Identifying student difficulty in problem solving process via the framework of the House Model (HM)

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Motivation

- There are many studies on problem solving process: Polya [1] , Larkin [2], Heller [3], Reif [4], etc
- However, we have little information how students have difficulties in each step of the process.

1) We tried to determine student specific difficulties in a given step when they solve mechanics problems, and investigate the reasons why students fell difficulties in this step

2) We also tried to determine if any change in patterns of student difficulty exist between easy and challenging problems.

Research Context

- Participants: 24 university students majoring in physics education and enrolled in an upper-level mechanics class
- Data Collection

: HM report, questionnaire, Exercise Self Report, individual interview

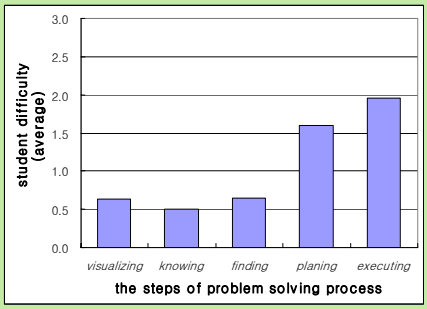
- 10 HM Problems (1/week)

House Model

We have developed a special framework, the House Model (HM) [5], for analyzing student difficulty when solving mechanics problems. The HM has a visualized structure and a natural process. The HM's order for solving a problem is generally from top to bottom (① Visualizing, ②Knowing, ③Finding, ④Planning, ⑤ Executing, ⑥Checking).

In visualizing step we sketch problem situation and mark coordinate, force and so on. In knowing step we write down variables and value which are given in problem. In finding step we confirm the question and find variables or values that the problem requests us. In planning step, after we combine point information from visualizing, knowing and finding, we think of problem solving strategy. In executing step, throughout applying the plan, we conduct calculation and find out the answer. In checking step, throughout verifying unit, sign and physics adequateness, we confirm the answer.

Result 1. Degree of student difficulty[6] in the process of problem solving



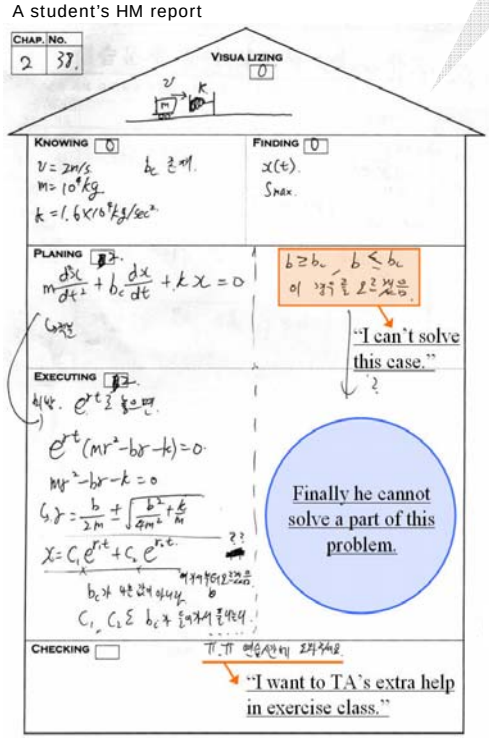
- The executing step is the most difficult step, and the planning step is the second most difficult step.
- As testing ANOVA and Tukey, we confirm that these difference is significant statistically.

3-week HM problem is one of challenging problems. Many student fail to solving this problem. The overall score of difficulty=3.11

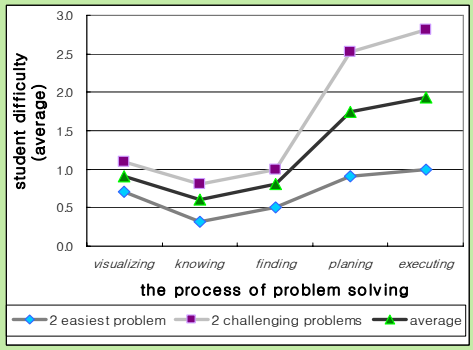
3-week HM problem (symon ch.2 #38)

A freely rolling freight car weighing 10^4 kg arrives at the end of its track with a speed of 2m/sec. At the end of the track is a snubber consisting of a firmly anchored spring with $k=1.6\times10^4$kg/sec^2. The car compresses the spring. If the friction is proportional to the velocity, find the damping constant b_c for critical damping. Sketch the motion x(t) and find the maximum distance by which the spring is compressed (for $b=b_c$). Show that if $b \geq b_c$, the car will come to a stop, but if $b \geq b_c$, the car will rebound and roll back down the track.

A student's HM report



Result 2. Comparison student difficulty between in easy and challenging problems



- Whether a problem is easy or not, the pattern(3-low/2-high) is maintained.
- However, as the problems increase in difficulty, the student difficulty in the planning and executing steps increase.

Result 3. The sources student difficulty in the process of problem solving

- The sources of student difficulty in solving mechanics problem process are related to student difficulty in each step.
- visualizing, knowing, finding steps: lack of basic physics knowledge and understanding the situation, poor English ability
- planning step: no essential concept
- executing step: lack of mathematical skill (differential equation, Taylor and Fourier series) , little experience in problem solving

TABLE 2. Comparison 2 easiest problems and 2 challenging problems by t-test. We found a mount of difference in planning and executing

Steps of HM		visualizing	knowing	finding	planning	executing
2 easiest problem n=30	**mean**	**0.63**	**0.33**	**0.50**	**0.93**	**1.00**
	std. dev	0.67	0.48	0.68	0.74	0.74
2 chall-enging problem n=20	**mean**	**1.10**	**0.75**	**0.90**	**2.50**	**2.80**
	std. dev	0.85	0.97	0.91	0.95	0.52
Difference		0.57	0.42	0.40	1.57	1.80
sig.		0.035*	.086	.082	.000**	.000**

reference

[1] G. Polya, How to solve it?, Princeton University Press 1957

[2] J. H. Larkin, Skilled problem solving in physics: A hierarchical planning model. University of California, Berkeley, 1978

[3] Heller, Kenneth and Patricia Heller. The Competent Problem Solver. University of Minnesota, 1992.

[4] F. Rief, Understanding Basic Mechanics. NY;John Wiley & Sons Inc. 1995.

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Summary

1) Students feel greatest amount of difficulty in the planning and executing steps.

2) Whether a problem is easy or not, this pattern is maintained. However, as problems become more challenging, difficulties in planning and executing steps increase.

3) The sources of student difficulty in solving mechanics problem process are related to student difficulty in each step.