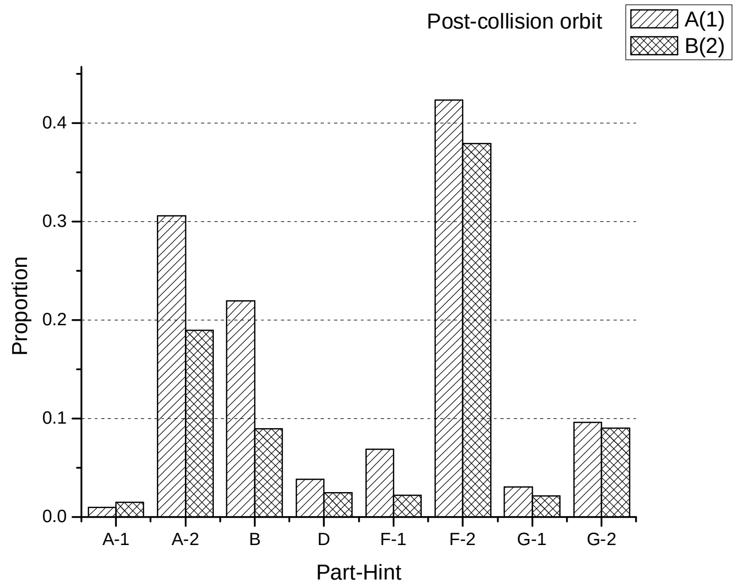

Figure 5

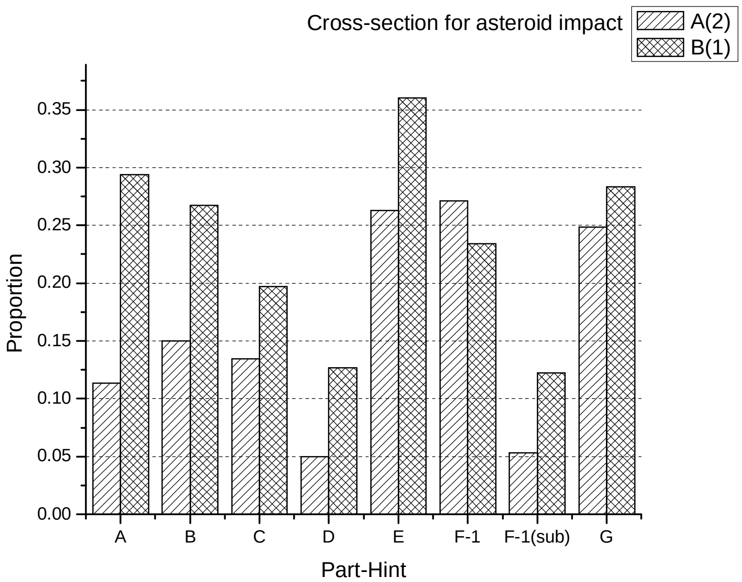

Figure 6

Table 1

Problem	Part-Hint	*p* < 0.1	*p* < 0.05	*p* < 0.01	*p* < 0.005
Collision at an angle	**A-1** Determining the conserved quantities				
	A-2 East-West component of $P_{initial}$				
	A-3 North-South component of $P_{initial}$				x
Colliding cars	**A-1** Conservation of momentum (definition)	x			
	A-2 X & Y components of momentum			x	
	A-3 About a vector and its components				
	A-4 Velocity and momentum (finding v the magnitude of the final v)				
Torques on a seesaw: a tutorial	**A** How to approach the problem				
	C Torques from the weight of the seesaw				
	D Balancing the seesaw	x			
	E-1 Sign conventions				
	E-2 Torque due to mother's push				
Finding Torque	**A** When force is applied at the pivot point				x
	B				x

	Finding **r** with respect to a reference point				
	C Clockwise or counterclockwise		x		
Post-collision orbit	**A-1** An implicit assumption about the violent collision				
	A-2 One form of mechanical energy (asks to write the potential energy)				x
	B Formula for angular momentum				x
	D Find the angle between radius and velocity vectors				
	F-1 Getting started		x		
	F-2 Express E in terms of L				
	G-1 Solution to quadratic equations				
	G-2 Are there always two solutions?				
Cross-section for asteroid impact	**A** Gravitation potential energy				x
	B Definition of angular momentum				x
	C Potential energy [when the asteroid reaches the surface of the earth]		x		
	D Direction of velocity before impact				x

	E Find the final velocity		x		
	F-1 Find the escape speed				
	F-1(sub) Definition of escape speed (a sub hint for F-1)			x	
	G Centripetal acceleration				

Discussion

We find that the hints act as a useful form of feedback for students to arrive at the correct solution to physics problems. In cases where there are more than one hint for a given main part we see that not many (about 2%) students use the first hint as the most useful hint to arrive at the solution. This is compared with the 26% who use the last hint as the most useful hint. The reason may be that it is the last hint that is more in line with the problem. Also, it is in line with the fact that students lost points for requesting hints. Therefore, they did not consider opening all the hints in between but attempted to gain most by using the last hint.

Learning from hints is exhibited by the reduction in requests for hints by the group who does a given problem second in a related pair. Most of the hints have commonalities between the problem pair with others capable of generalizing the knowledge elements. Thus, students were able to learn from the hints of the first problem and were able to transfer the acquired knowledge to the second problem, hence resulting in a reduction in requests. A good example of this is provided by the problem pair that involves gravitation. In “post-collision orbit” about 30% of the students in group A who solves it first asks for hint A-2 which asks them to write down the gravitational potential energy. Similarly, in “cross-section for asteroid impact” about 30% of the students in group B who solves it first ask for hint A which involves gravitational potential energy. We can see the significant reductions in requests by group B and group A in “post-collision orbit” and “cross-section for asteroid impact,” respectively having acquired the necessary knowledge from the hints of the respective first problems.

The influence of solving the tutorial problem first in the reduction of the hints requested for its subsequent related problem also holds for the last hint used before the correct solution as shown in figures 3 and 4. Here the reduction is highest (10%) for group A which solves “finding torque” after solving “torques on a seesaw: a tutorial.” This agrees with our previous observations (Morote, Warnakulasooriya & Pritchard). A future study will specifically try to understand the effectiveness of tutorials on the use of hints in related problems. These results provide further support for the cognitive theory of feedback where it is seen as a form of information (Mayer, 2003).

References

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