EFFECTS OF STUDENTS' BACKGROUNDS AND EXPERIENCES ON SCIENCE LEARNING

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Does Background Matter?

- Do students' background and past experiences matter?
- Should they?

Science in Context

* Many science teachers feel that providing daily-life or real-world contexts in their classes is a valuable part of their teaching style.
* Some evidence that contexts help students learn (Rennie & Parker)

Background? Experiences?

- Does context affect how a student interacts with a science classroom?
- Does background affect how a student interacts with a science classroom?
- Do past experiences affect how a student interacts with a science classroom?
- If so, what might have an effect?

Obvious and Non-obvious

* Women & Science program...suggests gender is important!
* Ethnicity
* Sexual orientation?
* Religion?
* Veteran status?
* Orphan?
* Car crash survivor?

What might be wrong with this?

* During a softball game, the batter hits a pop fly ball that takes 4 seconds to go up and come down. How high did it go?

Effects of gender

* Women take fewer science courses
* Women take different science courses
* Women get lower score on the SAT-Math
* Women get higher college grades
* Women get lower achievement scores

Effects of ethnicity and race

* Non-caucasians do worse on achievement tests
* Non-caucasians tend to take fewer science classes
* Fewer non-caucasians major in science

High school science

* Sadler and Tai have studied the effects of high school science and other factors on success in college science
* HS math helps
* HS science helps same science course in college

Sadler & Tai's work

* Algebra-based physics: women do better than men
* Calculus-based physics: women do worse than men
* This takes into account background

Other experiences

* Sports in high school?
* Music/playing an instrument?
* J. Blue has studied these two experiences; HS sports has mixed effect; HS music has mixed effect (helped on some questions, hurt on others)

Other factors

* Cultural biases and expectations affect student achievement
* Claude Steele's work on stereotype threat
* Much more work on stereotype threat

Cultural biases

* Students may not view themselves as scientists
* They may not internalize scientific beliefs
* UMD studies of belief vs. scientist answers

How can you get around these issues?

* What ways can you come up with to counteract the issues of race, gender, etc?
* What ways can you come up with to counteract the issues of past experiences?
* What ways can you come up with to counteract the issues of cultural biases?

Some solutions

* When creating problems or stories, use “you” as the protagonist
* Use the majors who take your class (biology major, packaging major)
* Use school/college examples

How far is too far?

* Being inclusive can be taken too far: political correctness is a negative term for many people
* You don't need to meet everyone's needs with every problem (gluten-intolerant, follicle-challenged)
* Variety keeps things interesting

What is a neutral context?

* Come up with neutral contexts for your area

Type of assignments?

* We have different types of learners in our courses
* Students have had different types of teachers
* How do we help everyone?

Multiple representations

* Pictures
* Equations
* Hand motions
* Graphs
* Verbal descriptions

Typical science class assignment

* Read a research article given to students by teacher, summarize it
* Appropriate for future scientists, others
* Appropriate for a facilities management major?

Different type of assignment

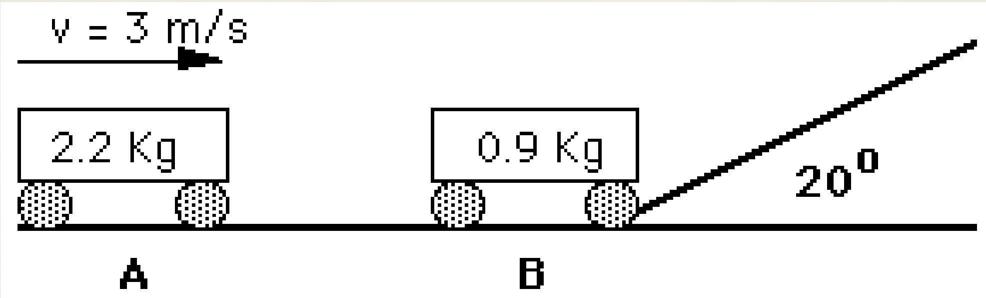
- Read any article in Science News, write a half-page paper including three things:
  - A two or three sentence summary of the science
  - Why you picked the article/why it was interesting
  - Implications for society because of the research

Univ. of MN Context-Rich Problems

* Designed to be inclusive
* Put “you” as the protagonist
* Use real life contexts
* Dependent on the student population (engineers vs. pre-meds)

Textbook problem

- Cart A, which is moving with a constant velocity of 3 m/s, has an inelastic collision with cart B, which is initially at rest as shown in Figure 8.3. After the collision, the carts move together up an inclined plane. Neglecting friction, determine the vertical height h of the carts before they reverse direction.



UMN CR Problem

* You are helping your friend prepare for her next skate board exhibition. For her program, she plans to take a running start and then jump onto her heavy duty 15-lb stationary skateboard. She and the skateboard will glide in a straight line along a short, level section of track, then up a sloped concrete wall. She wants to reach a height of at least 10 feet above where she started before she turns to come back down the slope. She has measured her maximum running speed to safely jump on the skateboard at 7 feet/second. She knows you have taken physics, so she wants you to determine if she can carry out her program as planned. She tells you that she weighs 100 lbs.

Your turn!

* An object is thrown off a cliff with a speed of 2 m/s at an angle of 30 degrees. If it hits the bottom of the cliff 1.8 seconds later, how high is the cliff?

Example context

* You have spent the day rock-climbing. A dense fog has rolled in, and you need to descend as soon as possible. You have 100 feet of rope, but you don't know how high a cliff you are standing on. You can't see the bottom of the cliff, so you need to determine the height of the cliff without having to climb down. Since you are taking physics, you decide to throw a small rock off the cliff; you hear it hit 1.8 seconds later. You estimate that you throw the rock at 2 m/s at an angle of 30 degrees. Is it safe to descend the rope?

Physics for Everyone

* Physics For Everyone: Designing Inclusive Physics Problems

  Shannon R. Dorato, Suzanne R. Foster, Katy-Robin Garton, Abigail L. Ryder, Hillary L. Swanson, Barbara L. Whitten, Physics Department, Colorado College.

* <http://www2.coloradocollege.edu/Dept/PC/RepresentativePhy/Pages/home.htm>

Sample Problem

- Barbara commutes from Castle Rock to Colorado Springs, every day—about 45 miles straight south on the interstate, where the speed limit is 75 mph. If she drives at 85 mph, how much time does she save on her daily round trip? How does this compare to the 20 minutes she spends talking to the policeman who gives her a speeding ticket?

Types of assessments?

* Typical assessment focus on one type of learning
* If we use multiple representations and multiple types of assignments, we need to use multiple assessments
* Not just “tell me what this word means” or “solve this problem for the velocity”

Multiple assessments

* Problem solving
* Projects
* Verbal descriptions/papers
* Stories?

Possible assessments

* Come up with multiple types of assessments that you might be able to use in your courses

Conclusions

* Many background variables and experiences affect how students respond to the science classroom
* As teachers, we need to take into account these variables and do the best job in helping everyone

References

- Context Rich Problems: http://groups.physics.umn.edu/physed/Research/CRP/crintro.html
- Physics for Everyone: http://www2.coloradocollege.edu/Dept/PC/RepresentativePhy/Pages/home.htm
- For references on research, please contact Laura McCullough (McCulloughL@uwstout.edu or 715-232-2536)

Gender, Context, and Assessment

- What are some specifics of how gender might affect science assessment?
- Does a question about a cannonball evoke the same response as a question about a baby's bowl?

Contexts: Male? Female?

* Typical physics contexts:
  * Baseball/Sports
  * Cannons/Military
  * Tools
* Abstract, context-less problems

The Force Concept Inventory

* The FCI is commonly used across the country in high schools and colleges
* 30 question test covers topics usually taught in first term introductory physics
* No math/calculations
* "Wrong" answers (distractors) were carefully chosen from research on common student misconceptions
* Significant gender gap favoring males

The Problem: Gender gap?

	Pre %	Post %	% Gain
Women (N=780)	35.6 (se=.5)		
Men (N=1997)	50.3 (se=.4)		

The Problem: Gender gap?

	Pre %	Post %	% Gain
Women (N=780)	35.6 (se=.5)	57.4 (se=.7)	
Men (N=1997)	50.3 (se=.4)	68.6 (se=.5)	

The Problem: Gender gap?

	Pre %	Post %	% Gain
Women (N=780)	35.6 (se=.5)	57.4 (se=.7)	21.8 (se=.6)
Men (N=1997)	50.3 (se=.4)	68.6 (se=.5)	18.4 (se=.4)

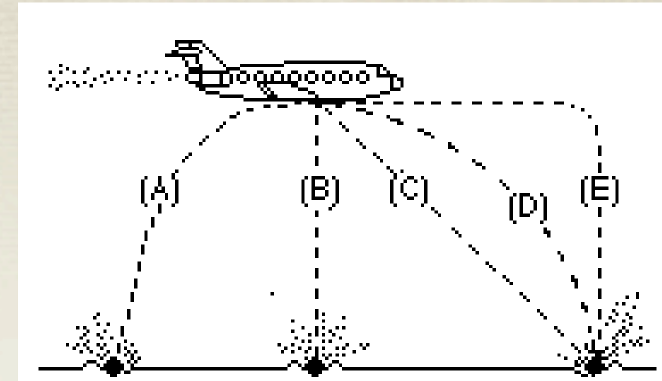
Why the gender gap?

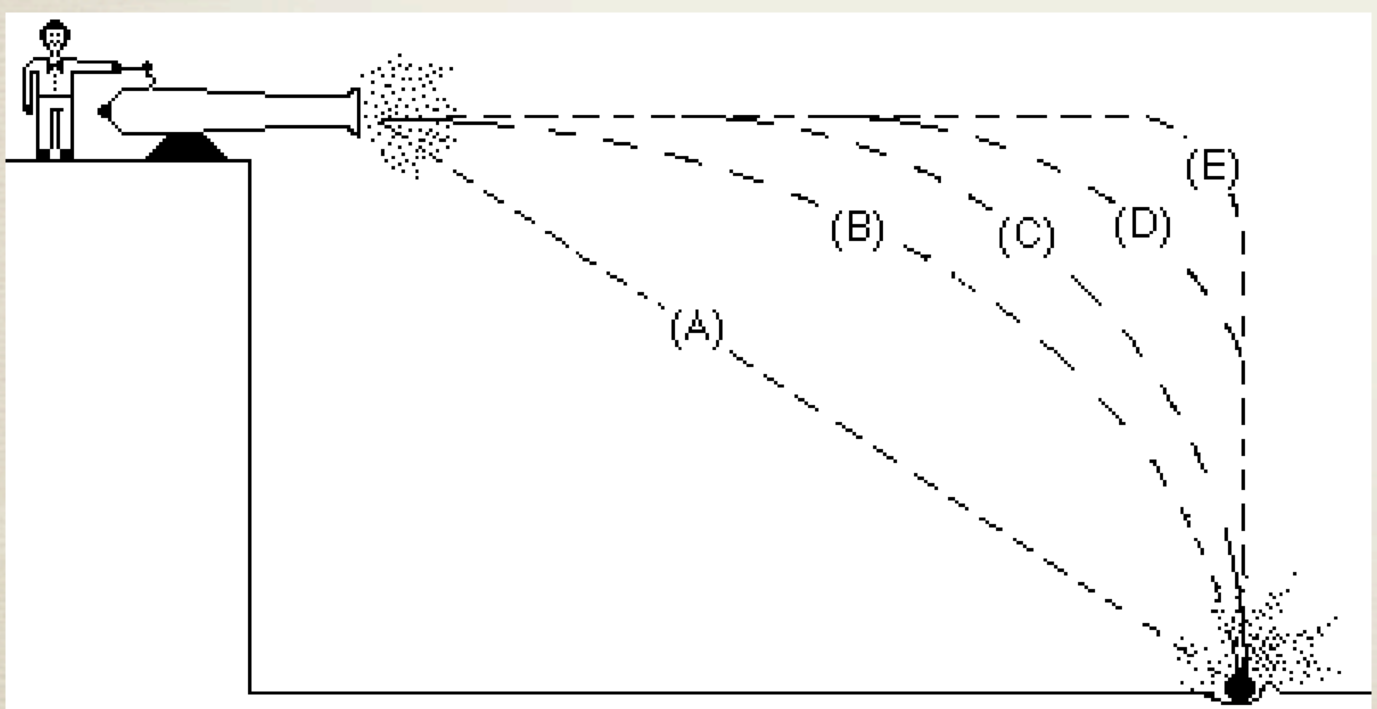
* What's up with this test?
* The men, the women, or the test?
* Possible test bias?

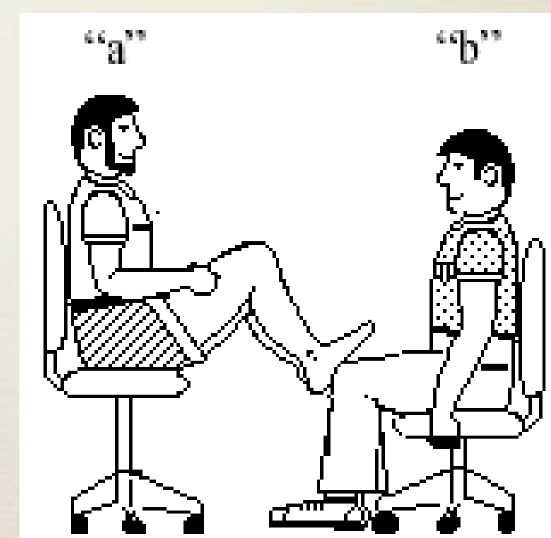
Test by males, for males?

* Written by a team of male physics education researchers
* Tested on mostly male high school students
* Stereotypically male contexts
* Almost every person is a male

FCI contexts





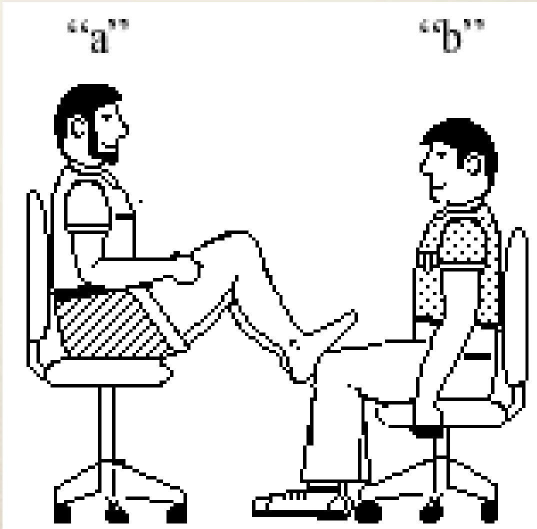


Context & Response?

- Rennie & Parker: changing context affected student response
  - Students preferred real-life context questions
  - More girls than boys preferred contextual questions (found the questions easier)
- Enderstein & Spargo: changing context from native to urban changed responses

Evidence for Contextual Interaction

* Translated version of the test in Thailand
* Students had major problems with this question
* Cultural context completely blocked the science of the question
* Context affects performance!



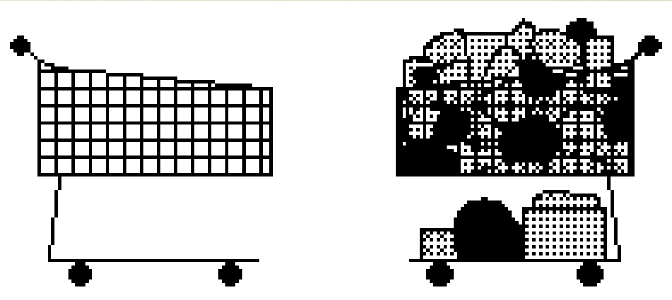
How to test context?

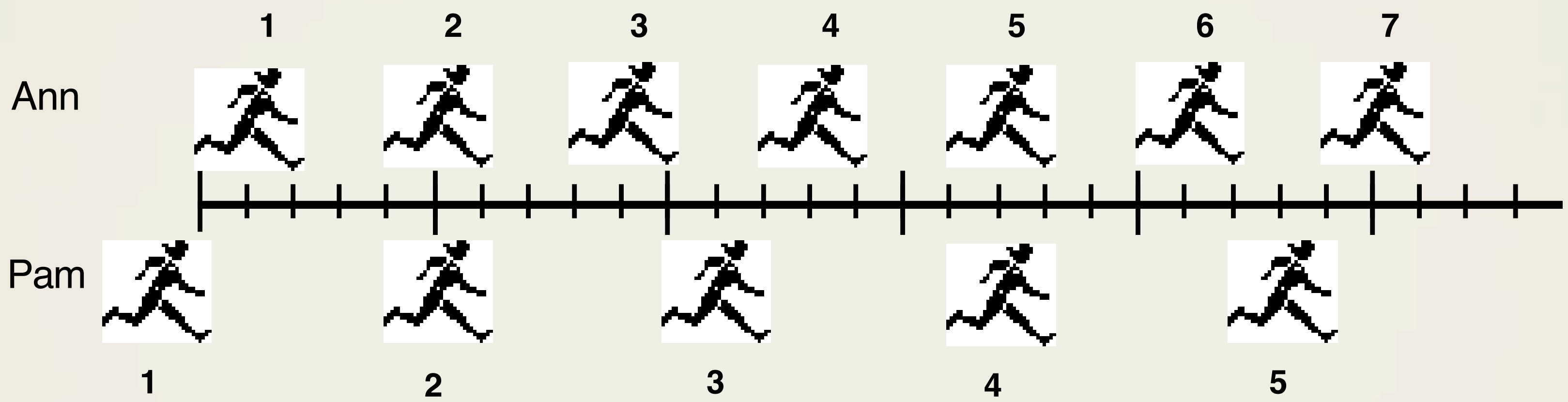
- Change the context!
- New version of FCI with stereotypically female contexts
- As far towards a female bias as possible
- Also more daily-life situations

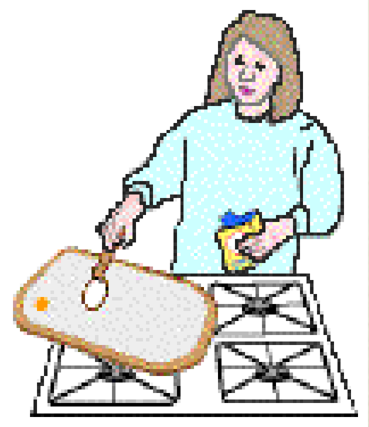
What's a Female Context?

* What stereotypically female contexts can you come up with?

New FCI contexts

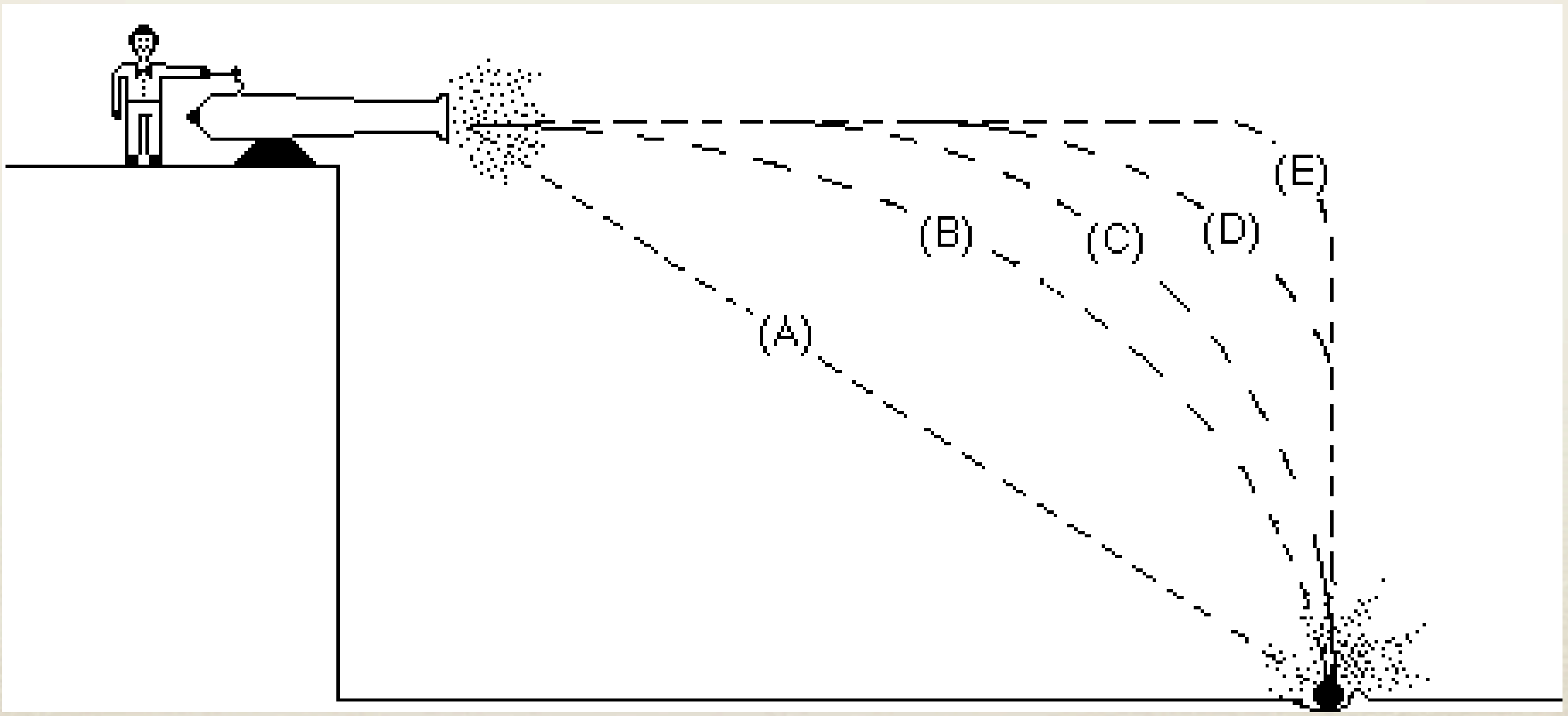






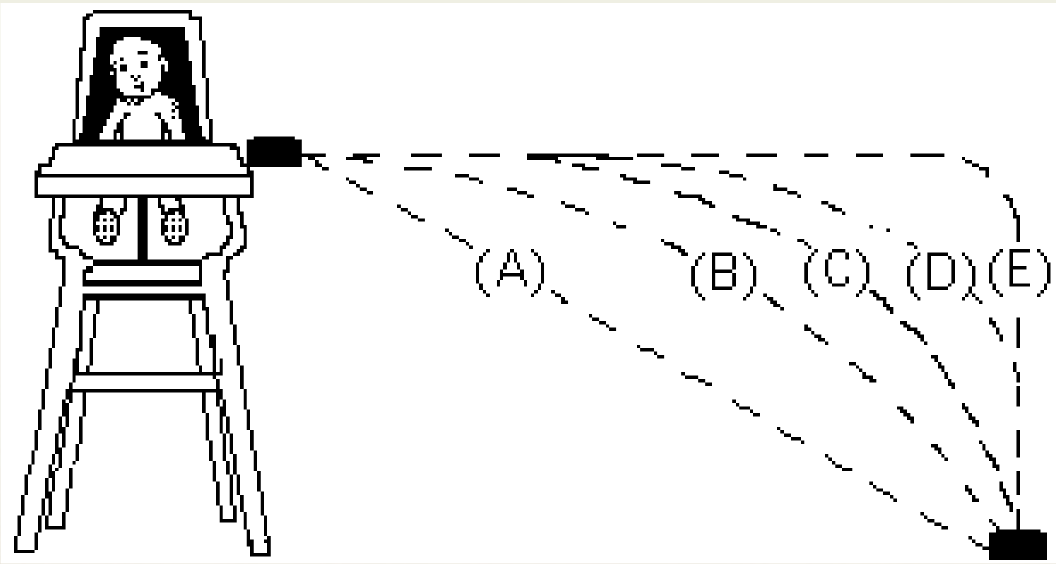
Original question

* A ball is fired by a cannon from the top of a cliff as shown in the figure below. Which of the paths would the cannon ball most closely follow?



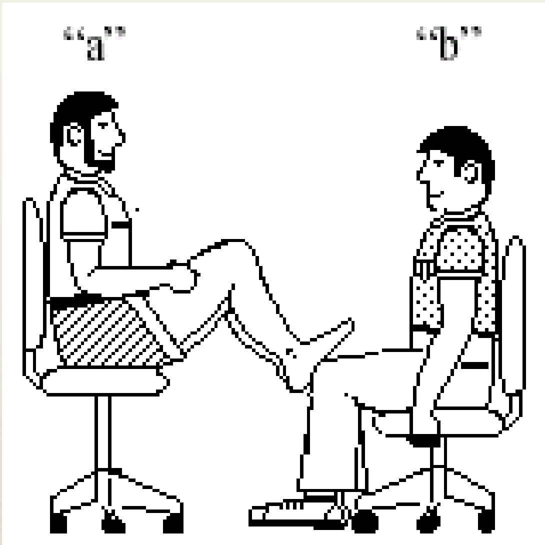
Revised question

* A baby in a high chair slides her bowl of food horizontally off the side of her flat tray with a quick push. Which path below best represents the path of the bowl?



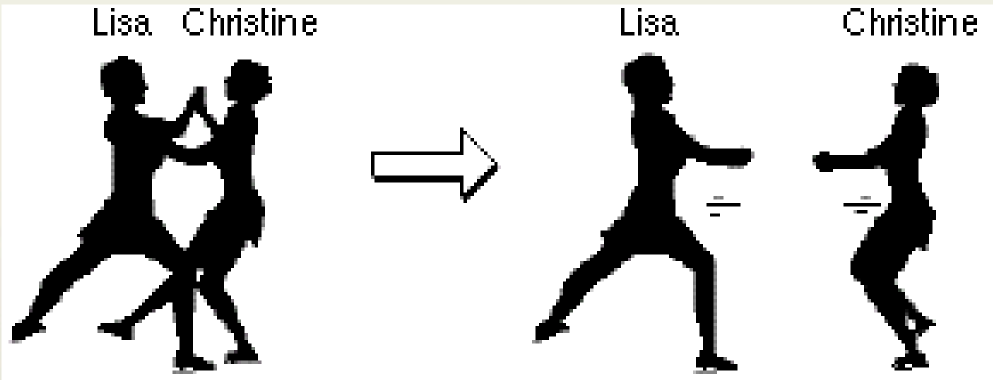
Original question

* In the figure, student “a” has a mass of 95 kg and student “b” has a mass of 77 kg. They sit in identical office chairs facing each other. Student “a” places his bare feet on the knees of student “b”. Student “a” then suddenly pushes outward with his feet, causing both chairs to move.



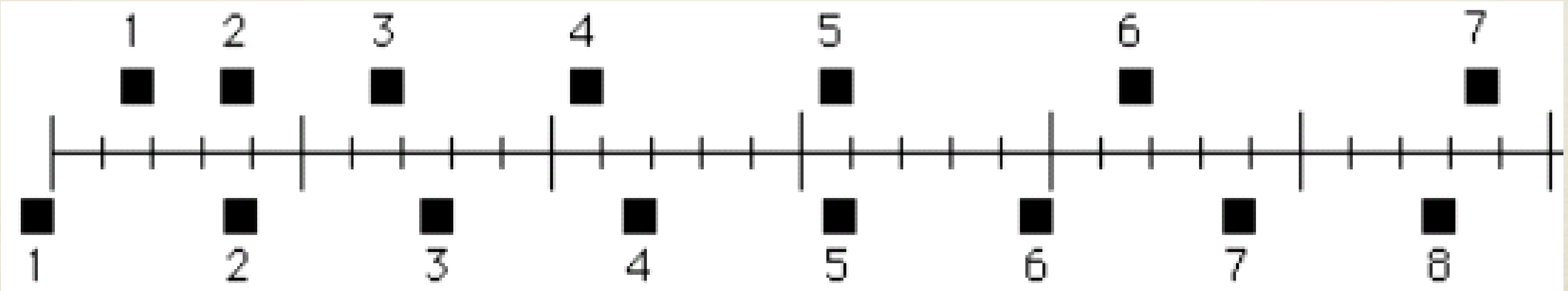
Revised question

* Two figure skaters, Lisa who has a mass of 95 kg and Christine who has a mass of 77 kg are standing on the ice with Lisa's hands braced against Christine. Lisa suddenly pushes off of Christine, causing them both to move.



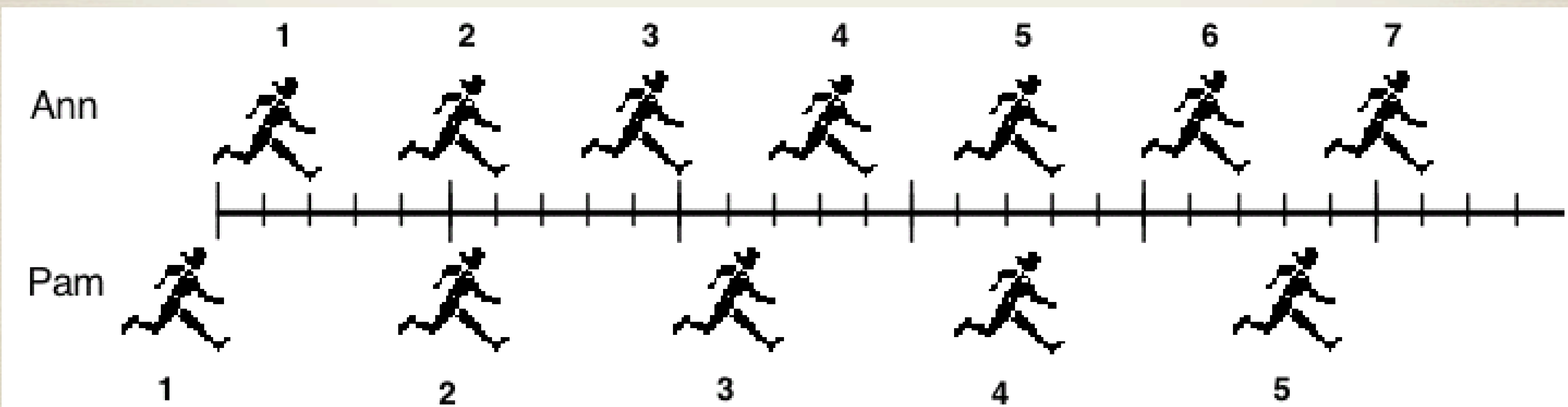
Original question

* The positions of two blocks at successive 0.20-second time intervals are represented by the numbered squares in the figure. The blocks are moving toward the right.



Revised question

* The positions of two joggers, Ann and Pam, are shown below. The joggers are shown at successive 0.20-second time intervals, and they are moving towards the right.



Testing conditions

- Four groups of data
  - Non-physics classes
  - UW-Stout physics students
    - Matched students (both tests)
  - UW-Stout physics students cued to test

Non-Physics Classes

% correct by gender and version (standard error)

	Original	Revised
Women	21.7 (0.94) N=106	22.3 (0.91) N=79
Men*	33.7 (1.9) N=56	28.5 (1.4) N=71

UW-Stout Physics-Unmatched

% correct by gender and version (pretest)

	Original	Revised
Women*	23.5 (0.95) N=99	29.4 (1.3) N=93
Men*	34.3 (0.99) N=184	39.4 (1.6) N=132

UW-Stout Physics-Matched

% correct by gender and version (pretest)

	Original	Revised
Women	25.3 (1.7) N=30	24.9 (1.4) N=30
Men	35.0 (1.6) N=100	33.6 (1.5) N=100

UW-Stout Physics-Cued

% correct by gender and version (pretest)

	Original	Revised
Women	23.3 (4.3) N=10	26.3 (2.7) N=10
Men	38.8 (3.6) N=31	38.5 (3.5) N=31

UW-Stout Physics Matched

* Average scores are the same; are they answering the questions the same? No!
* Overall an average of 13 questions answered differently; individuals had between 1 and 21 different answers
* Women averaged 15 questions different; individual answers between 5 and 21
* Men averaged 13 questions different; individual answers between 1 and 21

UW-Stout Physics Cued

- Did the cued students answer the questions the same? No!
- Overall average of 11 questions answered differently; individuals answered between 4 and 21 questions differently
- Women averaged 13 questions different; individual answers between 7 and 21
- Men averaged 10 questions different; individual answers

Questions provoking changed responses

* Looking at individual questions (not individual persons) the average % of the class changing responses to any particular question was 44%
* The biggest change was 58%, the smallest was 22% (on one question 58% of the class changed their answer)