Investigating the Perceived Difficulty of Introductory Physics Problems

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Research Questions:

1. Do students and instructors provide **similar difficulty ratings** for kinematics and work-energy problems?
2. Do the difficulty ratings provided by students **correlate with the rate at which students solve the problems correctly**?
3. Do the difficulty ratings provided by the students **correlate with the familiarity** of the problem as judged by the students?
4. Do the difficulty ratings provided by students and instructors **correlate with the complexity** of the problem?

Surveys of Problem Difficulty Estimation (SPDE)

SPDE Kinematics

- 10 problems (5 pt Likert Scale)
- Students: N=21 algebra-based intro
- Instructors: N=16 faculty & graduate students
- Students solved problem and rated familiarity and difficulty; Instructors rated difficulty

SPDE Work-Energy

- 16 problems (10 pt Likert Scale)
- Students: N=15 first year physics majors
- Instructors: N=14 faculty & graduate students
- Students and Instructors rated difficulty

Difficulty Scale for SPDE Kinematics

Rating		Example
1	Very Easy	Example: An ant travels .9 meters in 1 second. What is the ant's speed?
2		
3		
4		
5	Very Difficult	Example: As a science project, you drop a watermelon off the top of the Empire State Building, 320 m above the sidewalk. It so happens that Superman flies by at the same instant you release the watermelon. Superman is headed straight down with a speed of 35 m/s. How fast is the watermelon going when it passes Superman?

Familiarity Scale

1	I have solved this exact problem before.
2	I have solved a very similar problem before.
3	I have solved a somewhat similar problem before.
4	This problem has few similarities to problems I've solved before.
5	I have never solved a problem like this before.

Students' & Instructors' ratings of difficulty are different for many problems.

SPDE Median Difficulty Ratings from Students and Instructors and Mann-Whitney U Test Comparisons. Difficulty ratings are on a 10-point Likert scale for the SPDE Work-Energy and on a 5-point Likert scale for the SPDE Kinematics.

	Problem	P 01	P 02	P 03	P 04	P 05	P 06	P 07	P 08	P 09	P 10	P 11	P 12	P 13	P 14	P 15	P 16
SPDE Work-Energy	Median Student Difficulty	2	2	2	5	6	5	4	6	6	6	5	5	4	6	6	3
	Median Instructor Difficulty	2	2	2	4	5	6	6	7	4.5	6	7	7	7	5	5	6
	P Mann-Whitney U Test	.71	.85	.96	.10	**.04**	**.14**	**.01**	.24	.16	.79	**.01**	**.01**	**.00**	.91	.55	.00
SPDE Kinematics	Median Student Difficulty	1	1	3	2	2	2.5	3	2	3	3						
	Median Instructor Difficulty	1	2	3	3	3	4	4	2	3	3						
	P Mann-Whitney U Test	.36	**.01**	.07	.06	**.05**	**.00**	**.01**	.32	.58	.18						

Both Instructors' and Students' ratings of difficulty correlate with Students' score.

Correlation is higher for Instructors.

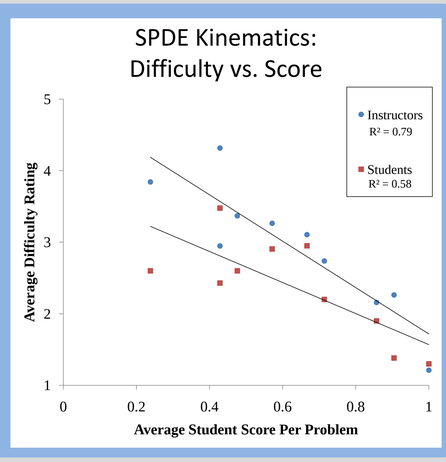
Correlations:

Instructors	R = 0.89,	p < 0.01
Students	R = 0.76,	p < 0.01

Problem Scoring:

1 point = correct answer (*allowing for minor arithmetic errors*)

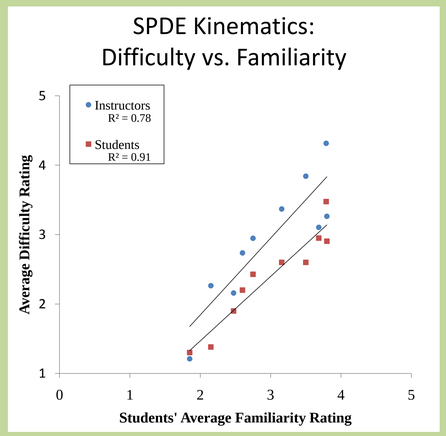
0 points = incorrect answer



Both Instructors' and Students' ratings of difficulty correlate with Students' ratings of familiarity.

Correlations:

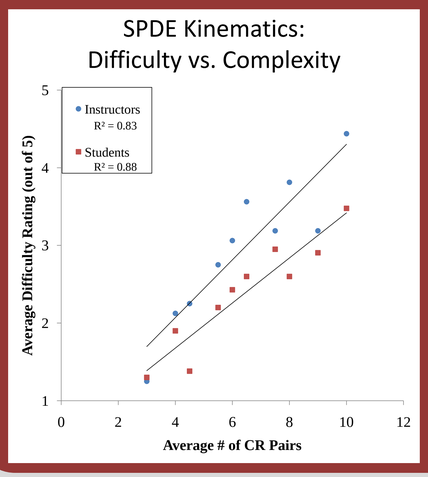
Instructors	R = 0.88,	p < 0.01
Students	R = 0.95,	p < 0.01



Both Instructors' and Students' ratings of difficulty correlate with problem complexity for the SPDE Kinematics.

Correlations:

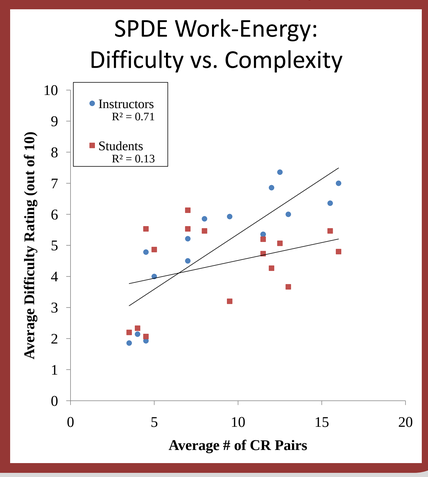
Instructors	R = 0.91, p < 0.01
Students	R = 0.94, p < 0.01



Only Instructors' ratings of difficulty correlate with problem complexity for the SPDE Work-Energy.

Correlations:

Instructors	R = 0.84, p < 0.01
Students	R = 0.36, p = 0.20



Determining Problem Complexity: An ECR Framework

***E*xposition**	*Descriptions of the problem situation*
***C*omplication**	*Questions to be answered*
***R*esolution**	*Answers to the complications*

Example:	*How much potential energy is stored in a spring with spring constant k = 170 N/m when it is compressed 5 cm?*
Exposition	A spring (spring constant = 170 N/m) is compressed 5 cm.
Complication 1	Find the potential energy of the spring.
Complication 2	What physics idea to use?
Resolution 2	Definition of potential energy for a linear spring $U = \frac{1}{2}kx^2$
Complication 3	Which quantities go with which variables?
Resolution 3	k = 170 N/m, x = 0.05 m
Resolution 1	Potential energy is 0.4 J

3 Complication/Resolution (CR) Pairs

CR Pair → Step or Decision

Complexity → # CR Pairs

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