Using an ECR Framework to Characterize Problem Difficulty

Elizabeth Gire
N. Sanjay Rebello

Kansas State University

This work is supported by the National Science Foundation under grant 0816207

1

Research Questions

How do students' and instructors' estimation of difficulty compare?

How does the complexity of a problem affect its perceived difficulty?

2

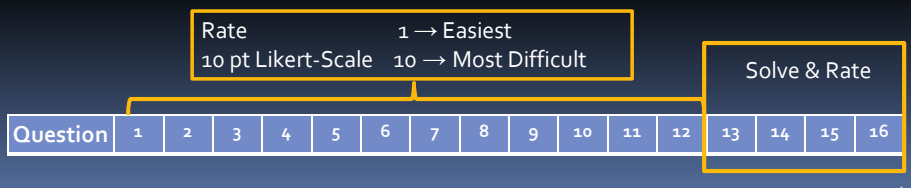
Project

- Developed a Survey of Problem Difficulty Estimation (SPDE)
- SPDE → Students & Instructors
- Developed a rubric for textbook style physics problems.
- Correlation between SPDE and the rubric

3

SPDE (Survey of Problem Difficulty Estimation)

- 16 Work & Mechanical Energy problems
  - ✓ Halliday, Resnick & Walker, 7th Ed.
  - ✓ Context Rich Problems
  - ✓ Numbers, symbols, equations, graphs, pictures
- Online Delivery



4

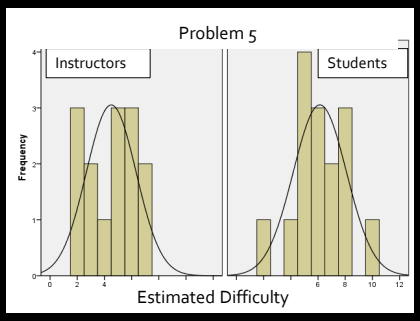
SPDE → Students & Instructors

15 Freshman Physics Majors

"Estimate the difficulty"

14 Instructors

"Estimate the difficulty for a student"



Independent Samples Mann-Whitney U Test

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16
P-value	.71	.85	.96	.10	.04	.14	.01	.24	.16	.79	.01	.01	.00	.91	.55	.00
Median Stu	2	2	2	5	6	5	4	6	6	6	5	5	4	6	6	3
Median Inst	2	2	2	4	5	6	6	7	4.5	6	7	7	7	5	5	6

5

Rubric - ECR Framework

Exposition — Liz is a post-doc in the Kansas State physics education research group.

Complication — The physics education community is unaware of the work that she is doing at Kansas State University.

Resolution — Liz goes to the AAPT 2010 Winter Meeting and gives a well-received talk about her research.

Baggett, 1979

6

ECR & Physics Problems

How much potential energy is stored in a spring with spring constant k = 170 N/m when it is compressed 5 cm?

Exposition

Spring with k = 170 N/m
compressed 5 cm

Complication

Calculate the potential energy

Complication
Resolution

What physics idea to use?
Definition of potential energy for linear spring
$U = \frac{1}{2}kx^2$

Complication
Resolution

Which numbers go with which variables?
k=170 N/m, x= 5 cm

Resolution

Value of the potential energy

3 CR Pairs

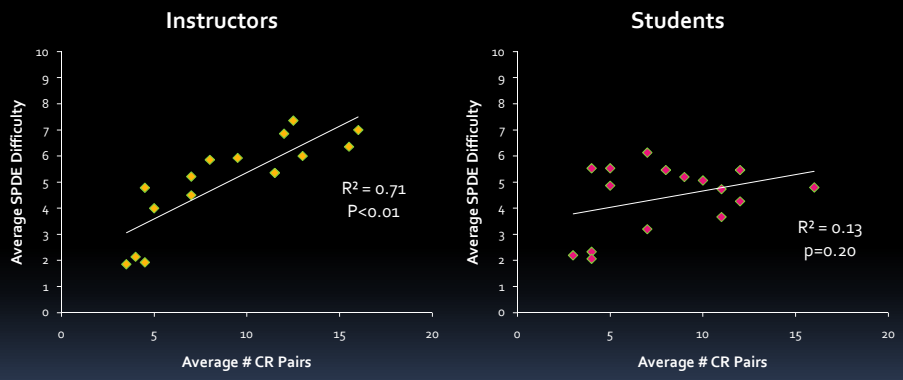
7

Reliability

Problems	Reliability
Solved Textbook Examples Halliday ,Resnick & Walker (7th ed) Knight (2004)	0.78
SPDE Problems	0.72

8

ECR & SPDE Correlation



9

Conclusions

- Student and instructor estimation of problem difficulty can be quite different
  - ✓ No global trend
  - ✓ Context rich problems → students estimate as easier
- Instructors' difficulty estimations rely more strongly on the number of steps in the solution than do students'.

→ Compare correct response rate with difficulty estimation & ECR score

→ Other physics topics

10

Thank You

egire@phys.ksu.edu

srebello@phys.ksu.edu

11

SPDE (Survey of Problem Difficulty Estimation)

- Online survey
- 16 Work & Mechanical Energy problems
  - ✓ Halliday, Resnick & Walker, 7th Ed.
  - ✓ Context Rich Problems
  - ✓ Numerical, equations, graphs, pictures

Rank 1 → Easiest
10 pt Likert-Scale 10 → Most Difficult

Solve & Rank

Position:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Winter	Q2	Q11	Q6	Q7	Q8	Q1	Q9	Q12	Q15	Q3	Q16	Q10	Q13	Q14	Q4	Q5
Spring	Q3	Q5	Q16	Q7	Q10	Q1	Q11	Q12	Q13	Q4	Q14	Q6	Q8	Q9	Q2	Q15
Summer	Q13	Q3	Q7	Q4	Q14	Q5	Q10	Q9	Q8	Q2	Q12	Q15	Q6	Q11	Q1	Q16
Fall	Q11	Q2	Q8	Q5	Q1	Q15	Q6	Q9	Q13	Q14	Q16	Q4	Q7	Q12	Q10	Q3

12

What makes a physics problem difficult?

Characteristics of the Problem

- ✓ Amount of information given in the problem
- ✓ How information given in the problem
- ✓ Amount of math manipulation involved in the solution
- ✓ Which physics ideas are involved in the solution

Interaction Between Problem & Solver

- ✓ What knowledge does the solver possess that can be used to solve the problem?
- ✓ What knowledge does the solver possess that they see as relevant to the problem?
- ✓ How familiar is the context?

13