



*Chaoyang School District Professional Development  
Course May 19-30 2015*



# Teaching Math & Science With Technology in the 21<sup>st</sup> Century

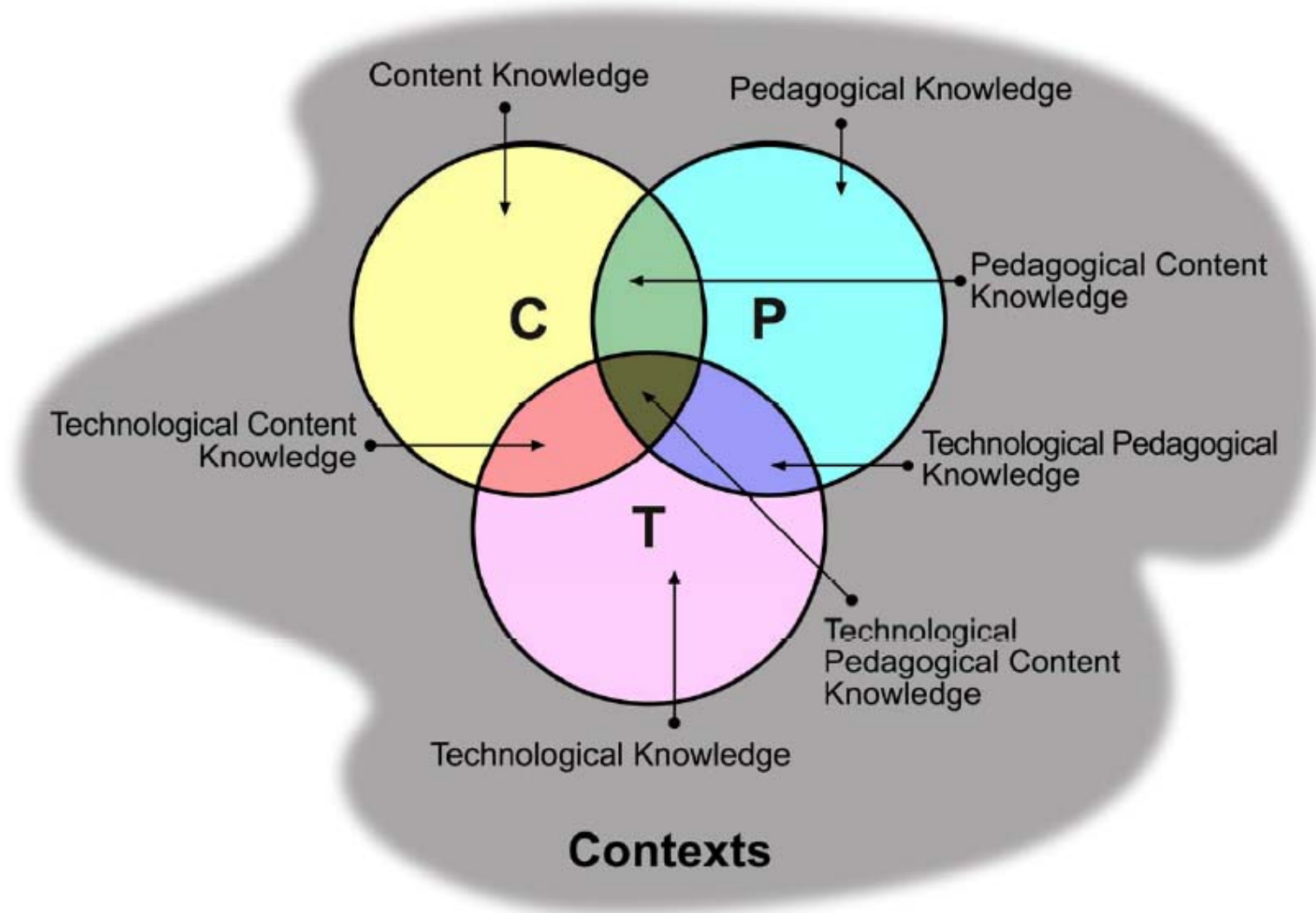


朝陽區 朝阳区

**Dr. Marina Milner-Bolotin**

**Day 2 - May, 2015**

# Day 2 – May 2015



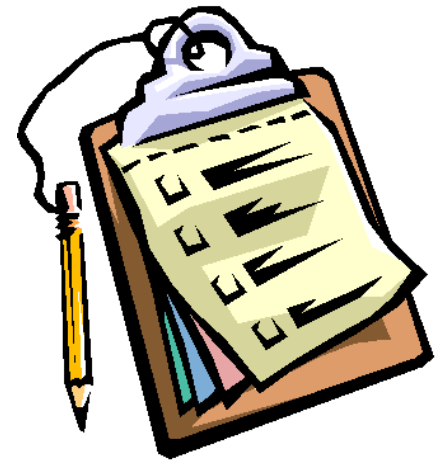
# I

## Course Tentative Schedule

Day	Technology	
1	Student engagement: Clickers, multimedia	✓
2	Peer Instruction and PeerWise: inquiry via questioning; Exploring GeoGebra	✓
3	Data collection and analysis; Desmos	
4	Computer simulations, games, and online learning environments	
5	Summary and projects' presentations	

# Agenda for the Day

- I. Active engagement: Peer Instruction Pedagogy
- II. Group activity: Designing conceptual math and science multiple-choice questions
- III. PeerWise Pedagogy introduction
- IV. PeerWise activity (group work)
- V. Group activity: Exploring GeoGebra
- VI. Summary of the day



# Agenda for the Day

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# I

# Active Engagement

## Group activity

1. What activities are your students engaged in your math and science classes?
2. Why do you choose these activities?
3. What learning do they promote?



# I

# Peer Instruction

**Have you heard of (used) Peer Instruction  
(clickers) outside of this course?**

1. Yes
2. No

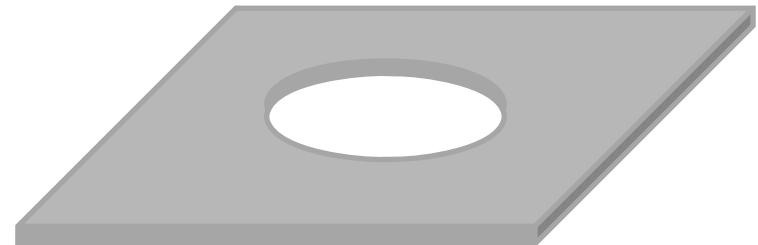


# Metal Expansion Puzzle



You have a uniform metal plate with a circular hole inside it. You heat it up by  $200^{\circ}\text{C}$ . **As a result of heating, the hole will:**

1. Increase
2. Decrease
3. Remain the same

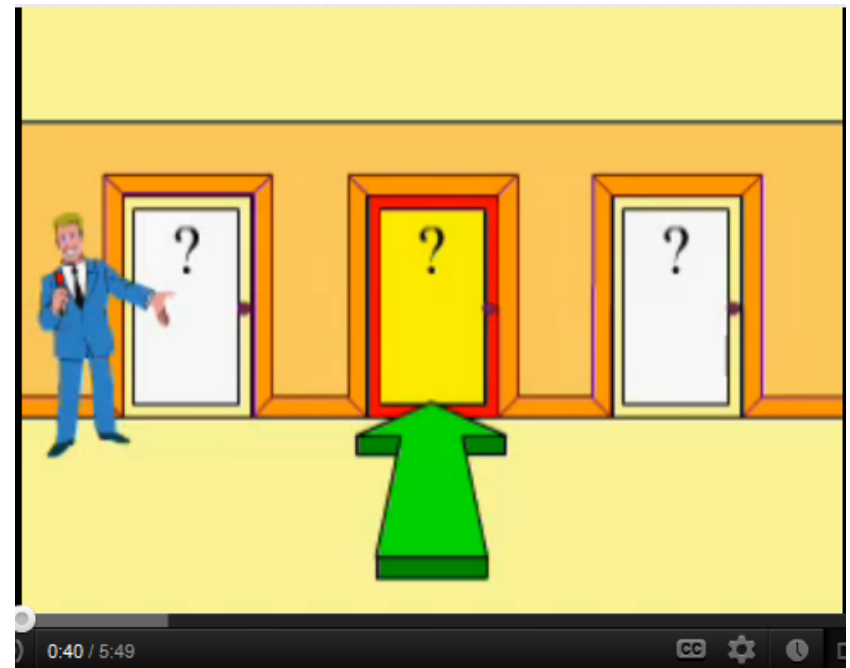




# The Monty Hall Problem: Let Us Make a Deal

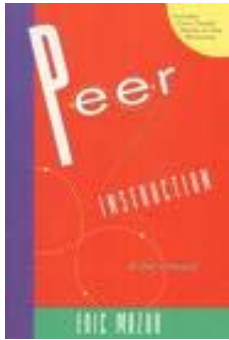


- A. Stick with the original choice
- B. Swap doors
- C. It doesn't matter



# I

# Peer Instruction



INTERACTIVE TEACHING  
Promoting Better Learning Using Peer Instruction and Just-in-Time Teaching

FEATURING the award-winning documentary  
FROM QUESTIONS TO CONCEPTS  
with Harvard Physics Professor Eric Mazur

Star Trek Award, 2005 WorldFest-Houston International Film Festival  
Bronze Plaque, 2004 Columbus International Film Festival  
Award of Distinction, 2006 Communicator Awards



Peer Instruction for Active Learning - Eric Mazur



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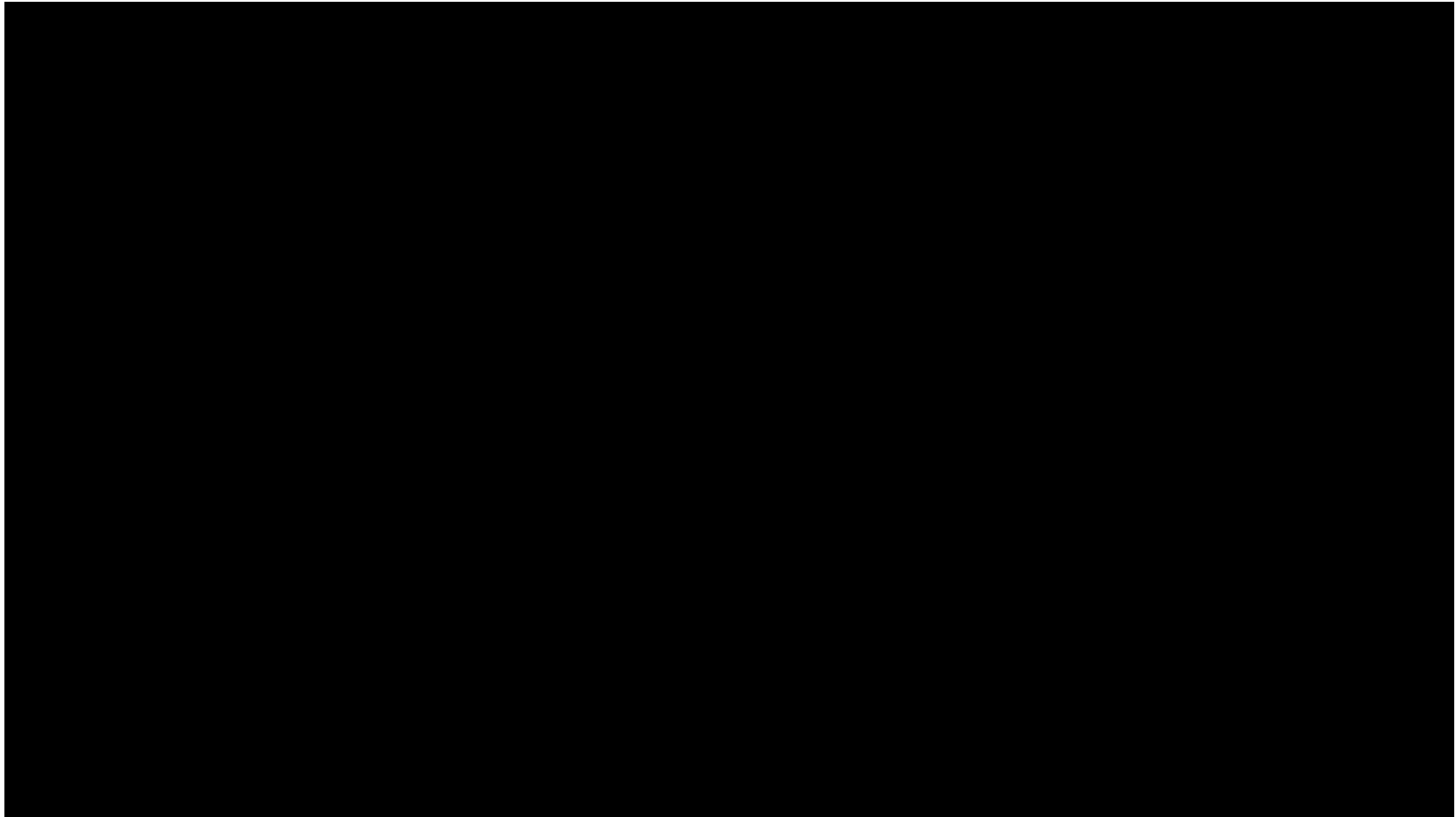
5,782

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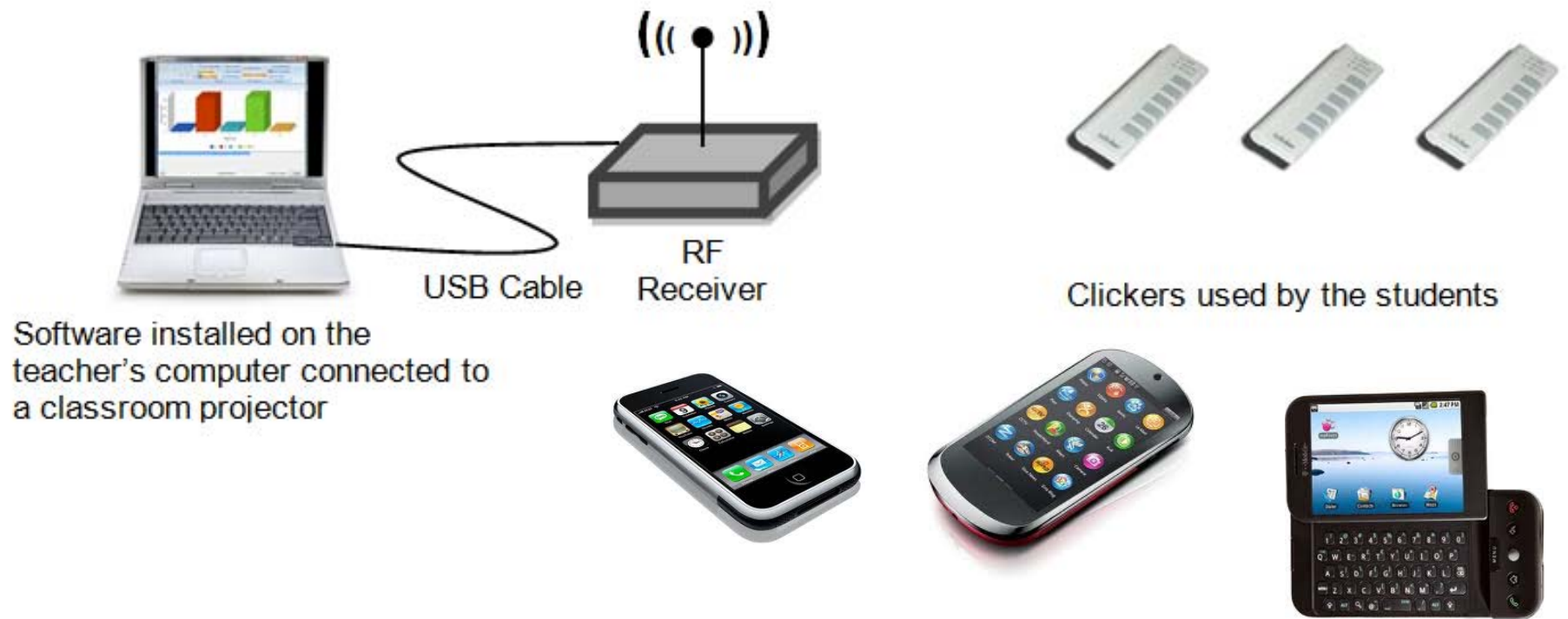
I

# Peer Instruction



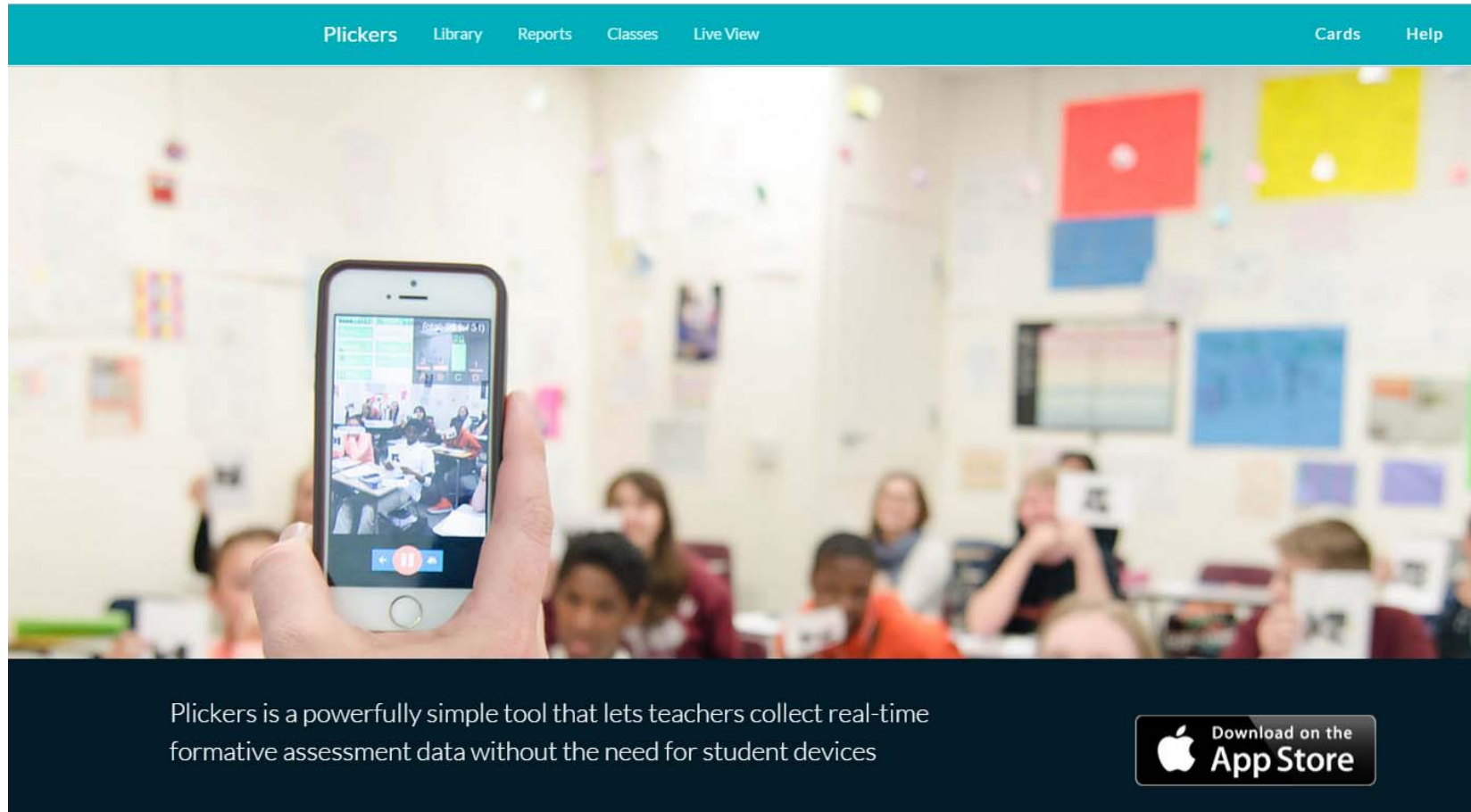
# I

# Technology for Peer Instruction



In near future smart phones, i-pads and other devices will replace clickers, **but the basic pedagogy will remain the same...**

# Technology for Peer Instruction - Plickers

The banner features a teal navigation bar at the top with links for 'Plickers', 'Library', 'Reports', 'Classes', 'Live View', 'Cards', and 'Help'. Below the navigation bar is a photograph of a hand holding a smartphone in a classroom. The phone's screen displays the Plickers app interface, which includes a grid of student photos and a 'Plickers' title. In the background, several students are seated at desks, holding up white cards with QR codes. The bottom of the banner has a dark blue background with white text and an Apple App Store download button.

Plickers is a powerfully simple tool that lets teachers collect real-time formative assessment data without the need for student devices

Download on the App Store

<https://www.plickers.com/>

# I

# Clicker-enhanced Pedagogy

## Stage 1

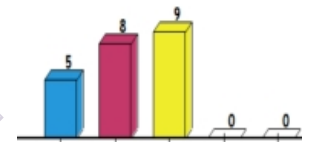
- Pose a multiple-choice science question

## Stage 2

- Students are given time to think and enter their individual responses using clickers (vote)

## Stage 3

- The responses are aggregated and displayed and a peer discussion follows



## Stage 4

- Students have a chance to vote again

## Stage 5

- Whole class discussion about correct, as well as incorrect responses (reasons for each)





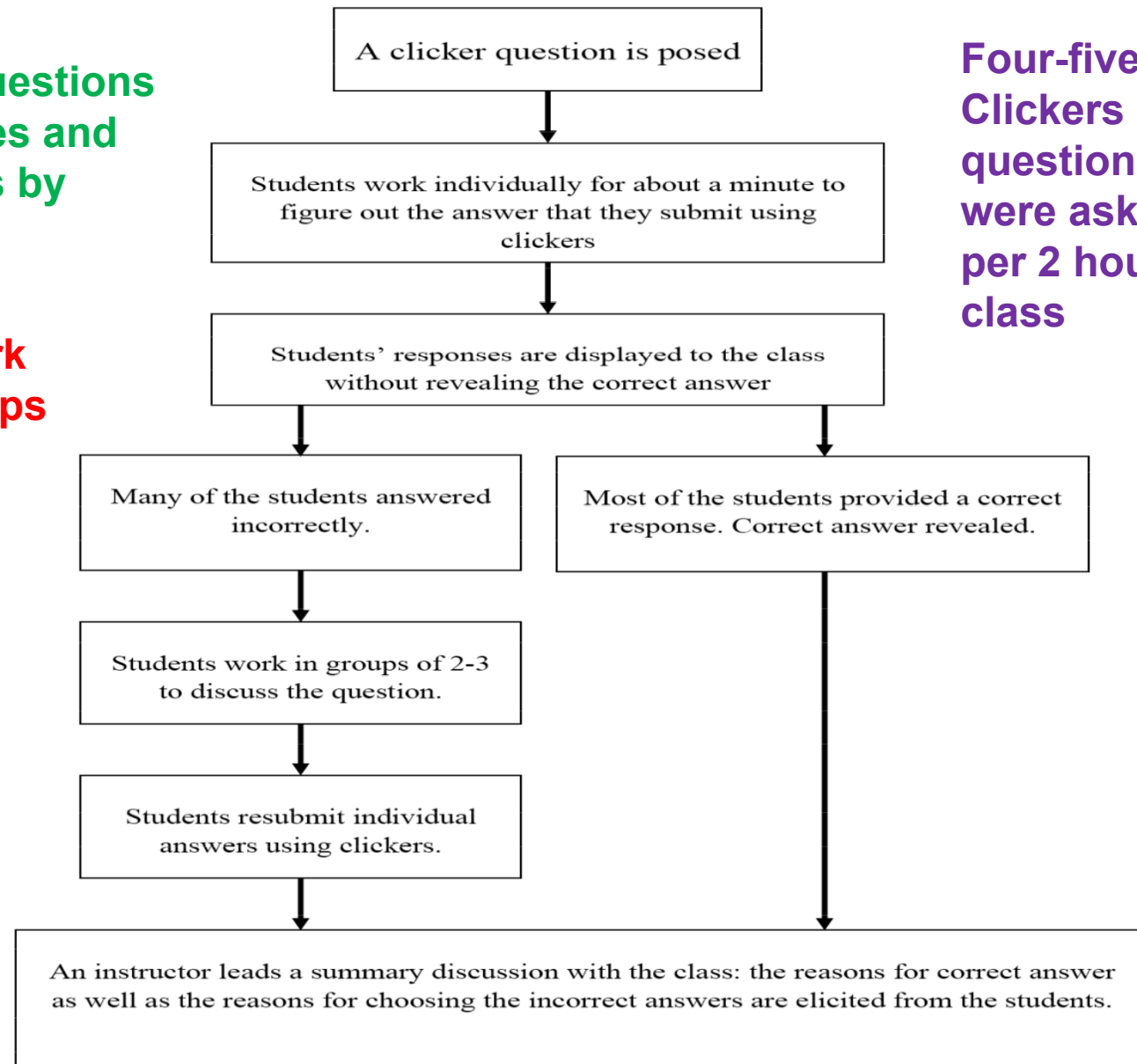
# Modified Peer Instruction

We design conceptual questions for our courses and use questions by others

Students work in small groups (of 2-3) to figure out conceptual questions

The answers to these questions are tested using simulations, demos, etc.

5/5/2015



Four-five Clickers questions were asked per 2 hour class



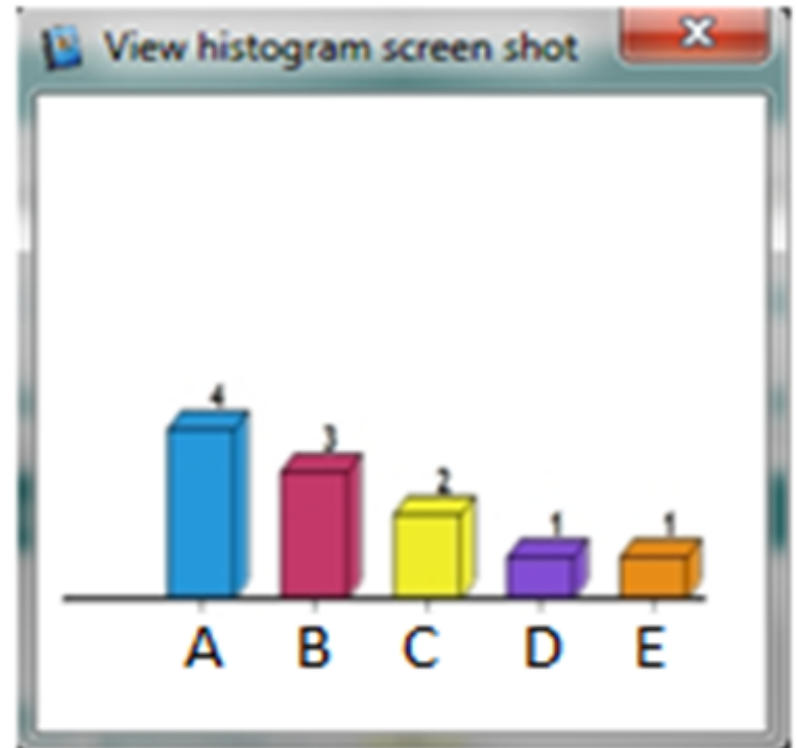
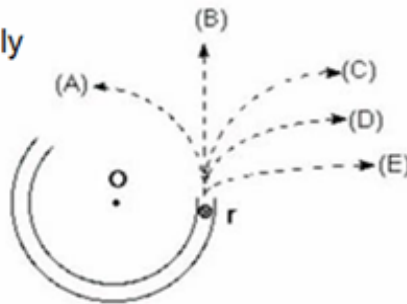
## I

# Challenging Assumptions

## Question

A ball travels through the circular track until point  $r$ , at which point it leaves the channel to travel across a frictionless floor. Assume a bird's eye view, and that all motion is in the horizontal plane.

Which path will the ball most closely follow after it exits the channel?



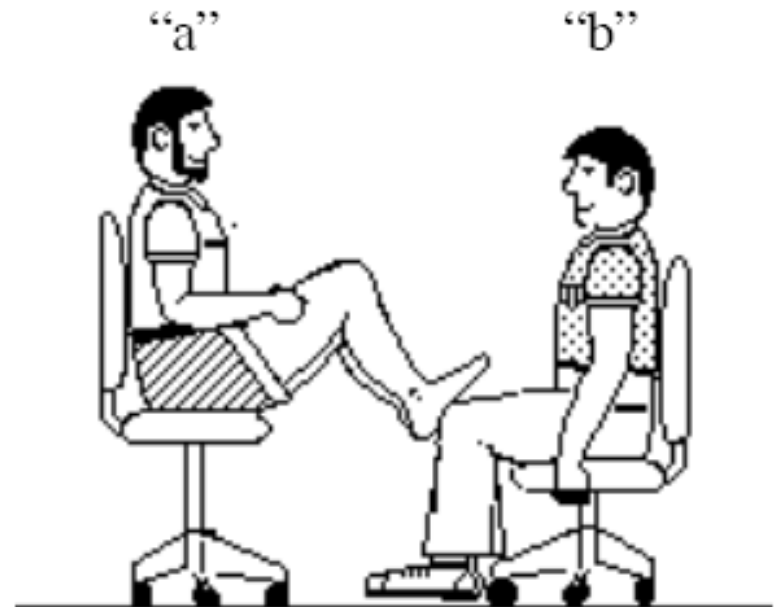
**Answers given by pre-service physics teachers**



# Force Concept Inventory Example

28. In the figure at right, 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", as shown. Student "a" then suddenly pushes outward with his feet, causing both chairs to move.



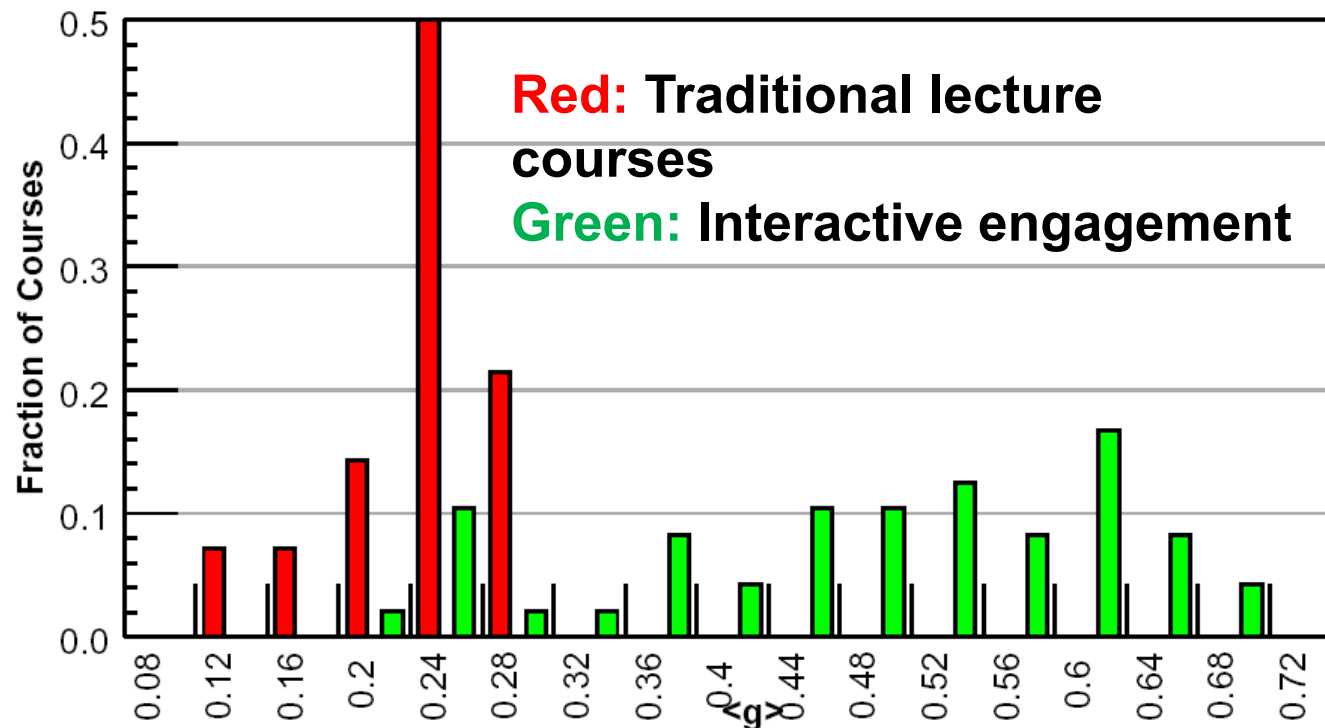
During the push and while the students are still touching one another:

- (A) neither student exerts a force on the other.
- (B) student "a" exerts a force on student "b", but "b" does not exert any force on "a".
- (C) each student exerts a force on the other, but "b" exerts the larger force.
- (D) each student exerts a force on the other, but "a" exerts the larger force.
- ➡ (E) each student exerts the same amount of force on the other.

# FCI Gain Factor

**FCI Gain:** fraction of unknown physics concepts learned

$$\text{Course gain: } \langle g \rangle = \frac{\text{Post (\%)} - \text{Pre (\%)}}{100\% - \text{Pre (\%)}}$$



R. Hake, "...A six-thousand-student survey..." AJP **66**, 64-74 ('98).

I

# How much do students learn?

- A. 10-20%
- B. 20-40%
- C. 40-60%
- D. 60-80%
- E. 80-95%

What % of what the students could have learned in our courses is actually learned?

$$\text{Course gain: } \langle g \rangle = \frac{\text{Post (\%)} - \text{Pre (\%)}}{100\% - \text{Pre (\%)}}$$



## I

# Clickers & Active Learning

2004, *The Physics Teacher*, 42(8), 47-48.

## Tips for Using a Peer Response System in a Large Introductory Physics Class

**Marina Milner-Bolotin**, Physics and Astronomy Department, Rutgers, The State University of New Jersey  
Piscataway, NJ 08854-8019; milnerm@physics.rutgers.edu

### Clickers beyond the First Year Science Classroom

Marina Milner-Bolotin

Tetyana Antimirova

Anna Petrov

2010, *Journal of College Science Teaching*,  
40(2), 18-22.

**T**each  
phy  
lenge for a

### Abstract:

This case study's primary objective is to describe the implementation of the electronic peer response-system (clickers) in a small (N=25) second



LUMAT 1(5), 2013

## 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, Technology, and Mathematics (STEM) education is Classroom Response Systems (CRS). In this study, we explore how instructors generate in-class discussion by soliciting student responses using CRS.

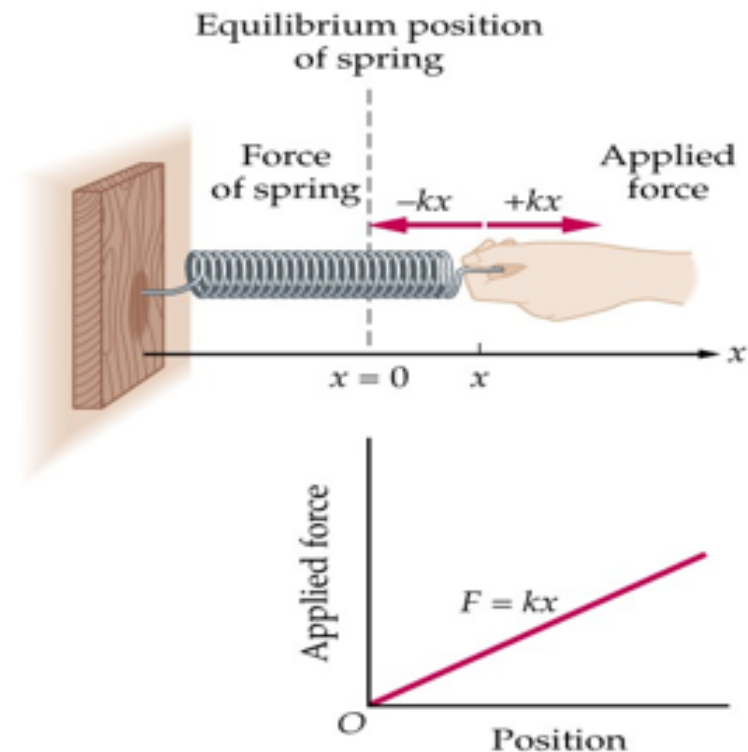
[LUMAT: Research and Practice in Math, Science & Technology Education, 2013. 1(5): p. 525-544.]

## I

# Peer Instruction Example

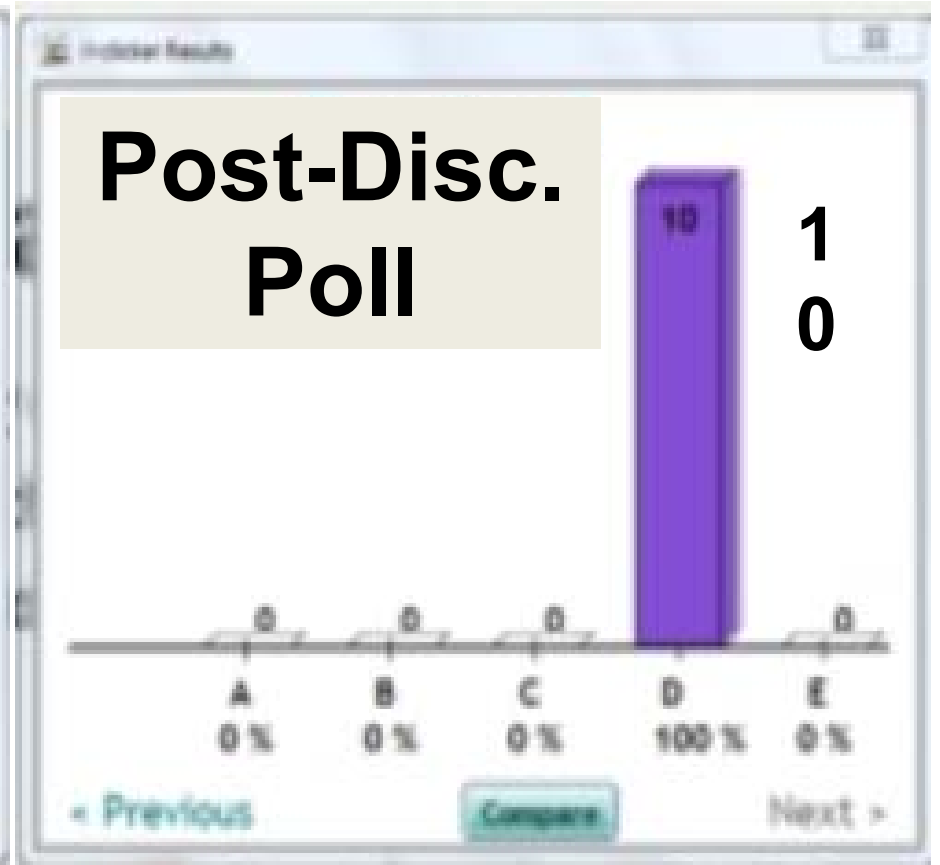
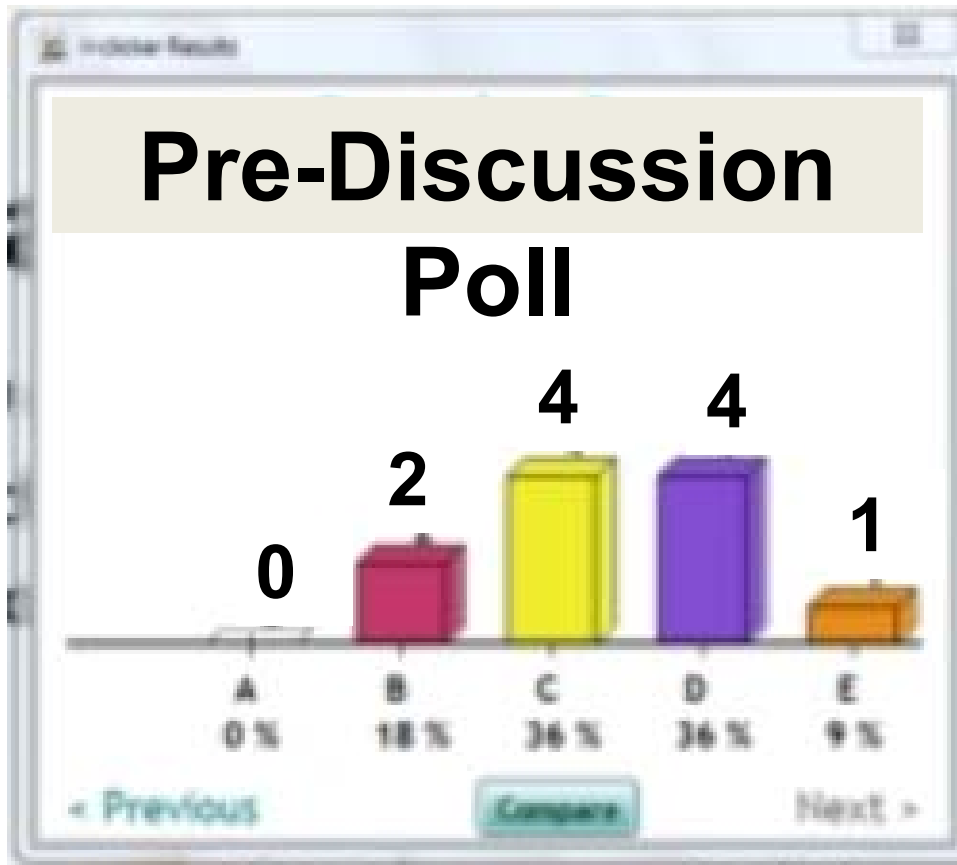
The work needed to stretch a spring **10 cm** from equilibrium (from  $x_1 = 0$  m to  $x_2 = 0.1$  m) is **10 J**. How much work needs to be done to stretch the spring additional **10 cm** (from  $x_2 = 0.1$  m to  $x_3 = 0.2$  m) ?

- A. 5 J
- B. 10 J
- C. 20 J
- D. 30 J
- E. 40 J



# I

# Peer Instruction in Action



**Respondents:** Physics Teacher-Candidates

# Math & Science Teaching & Learning through Technology

UBC a place of mind

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DEPARTMENT OF CURRICULUM AND PEDAGOGY

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through Technology

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WAVE MOTION AND OPTICS  
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EQUILIBRIUM  
ELECTROSTATISTICS

**CREATE**  
Community to Reimagine Educational Alternatives for Teacher Education

Resources

- Awards
- Current Students
- Prospective Students
- Faculty and Staff

CREATE is a faculty-wide initiative established by Dr. Rita Irwin, Associate Dean of Teacher Education programs, to inspire innovations in teacher education at UBC.

Seminars are held in Neville Scarfe, Room 310 from 12:30 – 2:00 p.m. (unless otherwise noted).

**Presentation about MSTLTT Project**  
On October 16th Dr. Marina Milner-Bolotin was invited to present a seminar to faculty and students at UBC Teacher Education Program

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mission is to design, test, evaluate and disseminate quality, research-based technology-supported educational materials for mathematics and science K-12 programs through creating a community of science and mathematics educators, researchers and students.

**MATH & SCIENCE TEACHING & LEARNING THROUGH TECHNOLOGY**

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



# Navigating the Resource



a place of mind



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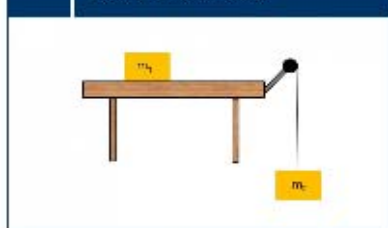
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## FORCES

### Blocks and a Pulley



Exploration of free body diagrams, two body acceleration, and Newton's law through the system of two blocks attached through a pulley and one of them resting on a table.

[acceleration](#), [forces](#), [friction](#), [Newton's laws](#), [pulleys](#), [string tension](#)

rating ★★★★★ (No Ratings Yet)

### Blocks on a Pyramid



Exploration of free body diagrams, two body acceleration, and newton's laws through the system of two blocks resting on a pyramid and attached by a pulley.

[acceleration](#), [forces](#), [friction](#), [gravitational acceleration](#), [net force](#), [normal force](#), [weight](#)

rating ★★★★★ (No Ratings Yet)

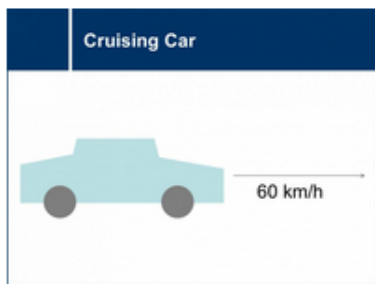
- + Mathematics
- Physics
  - » Vectors
- + Kinematics
- Dynamics
  - » Forces
  - » Springs
  - » Newton's Laws
- + Momentum
  - » Work,Energy,Power
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  - » Gravitation
  - » Wave motion and Optics
  - » Particle and Nuclear Physics

# I

# Navigating the Resource

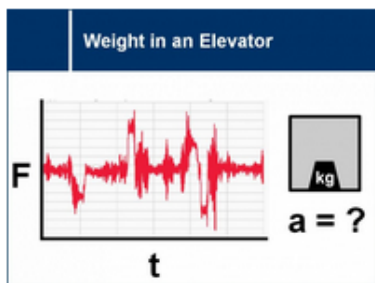


rating ★★★★★ (No Ratings Yet)



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)



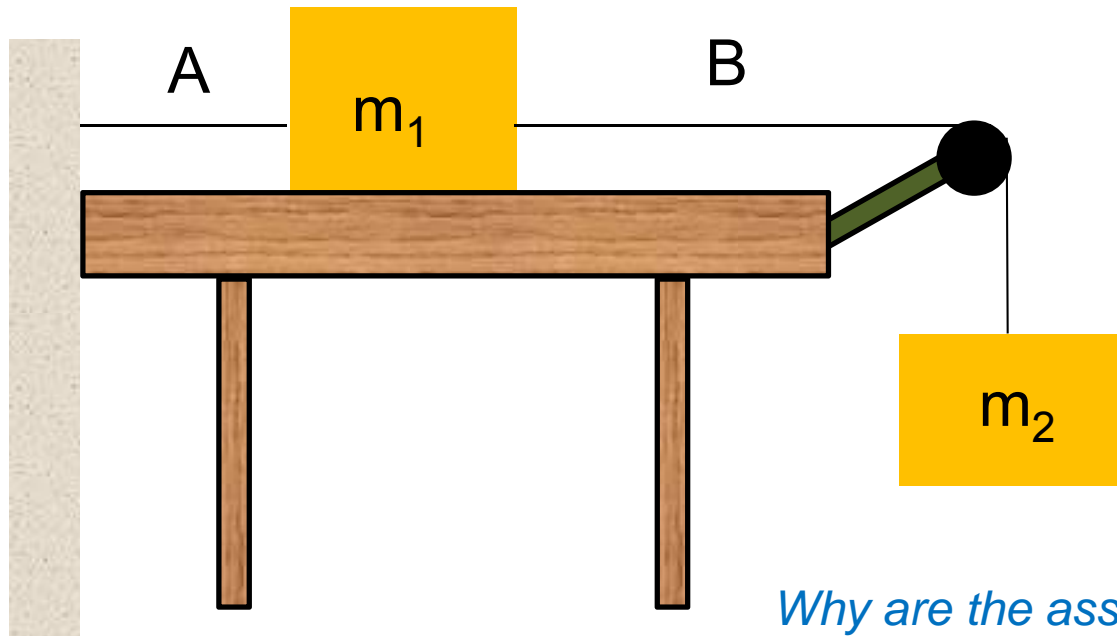
The following set of questions apply Newton's Second Law to scenarios with multiple blocks held together by the tension force from strings.

[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](#)  
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<http://scienceres-edcp-educ.sites.olt.ubc.ca/>

# Blocks and a Pulley

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?*

# I

# 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  $m_1 g$ . 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  $m_1 g$ . Thus the system is NOT in a free fall. Compare this questions to the previous one to see the difference.

I

# Break: Mental Exercise

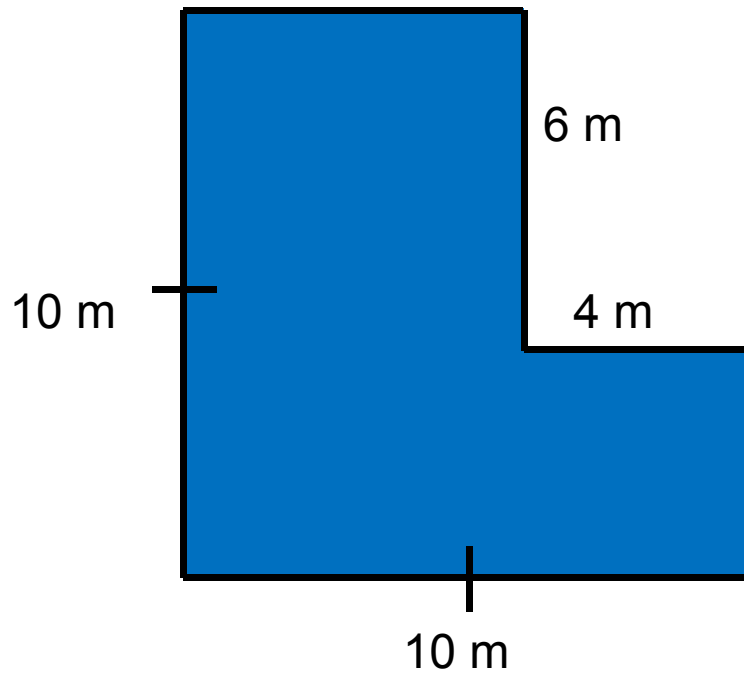


I

# Area



What is the area of the figure below?



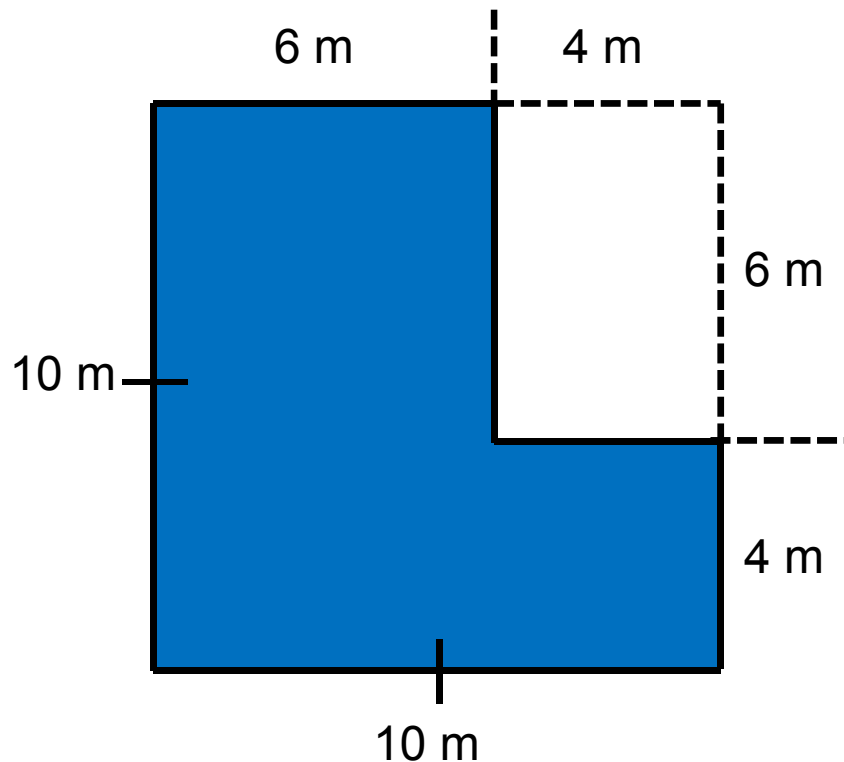
- A.  $24 \text{ m}^2$
- B.  $76 \text{ m}^2$
- C.  $100 \text{ m}^2$
- D.  $124 \text{ m}^2$
- E. Not enough information

# I

# Solution

**Answer:** B

**Justification:** The easiest way to find the area is to imagine a 10 m by 10 m square and subtracting a 4 m by 6 m rectangle.



$$A = 10 \text{ m} \times 10 \text{ m} - 4 \text{ m} \times 6 \text{ m} \\ = 76 \text{ m}^2$$

Alternatively, the shape's area can be found by dividing it into 2 rectangles and adding the areas together.

# I

## Logical reasoning



If  $m$  and  $p$  are positive integers and  $(m + p) \times m$  is even, which of the following must be true?

- (A) If  $m$  is odd, then  $p$  is odd.
- (B) If  $m$  is odd, then  $p$  is even.
- (C) If  $m$  is even, then  $p$  is even.
- (D) If  $m$  is even, then  $p$  is odd.
- (E)  $m$  must be even.

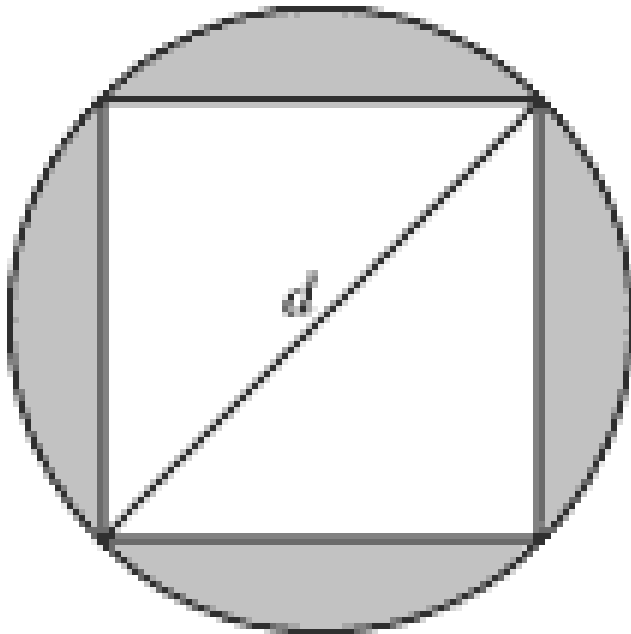


## I

## Logical reasoning



In the figure below, a square is inscribed in a circle with diameter  $d$ . What is the sum of the areas of the shaded regions, in terms of  $d$ ?



(a)  $d^2 \left( \frac{\pi}{4} - \frac{1}{2} \right)$

(b)  $d^2 \left( \frac{\pi}{4} - \frac{1}{4} \right)$

(c)  $d^2 \left( \frac{\pi}{2} - \frac{1}{4} \right)$

(d)  $d^2 (\pi - 2)$

(e)  $d^2 (\pi - 1)$

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# II

## Designing Multiple-Choice Questions: Group activity

### Group activity



1. While working with a partner, design 3 multiple-choice questions on the relevant topic. Consider distractors carefully.
2. Pair up with another group and answer each other's questions.

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# III

# PeerWise Online System



**EDCP357 (Winter 1, 2013)**

[Home](#) | [Main menu](#) > Comments written by you

## Comments written by you

Comments written by you, about questions you have answered, are shown below.

**Select an order:**

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## What is PeerWise?

Students use PeerWise to create and to explain their understanding of course related assessment questions, and to answer and discuss questions created by their peers.

<http://peerwise.cs.auckland.ac.nz/>

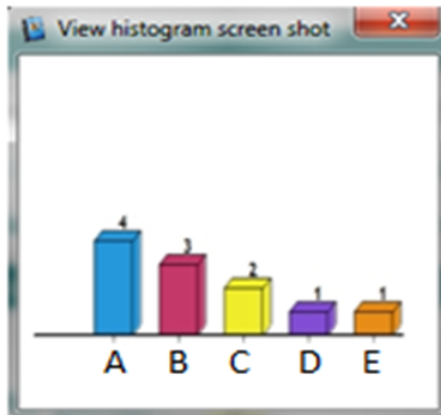
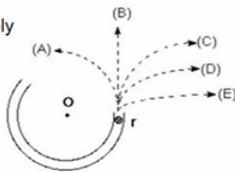
# III

# Technology-Enhanced Active Engagement Integration

## Question

A ball travels through the circular track until point  $r$ , at which point it leaves the channel to travel across a frictionless floor. Assume a bird's eye view, and that all motion is in the horizontal plane.

Which path will the ball most closely follow after it exits the channel?



PeerWise

EDCP357 (Winter 1, 2013)

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## Peer Instruction and PeerWise integration

# III

# PeerWise Pedagogy

LUMAT 1(5), 2013

[Res. & Pract. in Math, Sci. & Techn. Ed., 2013. 1(5):  
p. 525-544.]

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

Marina Milner-Bolotin  
Department of Curriculum and Ped  
marina.milner-bolotin@ubc.ca

Heather Fisher  
Department of Curriculum and Ped

Alexandra MacDonald  
Department of Curriculum and Ped

**Abstract** One of the most common  
and Mathematics (STEM) education  
instructors generate in-class discus

## EDUCATION CORNER

S  
P  
A  
C  
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D

## USING PEERWISE TO PROMOTE STUDENT COLLABORATION ON DESIGN OF CONCEPTUAL MULTIPLE-CHOICE PHYSICS QUESTIONS

BY MARINA MILNER-BOLOTIN\*  
DEPARTMENT OF CURRICULUM AND PEDAGOGY  
UNIVERSITY OF BRITISH COLUMBIA

Every physics instructor who ever used clicker-  
enhanced pedagogy knows that coming up with  
pedagogically effective conceptual questions  
contributed to PeerWise 1  
Table 1.

[Physics in Canada., 2014, 70(3): p. 149-150]

# III

# PeerWise Online System

[Home](#) | [Main menu](#) > [Your questions](#) > Question details

## Question stats

This question has been answered by 5 people and has an average rating of 4.20 (based on 5 ratings)

☒ **YES** The answer you suggested is the most popular answer

## Your question

Roger Federer tosses a tennis ball up in the air during his match against Rafael Nadal. When the ball reaches its highest point, its:



### Alternatives

OPTION	ALTERNATIVE	You suggested B is the correct option	
		FIRST ANSWERS	CONFIRMED ANSWERS
A	velocity is zero and acceleration is zero	1 (20.00%)	0 (0.00%)
B	velocity is zero and acceleration is non-zero	4 (80.00%)	3 (100.00%)
C	velocity is non-zero and acceleration is non-zero	0 (0.00%)	0 (0.00%)
D	velocity is non-zero and acceleration is zero	0 (0.00%)	0 (0.00%)
E	The answer depends on the initial speed of the ball.	0 (0.00%)	0 (0.00%)

### Explanation

The following explanation has been provided relating to this question:

At its highest point the ball should stop (it has zero instantaneous velocity). However, its acceleration is non-zero. The earth is pulling the ball down equally hard along the way, so its acceleration in its highest point is  $9.8 \text{ m/s}^2$ , and it is directed downwards.



improve explanation



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- IV. PeerWise activity (group work)**
- V. Group activity: Exploring GeoGebra
- VI. Summary of the day

# IV

# PeerWise Activity

<http://peerwise.cs.auckland.ac.nz/>

**PeerWise**  
The University of British Columbia

Home

Welcome home

Welcome to PeerWise. Simply choose a course below to get started. If you like, you can also create a new course or join an existing course

Your courses

You are currently a member of the following courses. Simply click on the course name to begin.

Course ID	Identifiers active	Questions	Answers	Comments	Last correct answer
<b>EDCP357 (Winter 1, 2013)</b>					
7904	10 / 10	525	2055	1246	11:00pm, 03 Dec
<b>EDCP357_2014</b>					
9453	12 / 12	303	1470	914	9:37am, 22 Apr
<b>ChaoyangSTEM_2015</b>					
11156	0 / 70	0	0	0	---

Student ID:

Student1\_ChB  
Student2\_ChB ...  
Student70\_ChB



Register at PeerWise use  
the username Student#

Your Identifier is:

Student1  
Student 2 ...

Your own password is the  
same as your student ID.

# IV

## PeerWise Activity: Registration

<http://peerwise.cs.auckland.ac.nz/>

### Creating new user:

- Institution: **The University of British Columbia**
- User name: **Student1\_ChB**
- Password: **\*\*\*\*\***

### Course to join:

- Course ID: **11156**
- Identifier: **Student1**



Student ID: Student1\_ChB  
Your Identifier is: Student1  
Your password = Your student ID.

# IV

## Exploring PeerWise (PW)

### Group activity



1. Register to PeerWise (PW) and explore the system.
2. Work with a partner, design 3 multiple-choice questions on the relevant topic. Enter them into PW.
3. Answer 3 questions designed by other people. Rate these questions and comment on them.

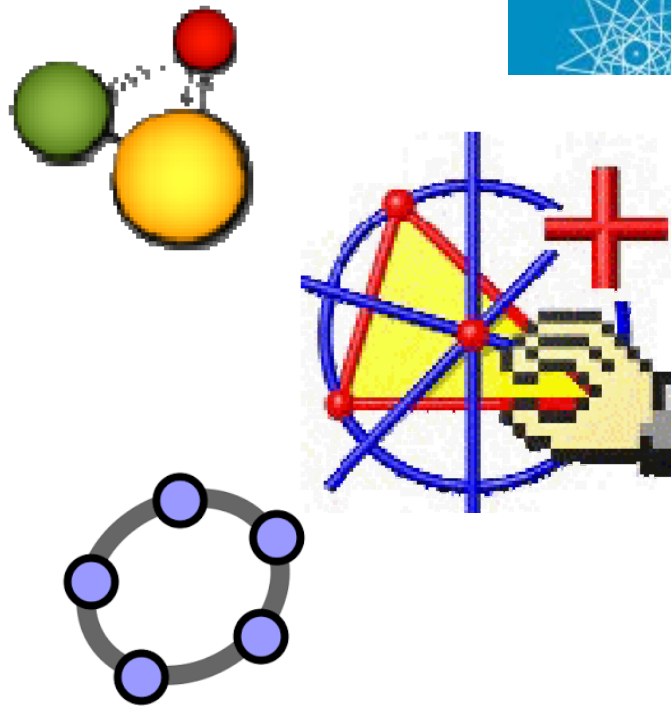
# Agenda for the Day

- I. Active engagement: Peer Instruction Pedagogy**
- II. Group activity: Designing conceptual math and science multiple-choice questions**
- III. PeerWise Pedagogy introduction**
- IV. PeerWise activity (group work)**
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# V

# Interactive Mathematical Tools

- Geometer's Sketchpad
- Cinderella
- Cabri
- GeoGebra



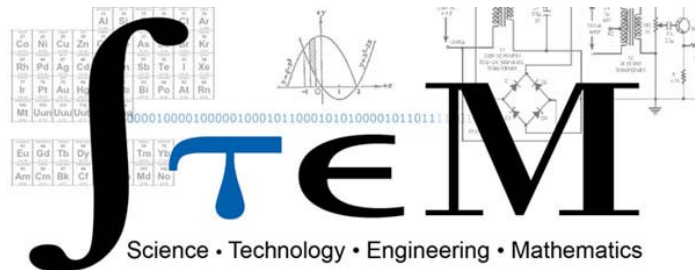
# V

# GeoGebra: What is it?

- Dynamic mathematics software
- Used for learning and teaching:

Geometry  
Calculus

Algebra  
Statistics



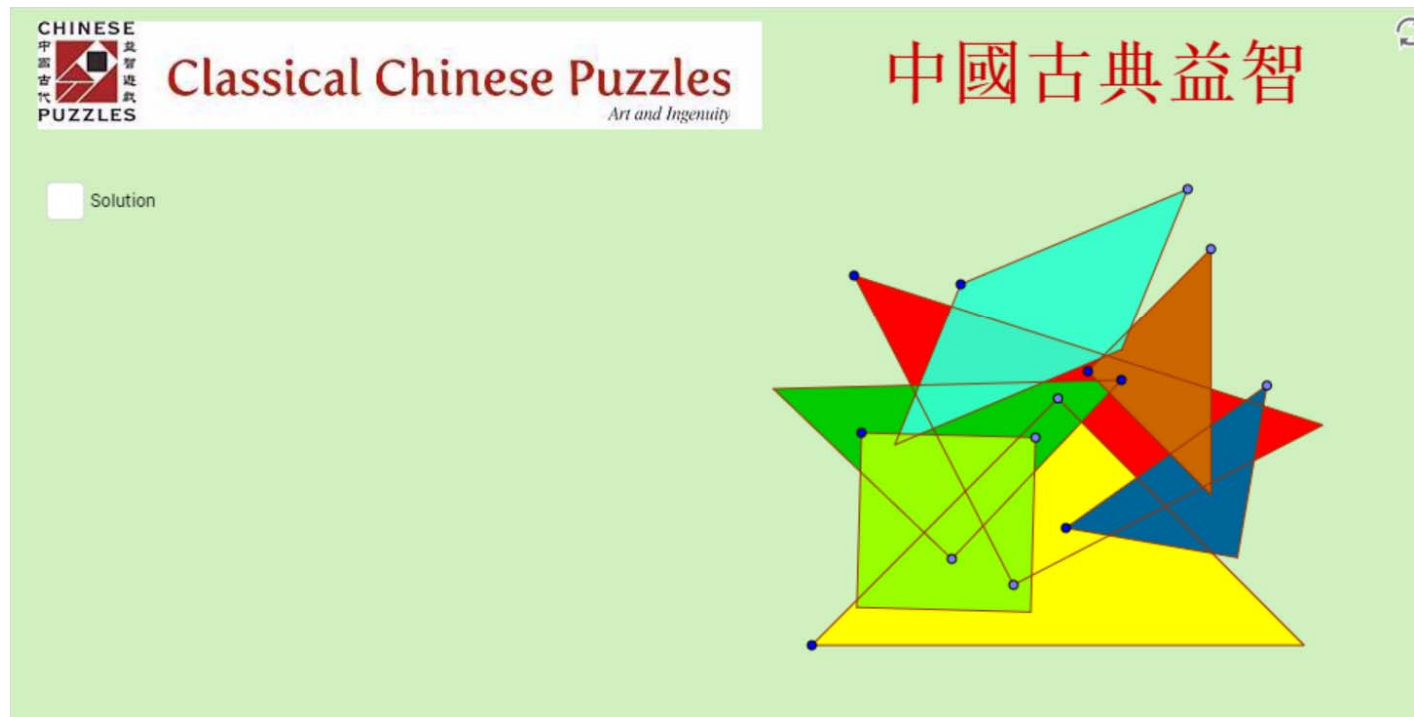
# V

# GeoGebra and Tangrams

<http://www.geogebra.org/student/m157562>

Classical Chinese Puzzles

<http://chinesepuzzles.org/tangram/>



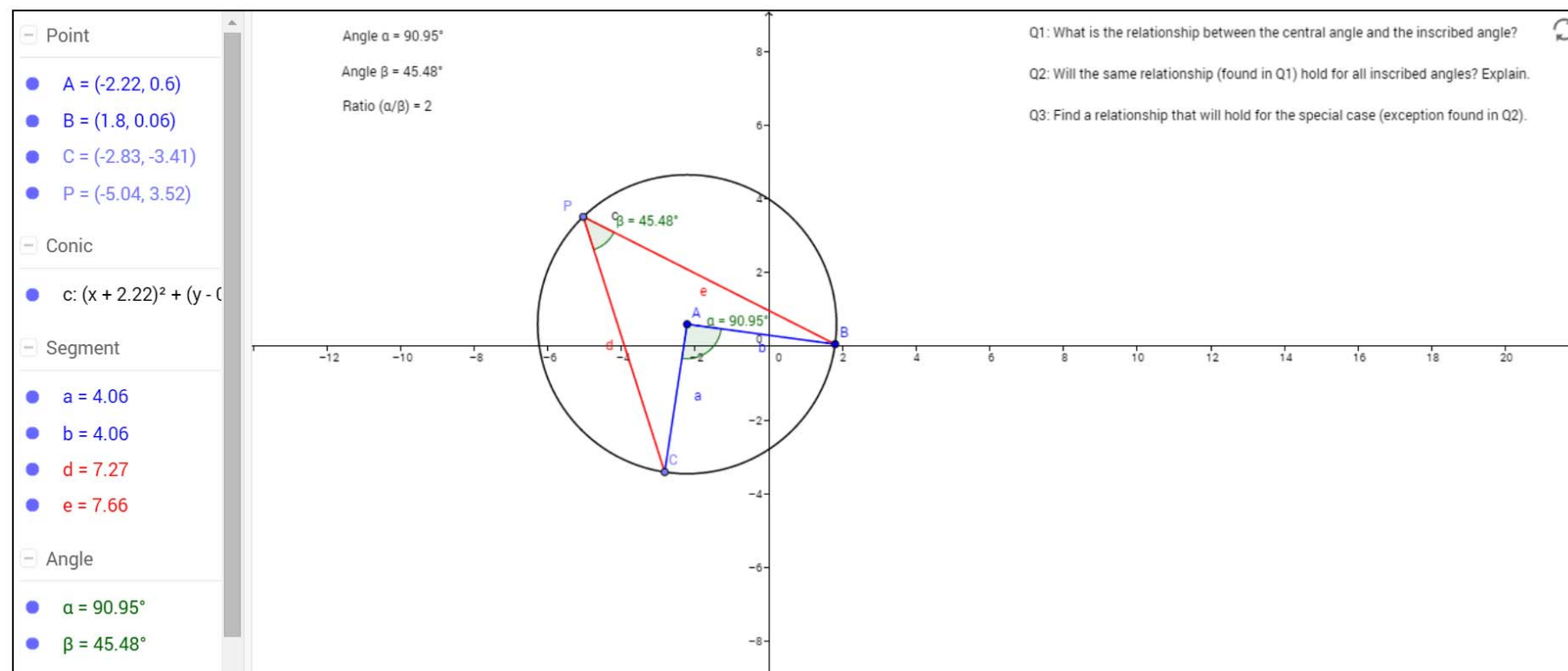


# GeoGebra Example Central Angle Theorem

<http://tube.geogebra.org/student/mCntMT6zE>

## Proof for the central angle theorem

Proof for the central angle theorem



# V

## GeoGebra: What can it do?

- Geometry: [Central Angle Theorem](#)
- Calculus: [Integration](#)
- Algebra: [Transformation of functions](#)
- Geometric construction: [Inscribed circles](#)
- More resources: [www.geogebra.org](http://www.geogebra.org)

# V

## GeoGebra: Why to use it?

- Dynamic and interactive
- Accurate construction (Vs. Drawing)
- Visualization of mathematical objects
- Exploration and discovery (what-ifs)

# V

# GeoGebra: Group activity

## Group activity

1. Visit [www.geogebra.org](http://www.geogebra.org)
2. Browse available materials
3. Work with a partner to design a GeoGebra activity you can use with your students them.



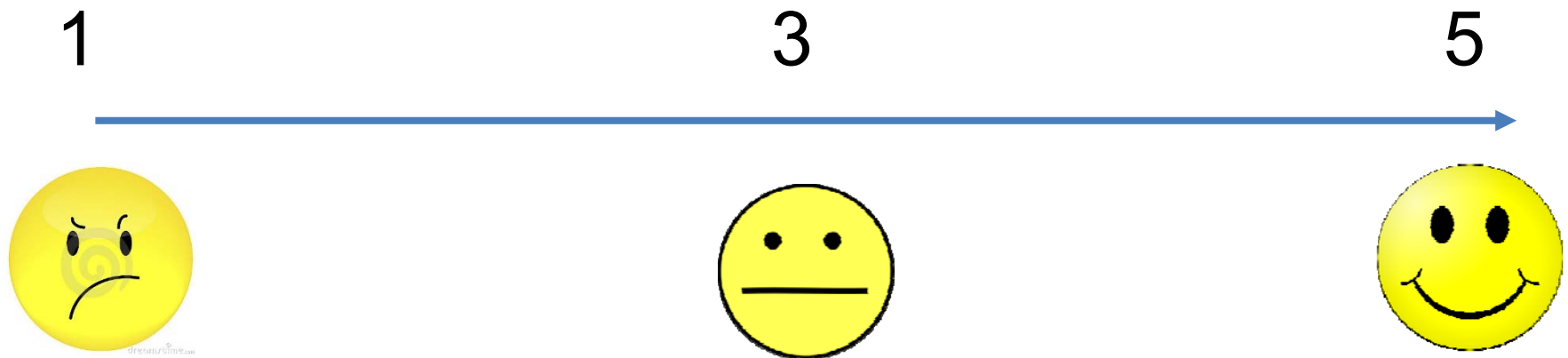
# Agenda for the Day

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## Day 2: Feedback 1

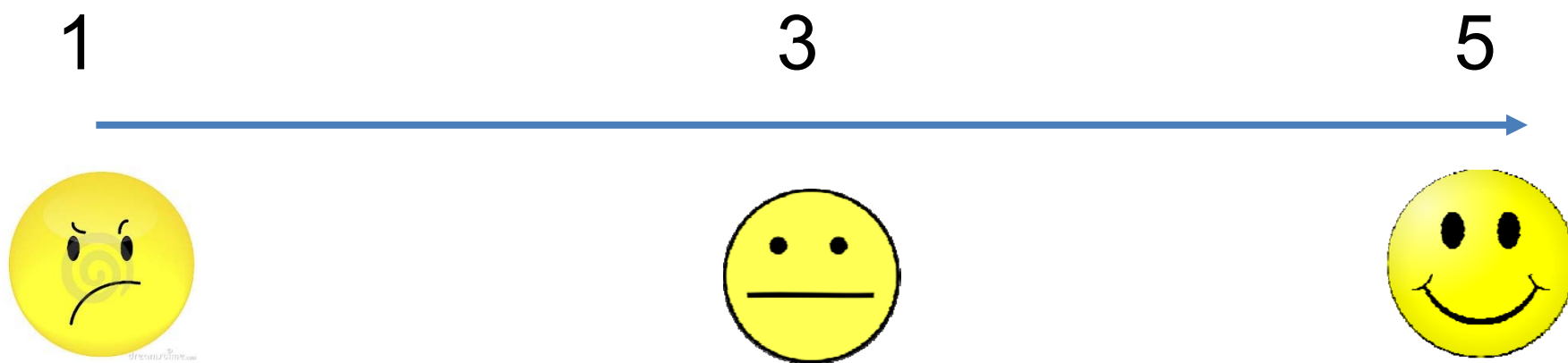
How satisfied are you with the day?





## Day 2: Feedback 2

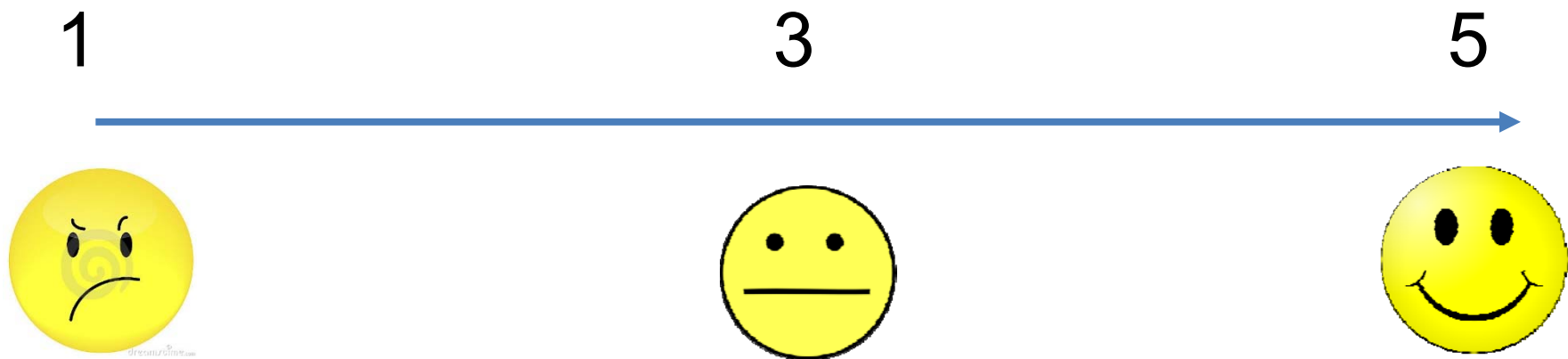
Do you feel you have learned new ideas for math and science teaching?





## Day 2: Feedback 3

Are you looking forward to Day 2?







## Day 2: Feedback 4

What was the pace of the day?

1

3

5





## Day 2: Feedback 5

What was the amount of information for you today?

1

3

5

