Canadian Association of Physicists

SUPPORTING PHYSICS RESEARCH AND EDUCATION IN CANADA

TEACHING AND LEARNING ENHANCEMENT FUND

The High Cost of Science Disengagement of Canadian Youth: Reimagining Physics Teacher Education for 21st Century

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Canadian Association of Physicists Sudbury, Ontario

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Supported by UBC Teaching & Learning Enhancement Fund

a place of mind

THE UNIVERSITY OF BRITISH COLUMBIA

TEACHING AND LEARNING ENHANCEMENT FUND

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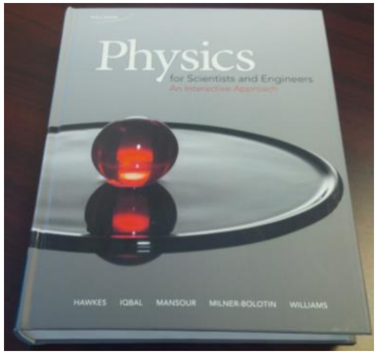
The Teaching and Learning Enhancement Fund: supporting and encouraging innovation in teaching and the learning environment

Generously supported by UBC TLEF 2012-2015: $151, 000

Dr. Marina Milner-Bolotin

- **Position:** Assistant Professor in Science Education, Faculty of Education, @ UBC
- **Field:** Math & Physics educator: K-college since 1991: Ukraine, Israel, USA, Canada (Vancouver & Toronto)
- **Passion:** Math & Science Teacher Education
- **Teaching Awards:** NSTA, UBC, Ryerson, CAP
- **Co-Author** of an undergrad. physics textbook
- **e-mail:** marina.milner-bolotin@ubc.ca
- **Web site:** http://blogs.ubc.ca/mmilner/



Outline

1. Introduction: Why should we care?
2. How do we engage our students?
   a. The value of meaningful STEM engagement
   b. What happens if we fail to engage them meaningfully
   c. Why teacher education matters
3. Reimagining physics teacher education
4. Summary: What is next

1. Why Should We Care?

Let's Talk Science. (2013). Spotlight on science learning: The high cost of dropping science and math.

AMGEN

let's talk science
inspiring discovery

Numbers Speak

1. Less than 50% of secondary graduates, complete grade 11 and 12 level math & science

2. Science disengagement costs money to students, parents, and Canada

20,000

The number of Ontario students who return each year for a fifth year of secondary school, after meeting graduation requirements[4].

$$$ - Numbers Speak

$2,790

The average cost of one semester of undergraduate university tuition or two semesters of college courses[5].

$6,111 to $10,800 per student

The institutional cost for each first-year Canadian college or university student who fails to progress to the second year[6].

$12,557

The average annual expenditure per student in publically funded schools (from Kindergarten to Grade 12) in Canada from 2011 to 2012 (ranging from $11,360 in PEI to $22,202 in the Northwest Territories)[7].

Other Report Findings

1. More job opportunities with STEM: **70%** of the top jobs require STEM, including skilled trades
2. Their earning power is higher by about **26%** regardless of whether they work in STEM or not
3. STEM is a key to modern innovation
4. Women are still underemployed in STEM fields
5. Many **skilled trades in Canada require K-12 STEM**

SKILLED WORKERS by 2020

One million

The number of skilled workers needed in Canada by 2020.

Conference Board of Canada

In 2014, Canada – 35 million people, ~18,000,000 workforce

Western Canada – Lack of Skilled Workers in Trades

Home » News » British Columbia

B.C. to make job skills main focus of education system

JUSTINE HUNTER AND JAMES BRADSHAW
VICTORIA AND TORONTO — The Globe and Mail
Published Tuesday, Apr. 29 2014, 4:06 PM EDT
Last updated Wednesday, Apr. 30 2014, 10:40 AM EDT

37 comments | 203 | 142 | 48 | 13 | +1 2 | Print / License | AA

British Columbia is shifting hundreds of millions in education dollars to force colleges and universities to produce skilled tradespeople for an expected construction boom over the next decade.

The driving force behind the changes is the province's quest for a new liquefied natural gas industry.

Industry wants the province to address the threat of a skilled labour shortage before companies make final investment decisions. The province estimates it will land $175-billion in new investment over the next decade if it can secure five LNG plants.

MORE RELATED T

Controversy over Foreign Skilled Workers Program

Globe and Mail, April 30, 2014

Canadian Report Card

Table 6:

CONFERENCE BOARD OF CANADA REPORT CARD: EDUCATION AND SKILLS IN CANADA 2013[20]

Overall	A
Secondary school completion	A
College completion	A
University completion	B
PhD graduates	D
Science, math, computer science and engineering graduates	C

Gender Gaps in STEM Education & Employment

THE PERCENTAGE OF FEMALE REGISTERED APPRENTICES IN “STEM-HEAVY” TRADES[12]

TRADE	1995	2000	2005	2010
Electronics	3	4	5	9
Heavy-duty equipment mechanic	1	0	1	2
Machinists	2	2	3	3
Millwrights	1	1	2	2
Plumbers, pipefitters	1	1	1	2
Welders	1	3	4	6

Gender Gaps in STEM Education & Employment

Table 4:
A COMPARISON OF AVERAGE EARNINGS OF MALE AND FEMALE DEGREE HOLDERS IN VARIOUS PROGRAMS OF STUDY[13]

AREA OF STUDY	MALE GRADUATE EARNINGS	FEMALE GRADUATE EARNINGS
Physics	$40,216	$31,545
Civil engineering	$60,000	$49,242
Nursing	$53,764	$47,985
Business administration	$48,405	$39,295

2. How do we engage our students?

1. Introduction: Why should we care?
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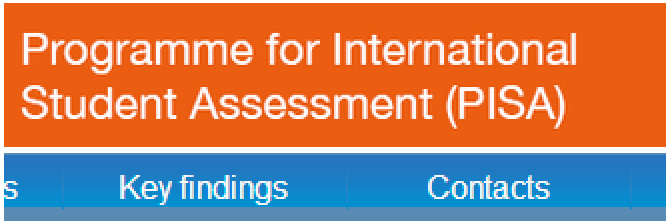
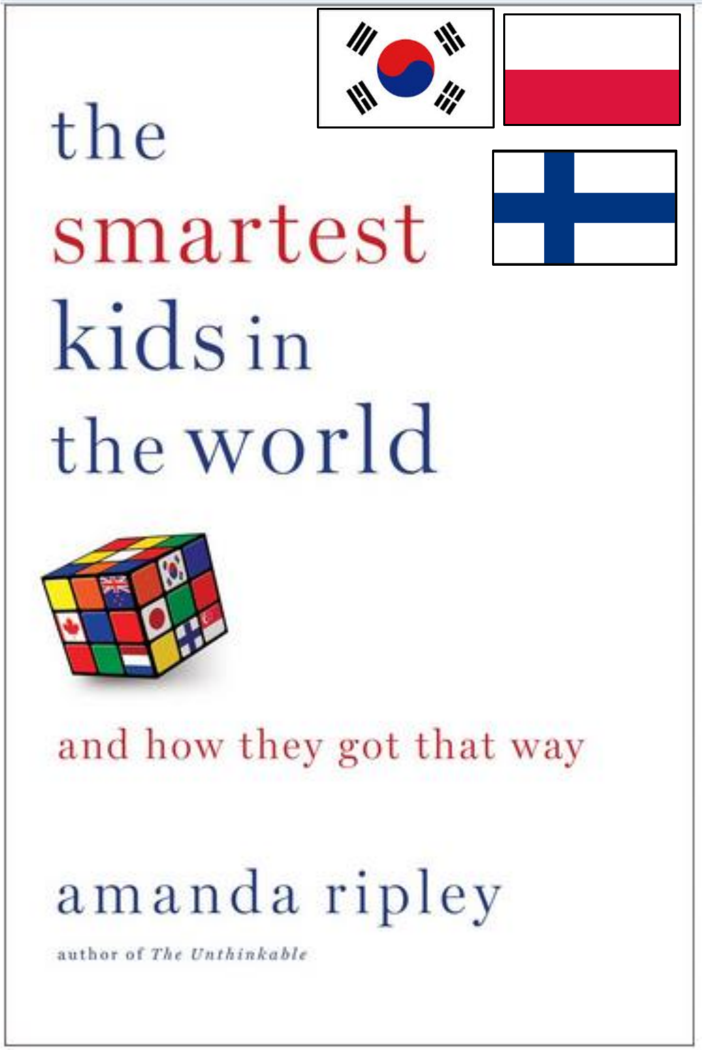
Intro: Why are our students disengaged from STEM?

OECD
BETTER POLICIES FOR BETTER LIVES



http://www.oecd.org/



Amanda Ripley: The Smartest Kids in the World…

Australian Broadcasting Corporation

Broadcast: 27/01/2014

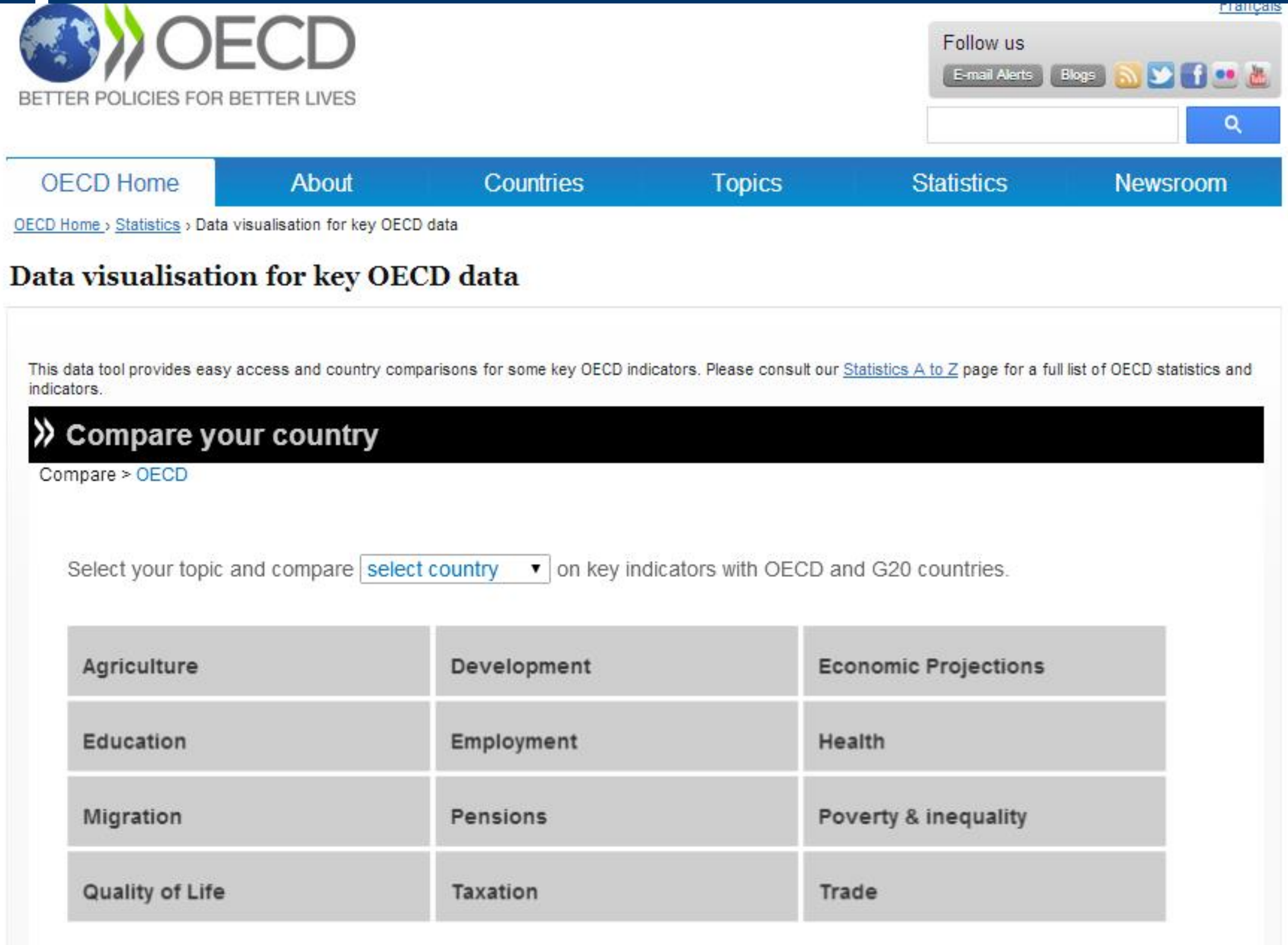
Reporter: Leigh Sales

Print

Some Ideas from the Book

1. Rigour for students and for **teachers:** doing work worth doing
2. Getting **used to productive failure**
3. Giving meaningful praise that is earned
4. Teachers’ quality is vital into prestige
5. Teachers’ **life long learning** and support

STEM Engagement across the World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This data tool provides easy access and country comparisons for some key OECD indicators. Please consult our Statistics A to Z page for a full list of OECD statistics and indicators.

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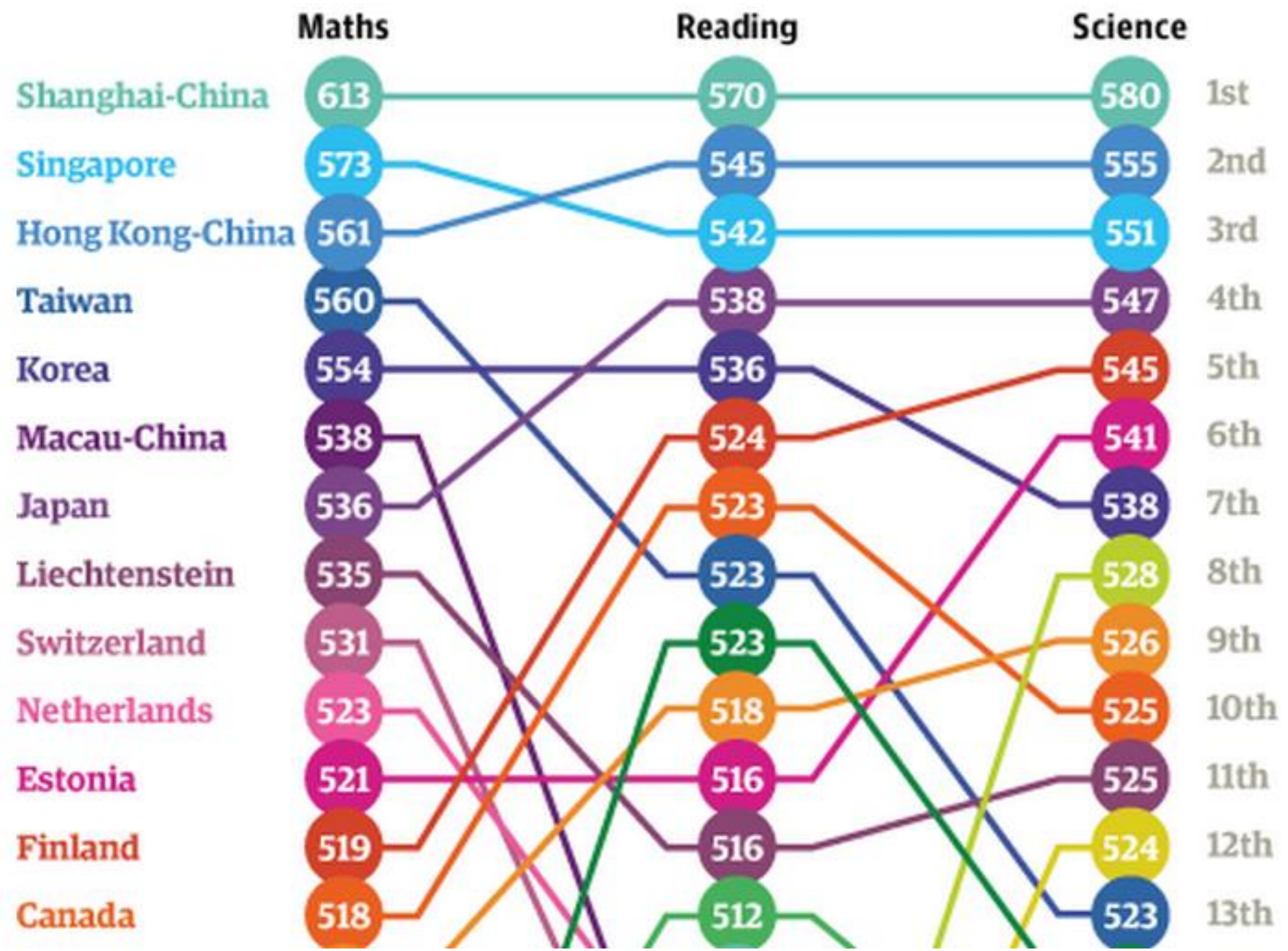
Compare > OECD

Select your topic and compare select country on key indicators with OECD and G20 countries.

Agriculture	Development	Economic Projections
Education	Employment	Health
Migration	Pensions	Poverty & inequality
Quality of Life	Taxation	Trade

PISA 2012 Results



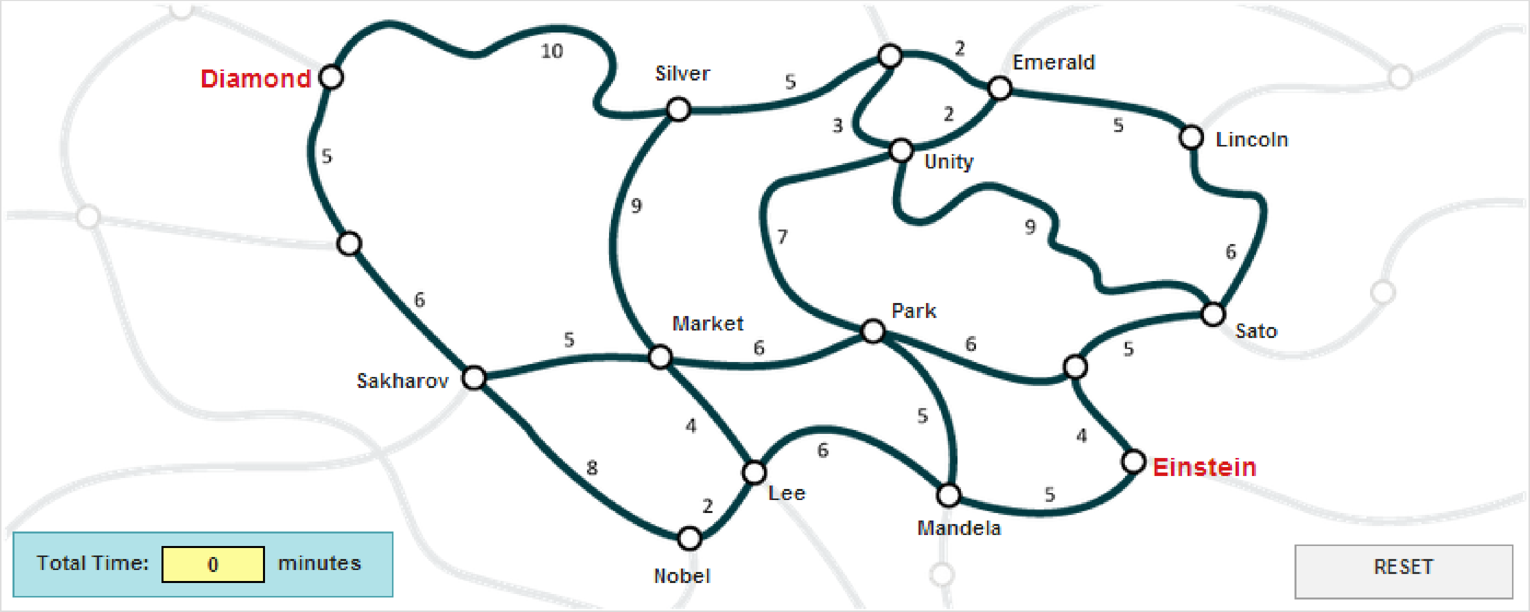
[OECD, PISA 2012 Results]

Example of a PISA Question

TRAFFIC

Here is a map of a system of roads that links the suburbs within a city. The map shows the travel time in minutes at 7:00 am on each section of road. You can add a road to your route by clicking on it. Clicking on a road highlights the road and adds the time to the **Total Time** box.

You can remove a road from your route by clicking on it again. You can use the RESET button to remove all roads from your route.



Question : TRAFFIC

Maria wants to travel from Diamond to Einstein. The quickest route takes 31 minutes. Highlight this route.

SUBMIT

RESULTS

Example of a PISA Question

Home | About PISA | PISA products | Key findings | Contacts

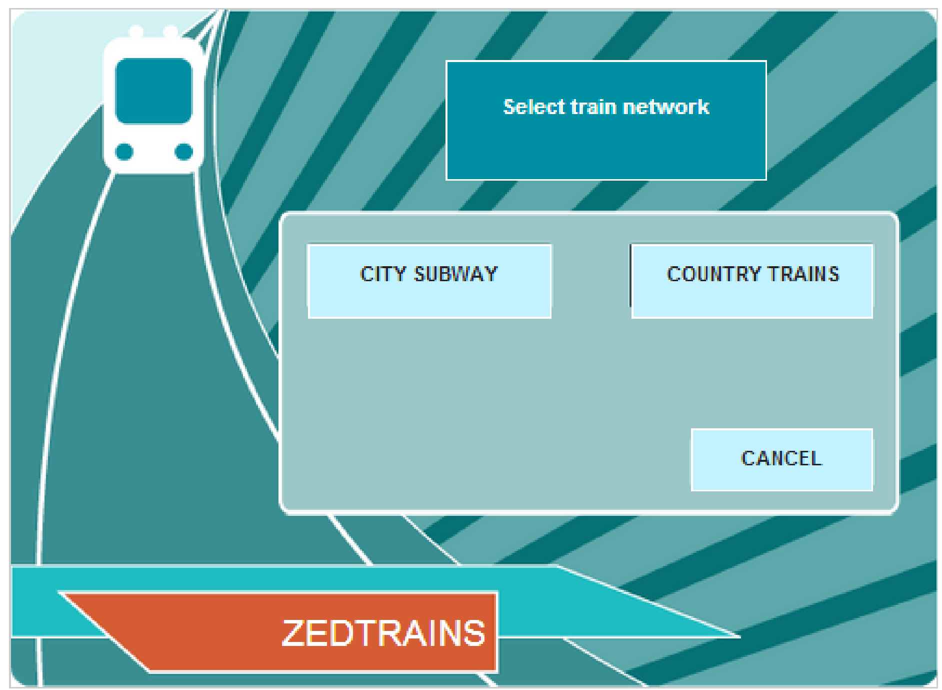
PISA › Try the test › Test questions › Question 4

TICKETS

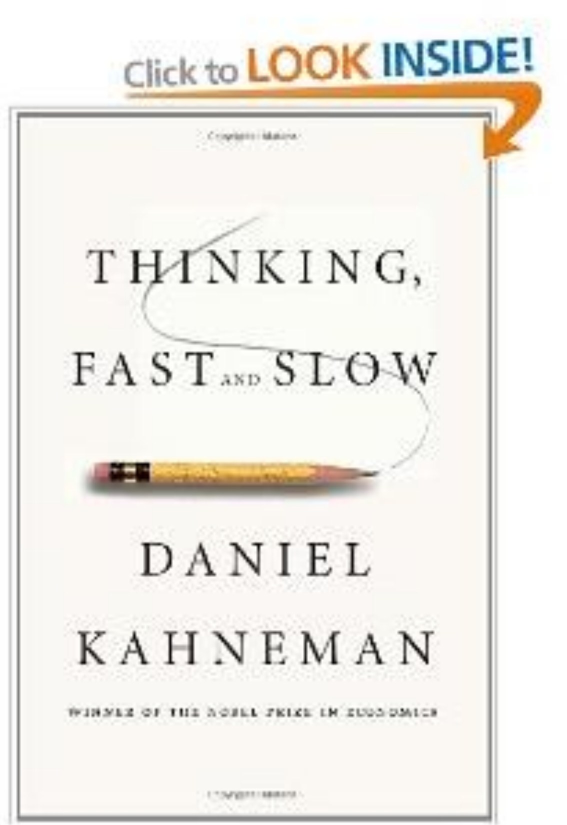
A train station has an automated ticketing machine. You use the touch screen on the right to buy a ticket. You must make three choices.

- Choose the train network you want (subway or country).
- Choose the type of fare (full or concession).
- Choose a daily ticket or a ticket for a specified number of trips. Daily tickets give you unlimited travel on the day of purchase. If you buy a ticket with a specified number of trips, you can use the trips on different days.

The BUY button appears when you have made these three choices. There is a CANCEL button that can be used at any time BEFORE you press the BUY button.



The Value of Meaningful STEM Engagement

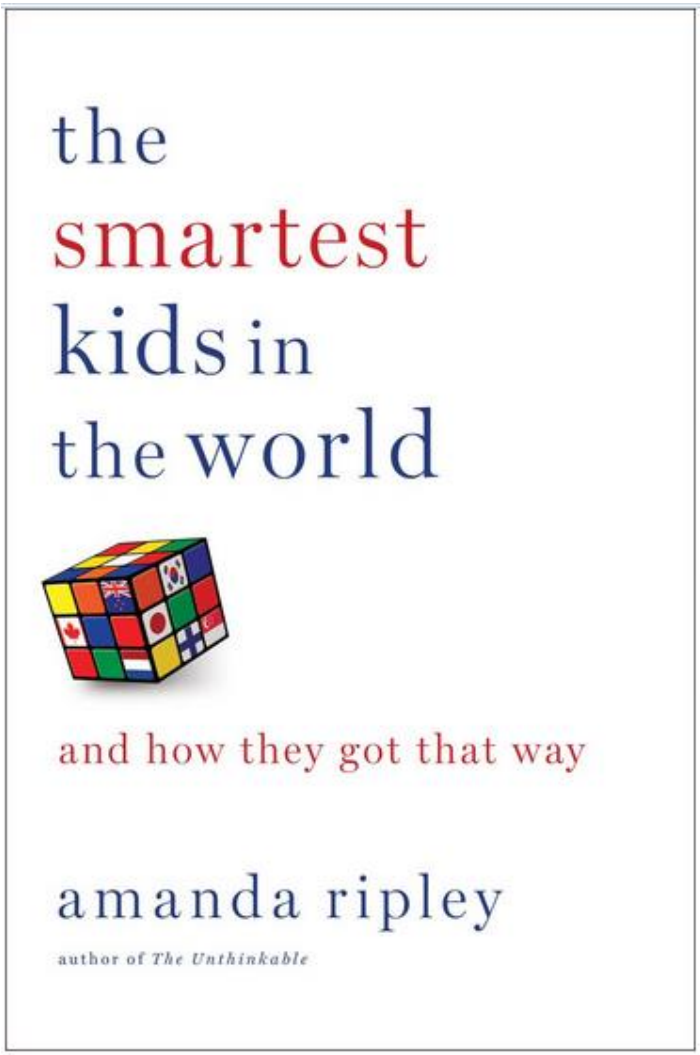


Central thesis: a dichotomy between two modes of thought:

"System 1" is fast, instinctive and emotional; "System 2" is slower, more deliberative, and more logical.

It delineates cognitive biases associated with each type of thinking by highlighting several decades of academic research to suggest that people place too much confidence in human judgment.

Why Teacher Education Matters



Prof. Maija Aksela, Helsinki, Finland

If we want to change how our students learn science we have to change how we prepare teachers, who goes into K-12 teaching, and how teachers' professional development is organized

3. Reimagining Physics Teacher Education

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Physics Teacher Education

LUMAT 1(5), 2013 [LUMAT: Research and Practice in Math, Science & Technology Education, 2013. **1**(5): p. 525-544.]

Modeling Active Engagement Pedagogy through Classroom Response Systems in a Physics Teacher Education Course

Marina Milner-Bolotin
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Heather Fisher
Department of Curriculum and Pedagogy, Faculty of Education, The University of British Columbia

Alexandra MacDonald
Department of Curriculum and Pedagogy, Faculty of Education, The University of British Columbia

Abstract One of the most commonly explored technologies in Science, Tech
and Mathematics (STEM) education is Classroom Respo
instructors generate in-class discussion by solici

Teacher Education Should Model Good Teaching Practices

1. Rigour for students and for **teachers:** doing work worth doing
2. Getting **used to productive failure**
3. Giving meaningful praise that is earned
4. Teachers' quality is vital – it takes time to prepare good STEM teachers
5. Teacher-candidates **should be mentored - life long learning** and support

PER Upcoming issue of *PiC* (Vol. 69, Summer Issue)

PiC volume is devoted to Physics Education Issues, Editors (C. Kalman, T. Antimirova and N. Lasry)

Physics in Canada Paper submission for a special PER issue

By Marina Milner-Bolotin

Department of Curriculum and Pedagogy, Faculty of Education, UBC

e-mail: marina.milner-bolotin@ubc.ca

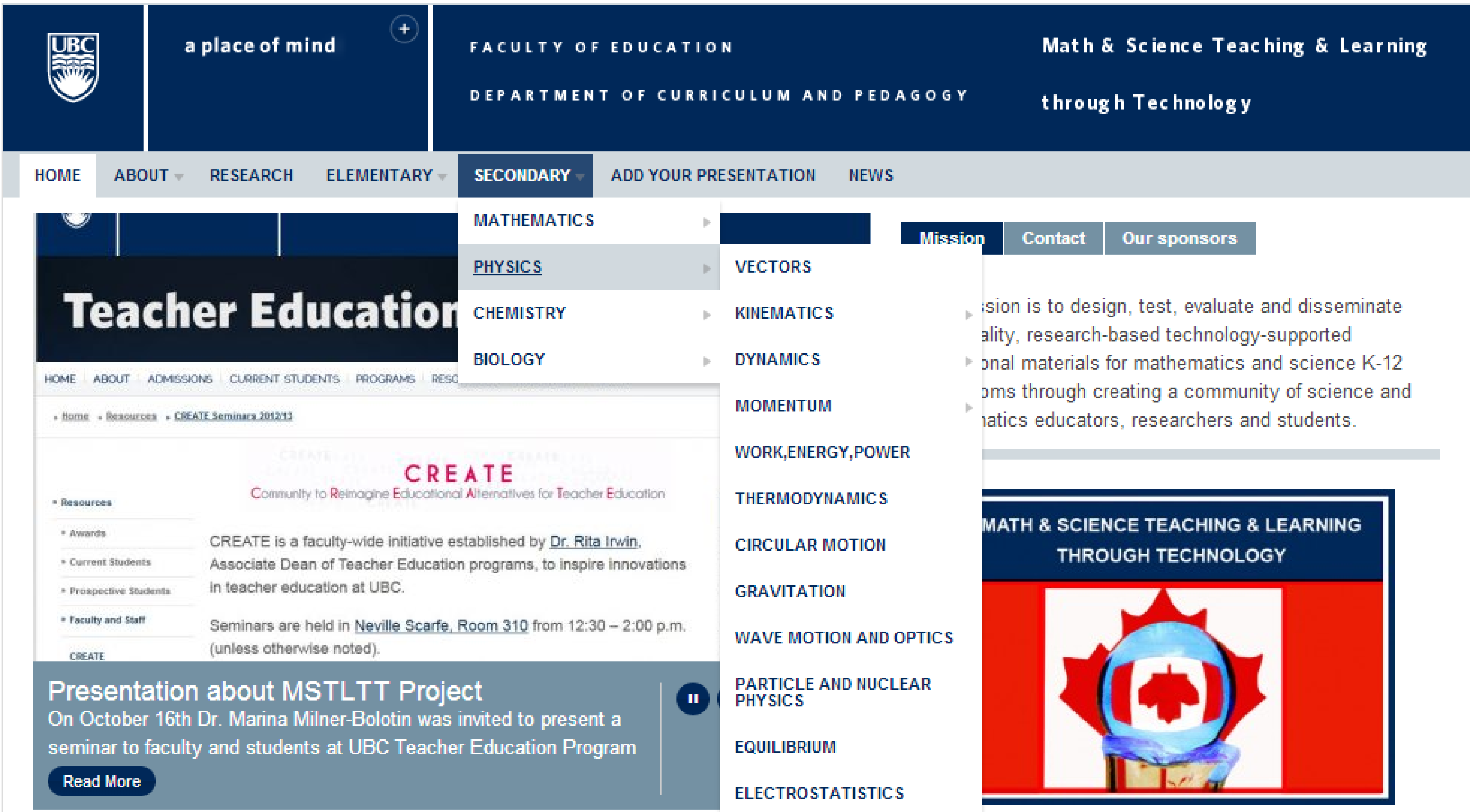
Title: Promoting Research-Based Physics Teacher Education in Canada: Building Bridges between Theory and Practice

Key words: physics teacher education, physics education research, educational technologies, conceptual understanding, Technological Pedagogical Content Knowledge.

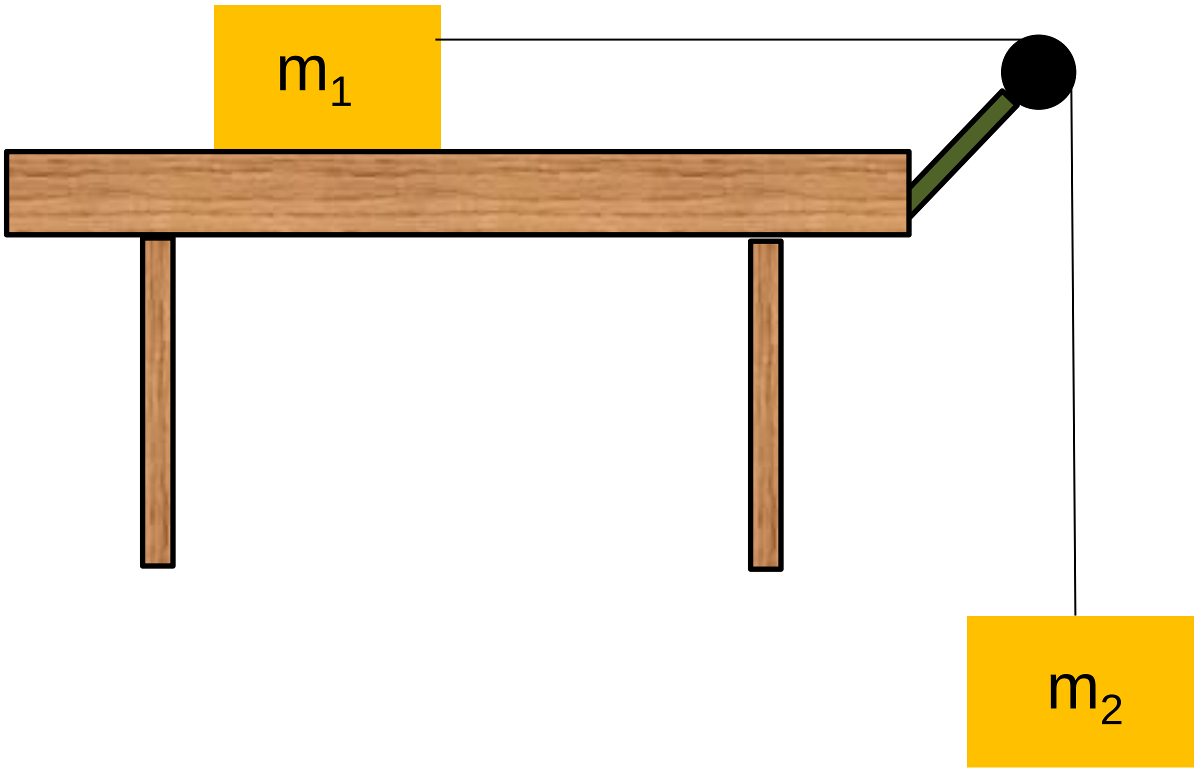
Abstract

For more than thirty years, extensive evidence has ...
... physics undergraduates. Some ...

Teacher Education Resources should be Based on Research

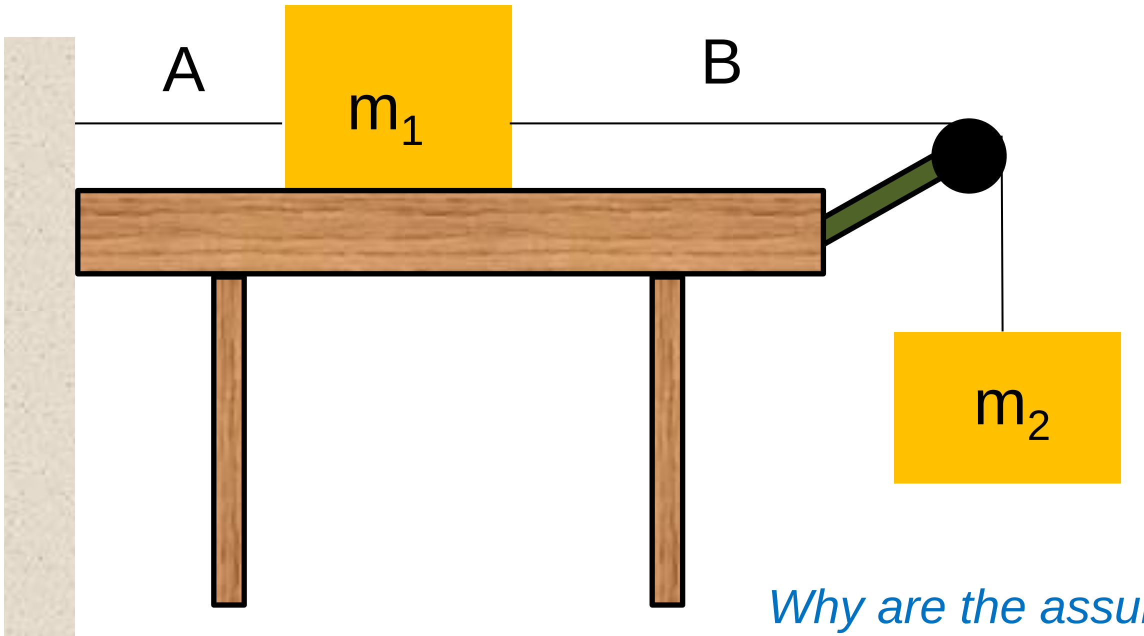


Blocks and a Pulley



Blocks and a Pulley II

Two blocks are connected via a pulley. The blocks are initially at rest as block m_1 is attached to a wall. If string A breaks, what will the accelerations of the blocks be? (**Assume** friction is very small and strings don't stretch)



A. $a_1 = 0;\ a_2 = 0$

B. $a_1 = g;\ a_2 = g$

C. $a_1 = 0;\ a_2 = g$

D. $a_1 = g;\ a_2 = 0$

E. None of the above

Why are the assumptions above important?

Solution

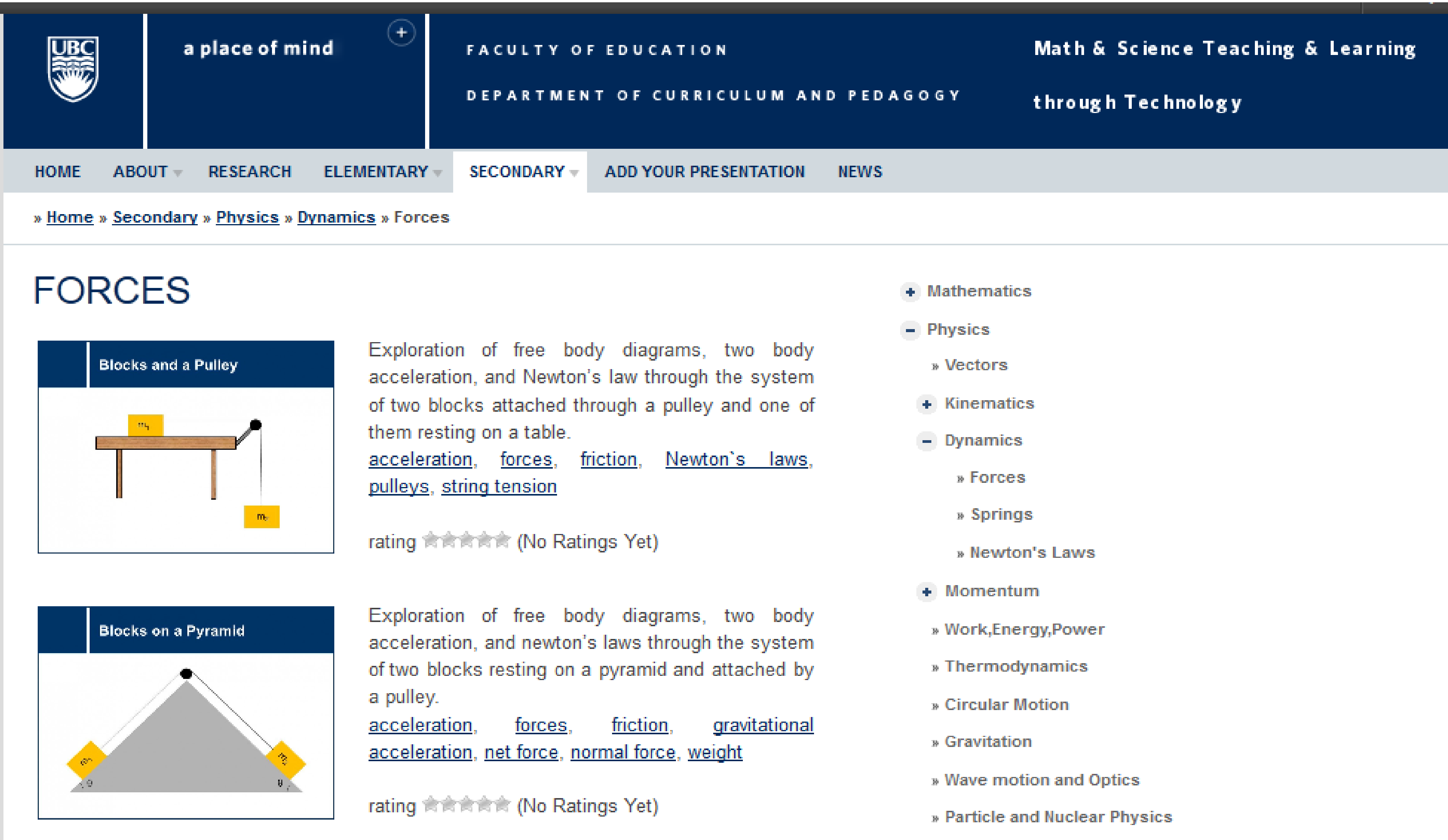
Answer: E

Justification: None of the above answers is correct. Consider two blocks as one system: one can see that the system has a mass of (m_1+m_2), while the net force pulling the system down is m_1g. Therefore, applying Newton's second law, one can see that the acceleration of the system must be less than g:

$$a = \frac{m_2 g}{(m_1 + m_2)} = \frac{m_2}{(m_1 + m_2)} g < g$$

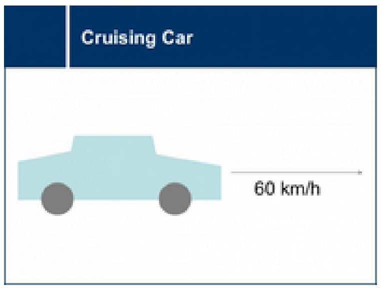
Some people think that the acceleration will be g. They forget that the system consists of two blocks (not just m_1) and the only pulling force is m_1g. Thus the system is NOT in a free fall. Compare this questions to the previous one to see the difference.

Navigating the Resource



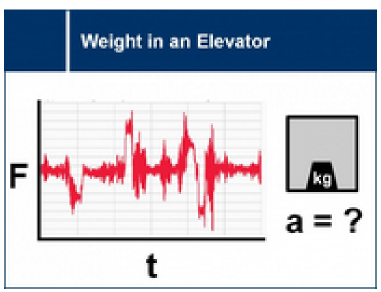
Navigating the Resource

rating (No Ratings Yet)



An introduction to acceleration and newton's laws using a demonstration of a commuting car.
acceleration, displacement, distance, forces, net force, velocity

rating (No Ratings Yet)



How does a reading on a scale change when on a moving elevator? Scenarios with an elevator moving at different velocities and acceleration will be considered. The concepts learned will then be used to analyze data from a real-life experiment.
acceleration, gravitational acceleration, mass, net force, normal force, real-life data, velocity, weight

rating (No Ratings Yet)

The following set of questions apply Newton's Second Law to scenarios with multiple blocks held together by the tension force from strings.

acceleration area centripetal force common ratio conservation of energy conservation of momentum Conversion Factors counting current displacement distance elastic collisions forces frames of reference free-body diagrams friction graphs gravitational acceleration gravitational potential energy inelastic collisions kinetic energy molar mass mole net force normal force numbers patterns percentages permutations power probability projectile motion ratios rectangles resistance sequences series tension triangles trigonometry unit circle vectors velocity voltage weight

http://scienceres-edcp-educ.sites.olt.ubc.ca/

Are Good Recourses Enough?

1. Teachers need to want to use these resources and to be supported by Science Educators.
2. Resources are only as good as the teachers can make pedagogically effective use of them

4. What is Next?

1. Introduction: Why should we care?
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STEM in Canada: Can We afford to keep our educational system?

I hope that Canadian Educational System will undergo a major transformation in this century (like Finland did):

a) Teaching should become a **profession**, not a job
b) Teachers should be paid adequately and supported
c) Teacher Education Programs should accept highly-qualified candidates (the best ones)
d) Teachers should be held **accountable for the quality of their work**
e) Teaching should become one of the most desirable, respected and valued professions in Canada.

Teachers Matter

Français

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Attracting, Developing and Retaining Effective Teachers - Final Report: Teachers Matter

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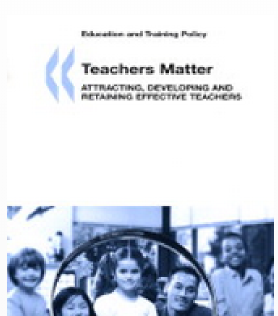

Attracting, Developing and Retaining Effective Teachers - Final Report: Teachers Matter

Teachers Matter provides a comprehensive, international analysis of trends and developments in the teacher workforce in 25 countries around the world; research on attracting, developing and retaining effective teachers; innovative and successful policies and practices that countries have implemented; and teacher policy options for countries to consider. While documenting many areas of concern about teachers and teaching, the report also provides positive examples of where policies are making a difference. It spotlights countries where teachers' social standing is high, and where there are more qualified applicants than vacant posts. Even in countries where shortages have been a

The 2014 CAP HS Teaching Award

2014 Medal Winners | francais

CANADIAN ASSOCIATION OF PHYSICISTS

ASSOCIATION CANADIENNE DES PHYSICIENS ET PHYSICIENNES

PRESS RELEASE / FOR IMMEDIATE RELEASE

The 2014 CAP Award for Excellence in Teaching High School/CEGEP Physics (British Columbia and Yukon)

is awarded to

Ms. Susan Hunter-Jivung

The Canadian Association of Physicists (CAP) is pleased to announce that the 2014 CAP Award for Excellence in Teaching High School/CEGEP Physics (British Columbia and Yukon) is awarded to Ms. Susan Hunter-Jivung, Lord Tweedsmuir Secondary School, her expertise in encouraging students to attain the highest standards in physics, which have resulted in her students receiving a broad range of local and national awards in physics.

Susan Hunter-Jivung has devoted much of her time to recruiting, mentoring and inspiring teens to embrace physics challenges at the university level. She runs physics and science challenge clubs which undertake many competitions and supports students in the pursuit of excellence. This has resulted in much success and seven consecutive years of regional and national science fair winners. In 2012, Susan was recognized by the South Fraser Science Fair with the award for the outstanding teacher mentor.

As an innovative teacher, Susan served on the advisory committee for technology in the science 9 curriculum. This lead to the adoption of Vernier materials and a number of web based activities. Through mentoring a SFU program she taught new applications guiding teachers into renewed practice. Susan is a regular presenter at teaching conferences. Her topics include energy conservation, new technologies and equality awareness. Over the past three years she has been working with her physics students on pilot projects for BC Hydro, Translink, and Pulse Energy on energy issues. She has incorporated PHET, video making and facebook into her physics classroom.

Susan became involved with being a teacher sponsor for the introduction of the international Physics Masterclass to BC universities. She held after school tutorials for participants, to prepare for the workshops on particle Physics. Her involvement has been described by Marcello Pavan of Triumf at UBC as: “absolutely invaluable, helping us develop the program during the first few nascent attempts at the Masterclasses - it is clear that not only does she care deeply about her students and their learning, she is a dedicated educator with very high standards.”