Teaching to Learn and Learning to Teach

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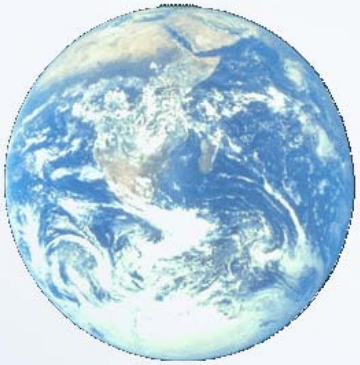


STEM Education: A Global Emphasis

- **Trends in International Mathematics and Science Study (TIMSS)**
  (4th and 8th grade students)
  U.S. Ranking
  - 24 (1995), ~12 (2003), ~11(2007)
- **Program for International Student Assessment (PISA)**
  (15-year-old school children)
  U.S. Ranking
  - 15 (2000, Reading), 24 (2003, Math), 21 (2006, Science)

International Studies: Opportunities for New Research

Level of Math Questions in Chinese University Entrance Test

Math enthusiasts are being challenged to answer a sample question from Chinese university entrance tests.

BBC
04/25/2007

The tests are set for prospective science undergraduates.

The UK's Royal Society of Chemistry is offering a £500 prize to one lucky but bright person who answers the question below correctly.

National test set by Chinese education authorities for pre-entry students

As shown in the figure, in square prism $ABCD—A_1B_1C_1D_1$,

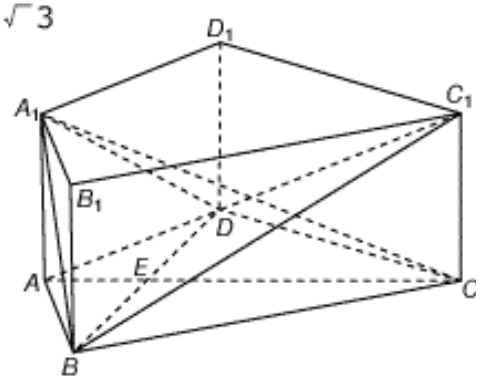
$AB=AD=2$, $DC=2\sqrt{3}$, $AA_1=\sqrt{3}$

$AD \perp DC$, $AC \perp BD$, and foot of perpendicular is E,

(i) Prove: $BD \perp A_1C$:

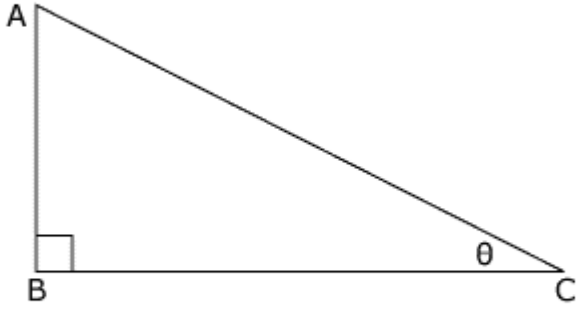
(ii) Determine the angle between the two planes A_1BD and BC_1D:

(iii) Determine the angle formed by lines AD and BC_1 which are in different planes.



Diagnostic test set by an English university for first year students

In the diagram (not drawn to scale), angle ABC is a right angle, AB = 3m BC = 4m



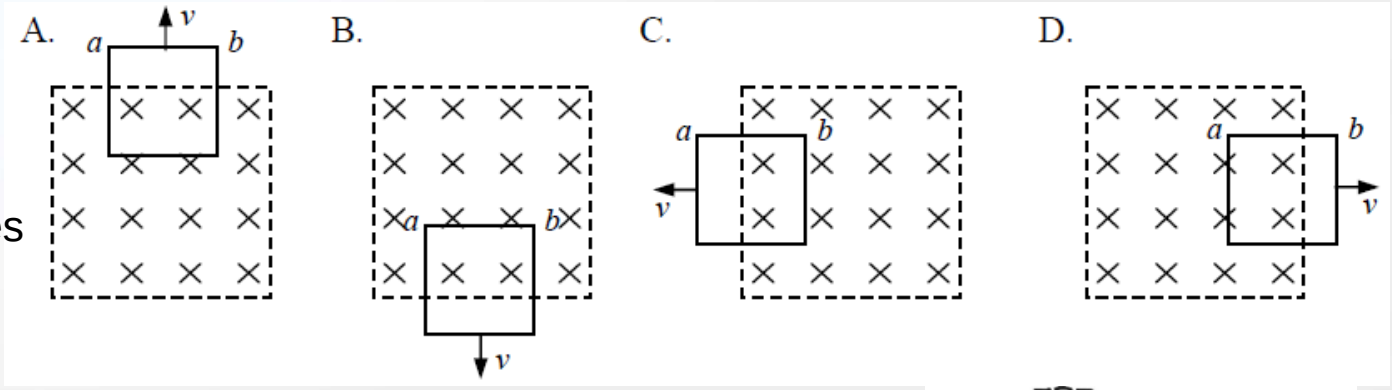
(i) What is the length of AC

(ii) What is the area of triangle ABC (above)?

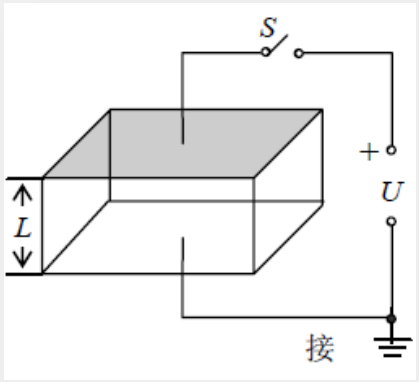
(iii) What is the tanθ of the triangle ABC (above) as a fraction?

Physics Questions in Chinese University Entrance Test (20~25 questions in 2 hrs)

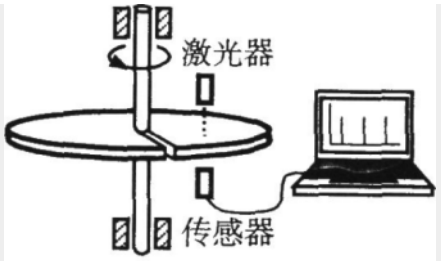
Frame is made with resistance wire.
Which situation gives largest $|V_{ab}|$?

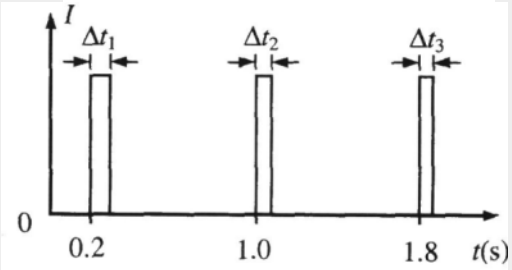


Give M_A, M_A, and m_{block}.
All surfaces are frictionless.
How high does the block rise on B?



Given N, q, m, Area, L, no collision (diluted).
Time to clean ?
Work done to particles?
When is $KE_{particle}$ =Max?

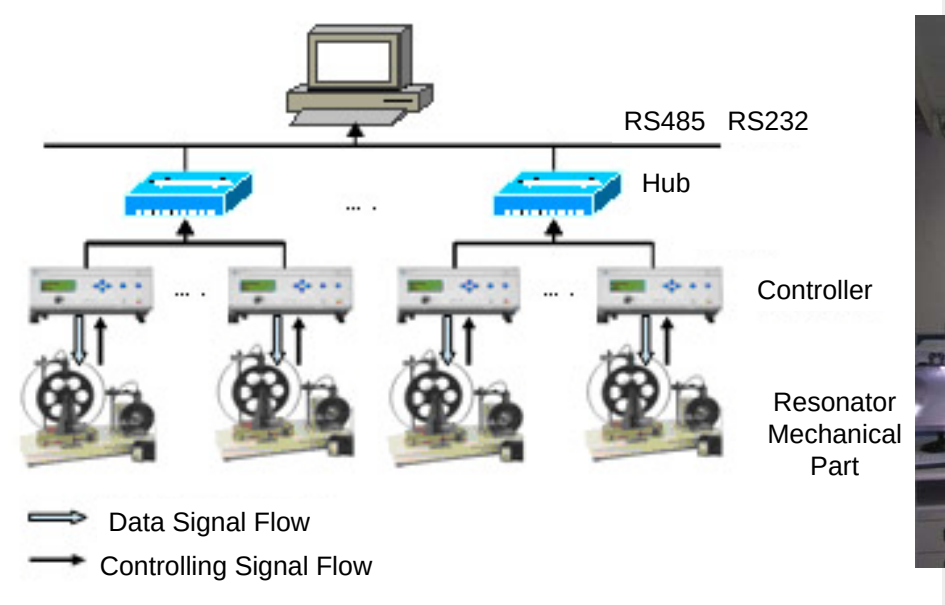




Given Δt_1 Δt_2. Ask for ω=?
Which way the head moves to? Δt_3=?

Learning from our collaborators

- Different approaches that may bring new ideas and field tested experiences for our development.



The content requirements for the high school teacher education program

The required courses in the physics department of Huazhong Normal University are listed as following.

- Mandatory courses:
  - Advanced Mathematics A(1,2), Linear Algebra A,
  - Mechanics, Thermodynamics and molecular physics, Optical, Static Electricity and magnetism, Analytical mechanics, Methods of mathematical physics, Atomic Physics, Electrodynamics, Quantum Mechanics, Statistical physics, Analog Electronics; Physics Experiments Level 1, 2, 3. Analog Electronic Experiments.
    Credits for the above courses total to 65.
  - 16-credits of professional education courses such as introductory education, psychology, teaching in physics, physics teaching skills, and modern educational technology.
- Elective courses: 24 credits including advanced physics courses, professional education courses, teaching practice, and graduation design.

Science Teacher Education and Preparation

Science Education Master Program in Physics

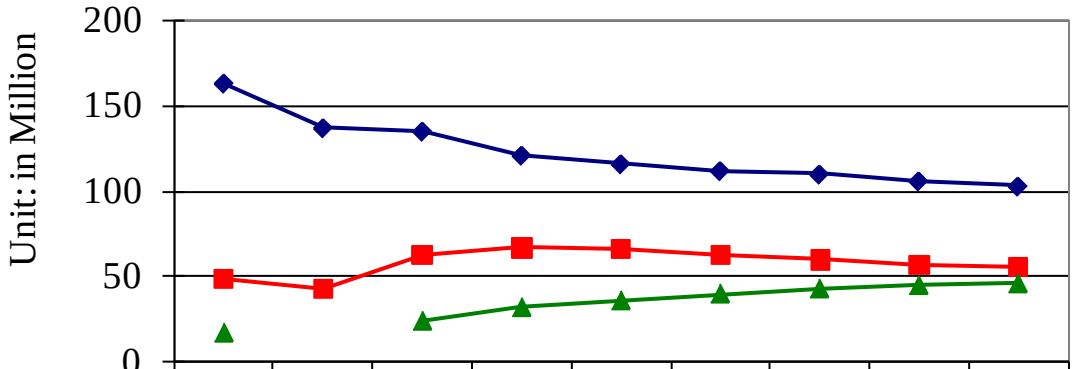
PHYSICS

PHYSICS		
Astron 291	Astrophysics	5 _____
Geog 520	Climatology	5 _____
Phys 131	Particles & Motion	5 _____
Phys 132	Electricity & Magnetism	5 _____
Phys 133	Thrml, Waves, & Quant	5 _____
Phys 261	Dyn of Part & Waves I	4 _____
Phys 262	Dyn of Part & Waves II	4 _____
Phys 263	Dyn of Part & Waves III	4 _____
Phys 517	Intro Electronics	4 _____
Phys 670 (or 108)	Physics for Teachers	3-5 _____

School Enrollments

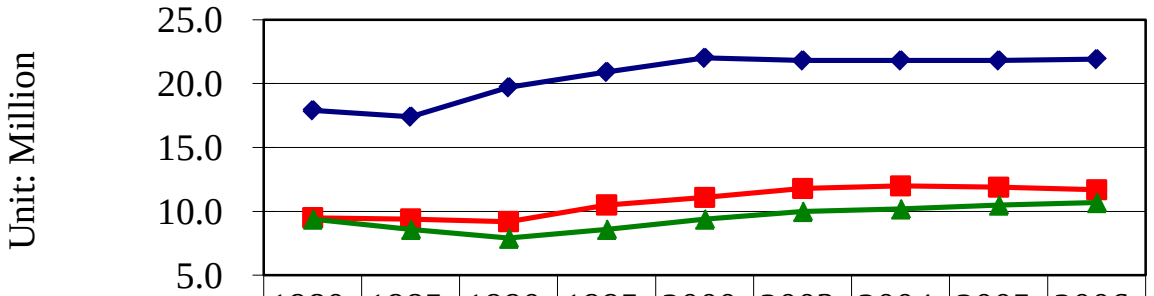
In China in 2008, the gross enrollment ratios are 99.5%, 98.5%, and 74% respectively in elementary, junior secondary, senior secondary schools.

Student Enrollments in China



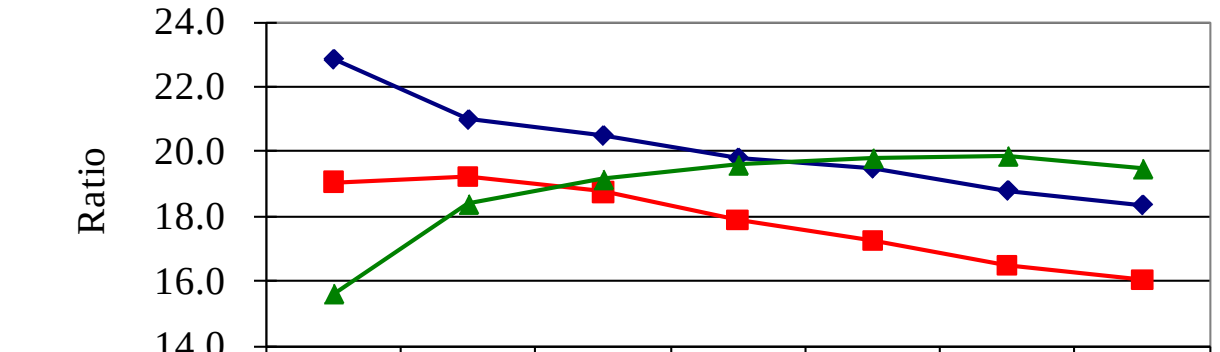
	1980	1985	2000	2003	2004	2005	2006	2007	2008
Grade1-6	163	137	135	121	116	112	110	106	103
Grade7-9	49	43	63	67	66	63	60	57	56
Grade10-12	17		24	32	36	40	43	45	46

Students Enrollments in the US

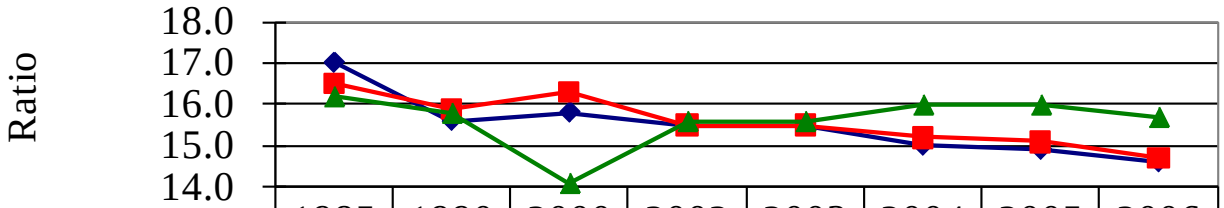


	1980	1985	1990	1995	2000	2003	2004	2005	2006
Grade1-6	17.9	17.4	19.7	20.9	22.0	21.8	21.8	21.8	21.9
Grade7-9	9.5	9.4	9.2	10.5	11.1	11.8	12.0	11.9	11.7
Grade10-12	9.4	8.6	7.9	8.6	9.4	10.0	10.2	10.5	10.7

Student to teacher ratio



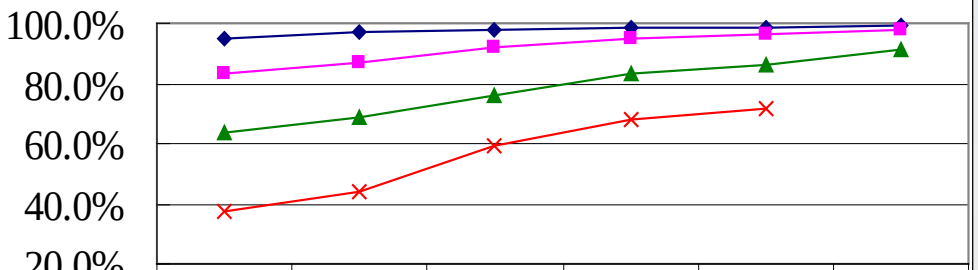
	2000	2003	2004	2005	2006	2007	2008
Grade1-6	22.8	21.0	20.5	19.8	19.5	18.8	18.4
Grade7-9	19.1	19.3	18.8	17.9	17.3	16.5	16.1
Grade10-12	15.6	18.4	19.2	19.6	19.8	19.9	19.5



	1985	1990	2000	2002	2003	2004	2005	2006
Grade1-6	17.0	15.6	15.8	15.5	15.5	15.0	14.9	14.6
Grade7-9	16.5	15.9	16.3	15.5	15.5	15.2	15.1	14.7
Grade10-12	16.2	15.8	14.1	15.6	15.6	16.0	16.0	15.7

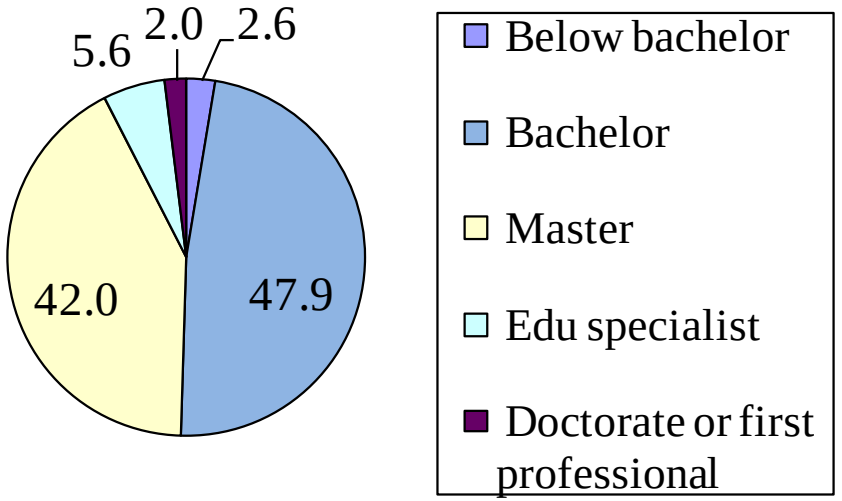
Percentage of teachers with required degrees

Teachers' Degree Qualified,China



	1998	2000	2003	2005	2006	2008
Elementary	94.6%	96.9%	97.9%	98.6%	98.9%	99.3%
Junior Secondary	83.4%	87.0%	92.0%	95.2%	96.3%	97.8%
Regular Senior Secondary	63.5%	68.4%	75.7%	83.5%	86.5%	91.6%
Vocational Senior	37.4%	44.3%	59.4%	67.7%	71.9%	

Percentage of Teachers' Degree,US



Issues in STEM Education

- Concerns in China
  - Too much content training
  - Lack of real world problem solving skills
  - Loss of interests in learning among college students
- Concerns in USA
  - Behind expected performance level in science and mathematics
  - “Fear” of science and mathematics
- Common goals in education “reform”
  - Balance STEM content learning and ability developing
  - Enable the new generation with the right set of knowledge, skills, and attitudes so that they not only become effective problem solvers but also good “problem creators”.

Currently both countries seem to be moving towards each other. The solution is probably in the midway.

Knowledge and Reasoning

- What people know
- What people can do

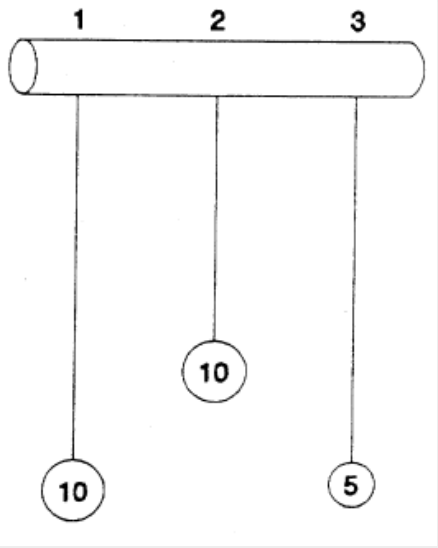
- Scientific Reasoning:
  - Domain general skills

- Example

  Identify and control variables
  - universally needed in all science disciplines

Scientific Methods

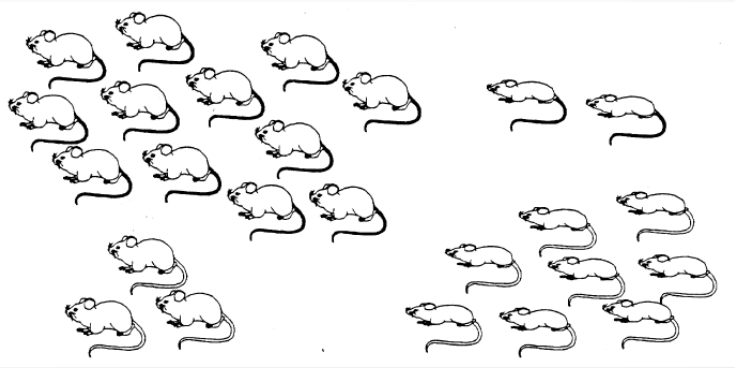
- Observation
- Research Question
- Hypothesizing
- Experimentation
- Data Interpretation & Evaluation

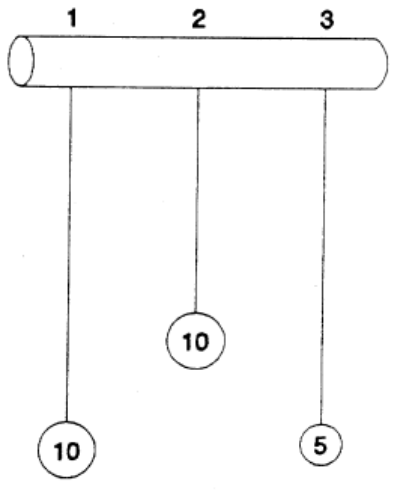


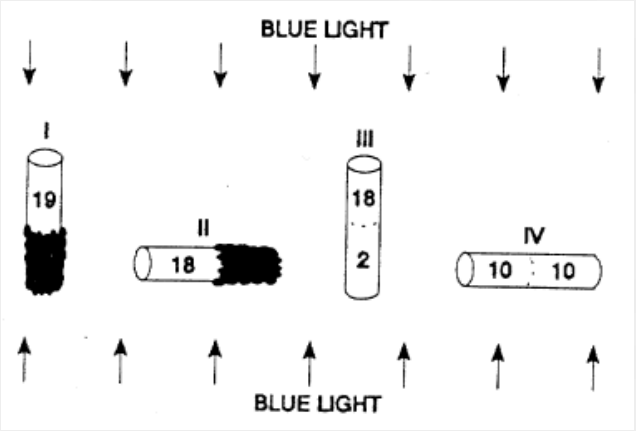
Assessment of Scientific Reasoning

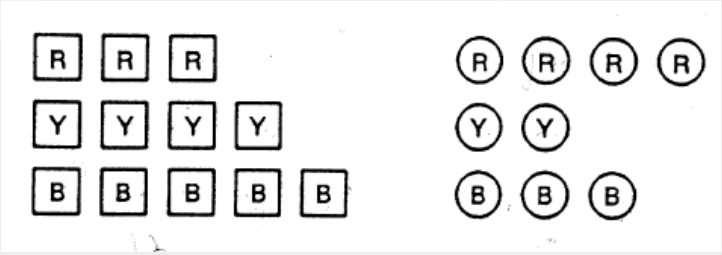
- Ability Dimensions:
  - Conservation of volume and mass
  - Proportional reasoning
  - Probabilistic reasoning
  - Control variables
  - Correlation reasoning
  - Hypothesis deductive reasoning and hypothesis testing/evaluation
- Test Format
  - MC type
  - Paired question and explanation

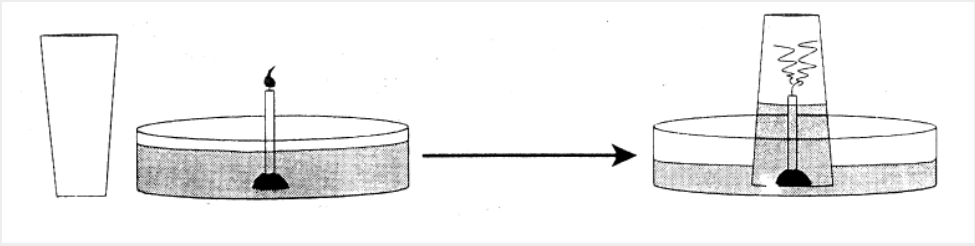
The Lawson's Scientific Reasoning Test

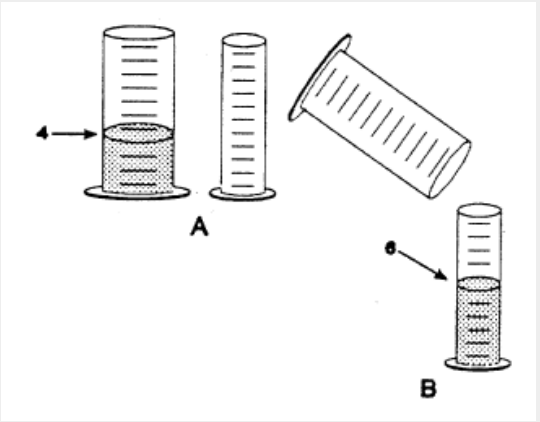










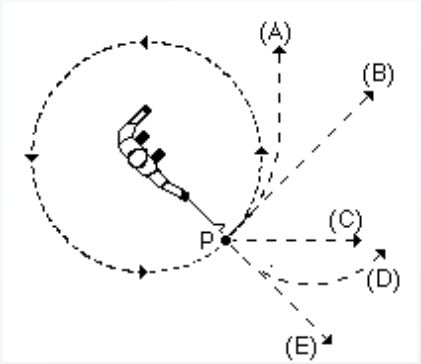


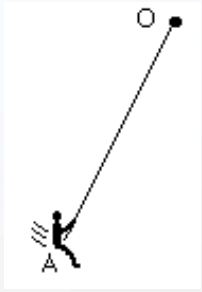
Does STEM content learning affect the development of scientific reasoning abilities?

- Main variables:
  K-12 training on science and mathematics
  - Chinese Students (5~6 years of physics courses, mandatory, complex level)
  - US Students (1~2 semesters' of physics, elective, basic level)
- Measures:
  - FCI, BEMA* – STEM content
  - Scientific Reasoning (24Q, MC)

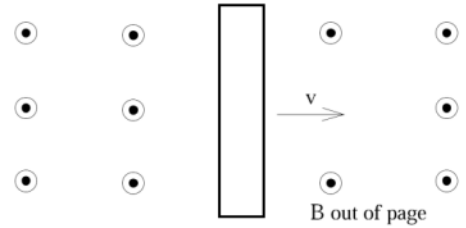
* FCI – force concept inventory (mechanics, 30Q, MC)
BEMA – brief electronic and magnetism assessment (E&M, 31Q, MC)

The FCI and BEMA Tests

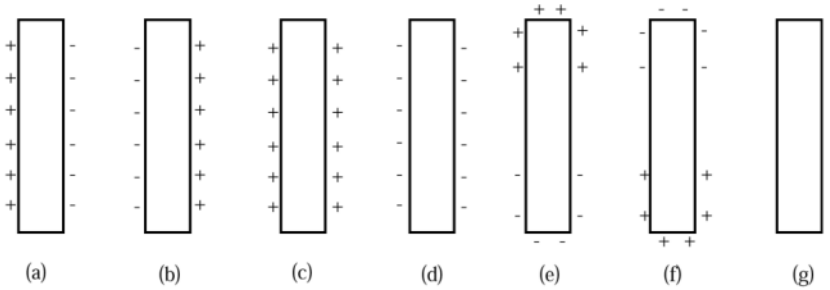


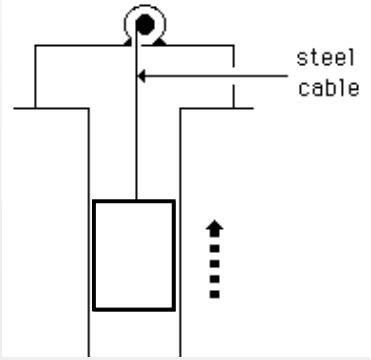


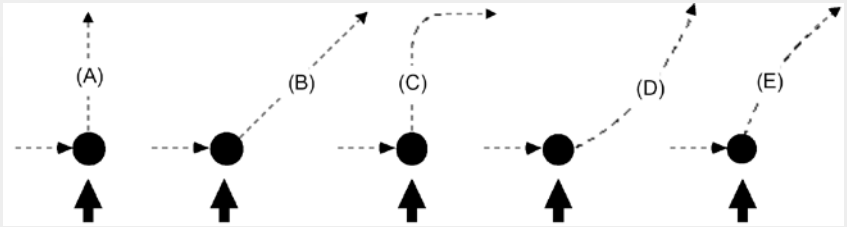
A neutral metal bar is moving at constant velocity v to the right through a region where there is a uniform magnetic field pointing out of the page. The magnetic field is produced by some large coils which are not shown on the diagram.

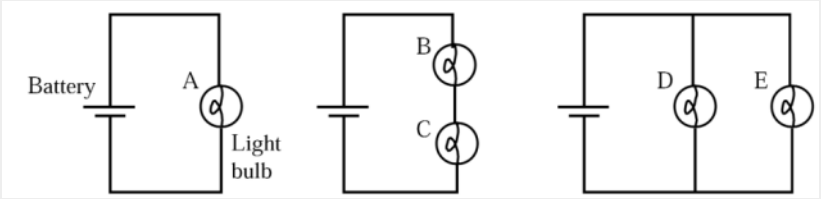


Q30 Which of the following diagrams best describes the state of the metal bar?

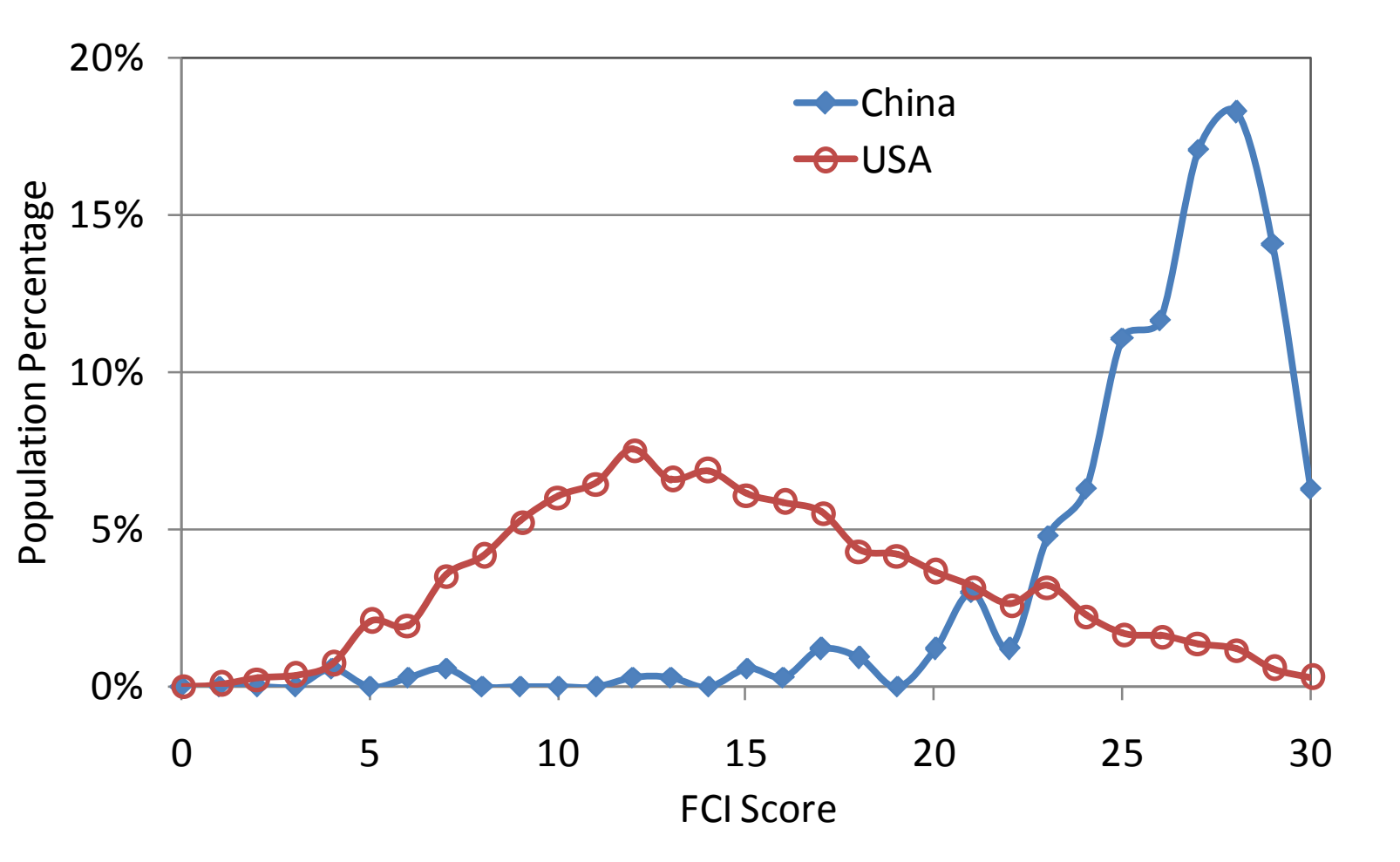




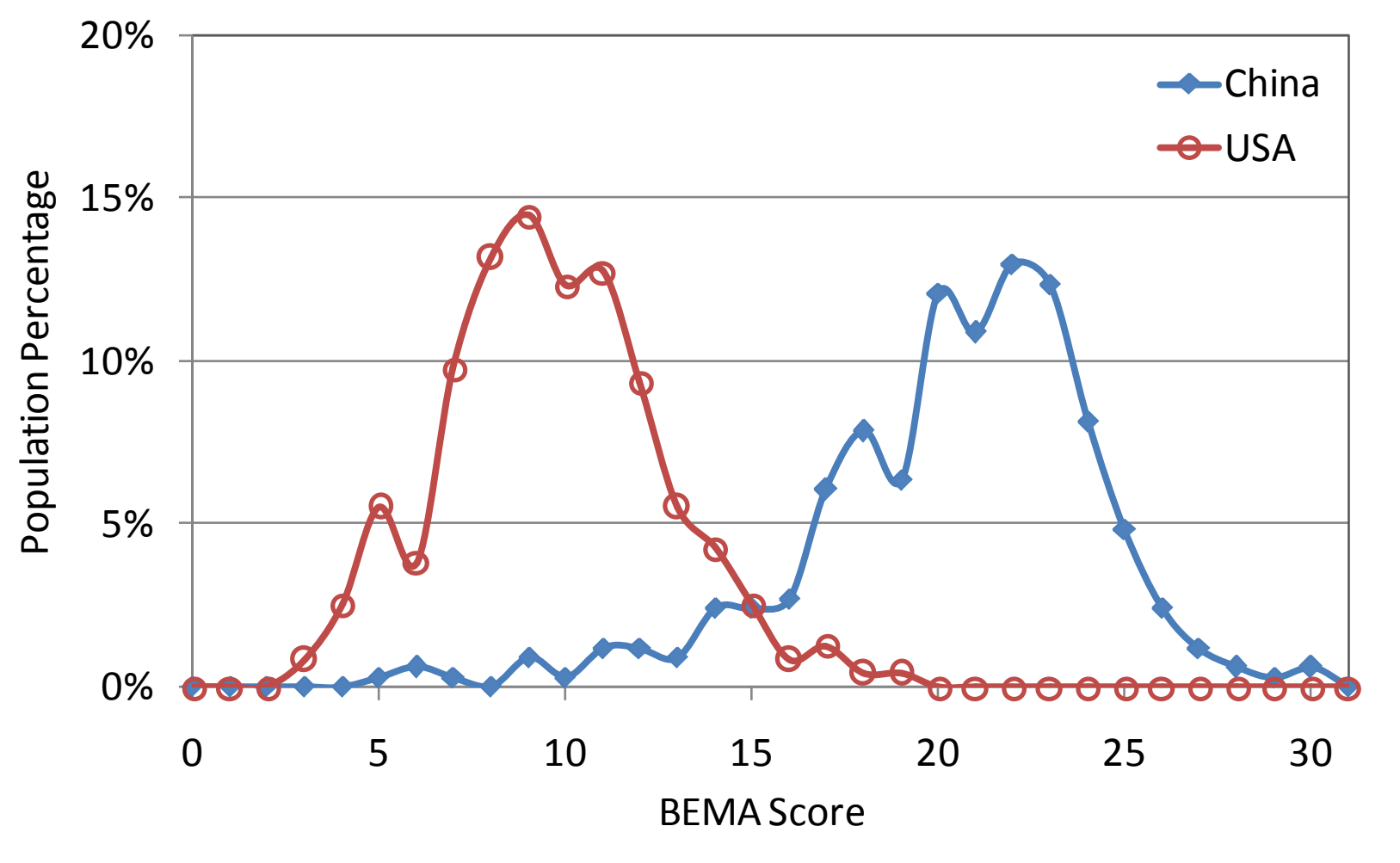




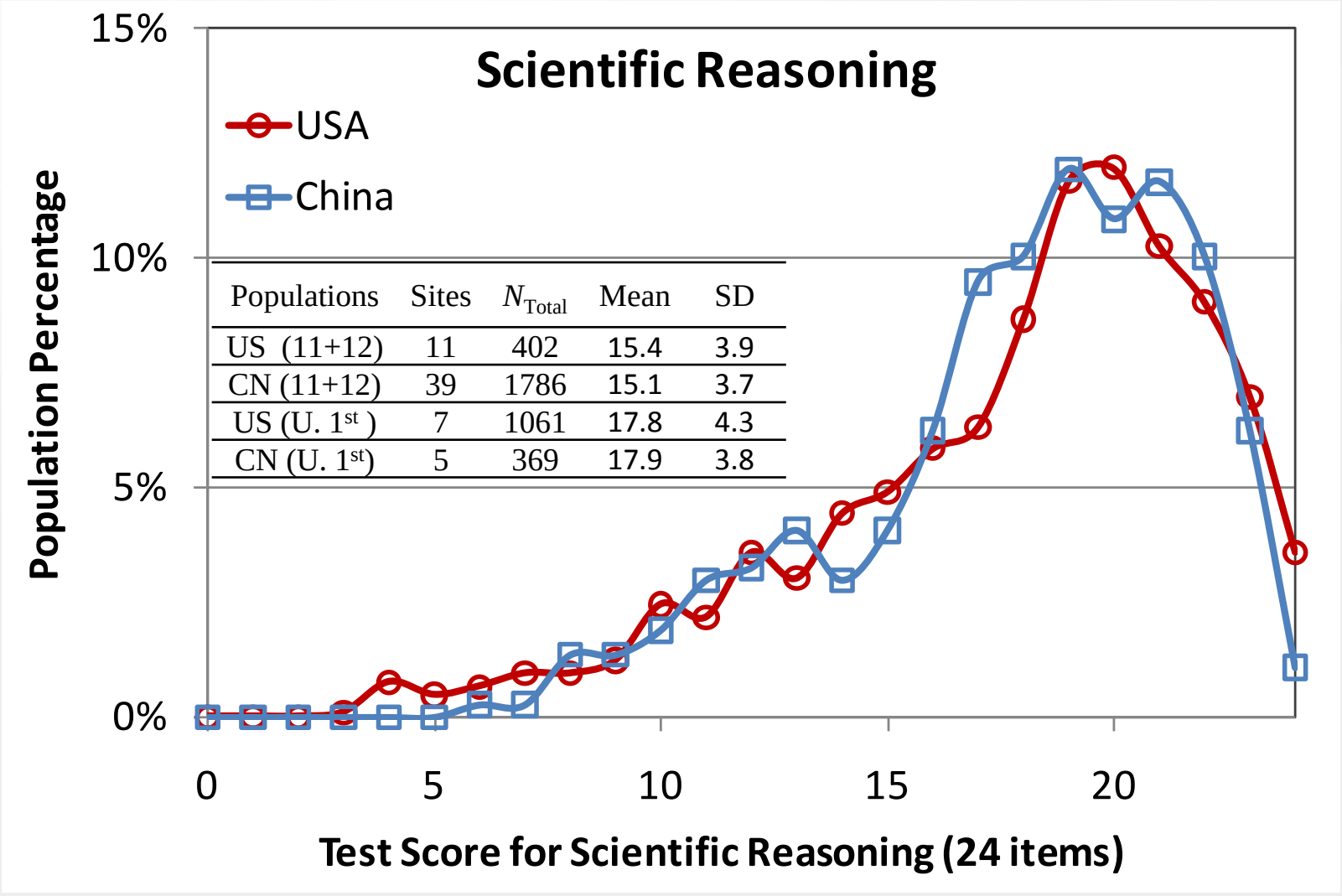
First Year College Students' FCI Results



First Year College Students' BEMA Results



First Year College Students' Lawson Results



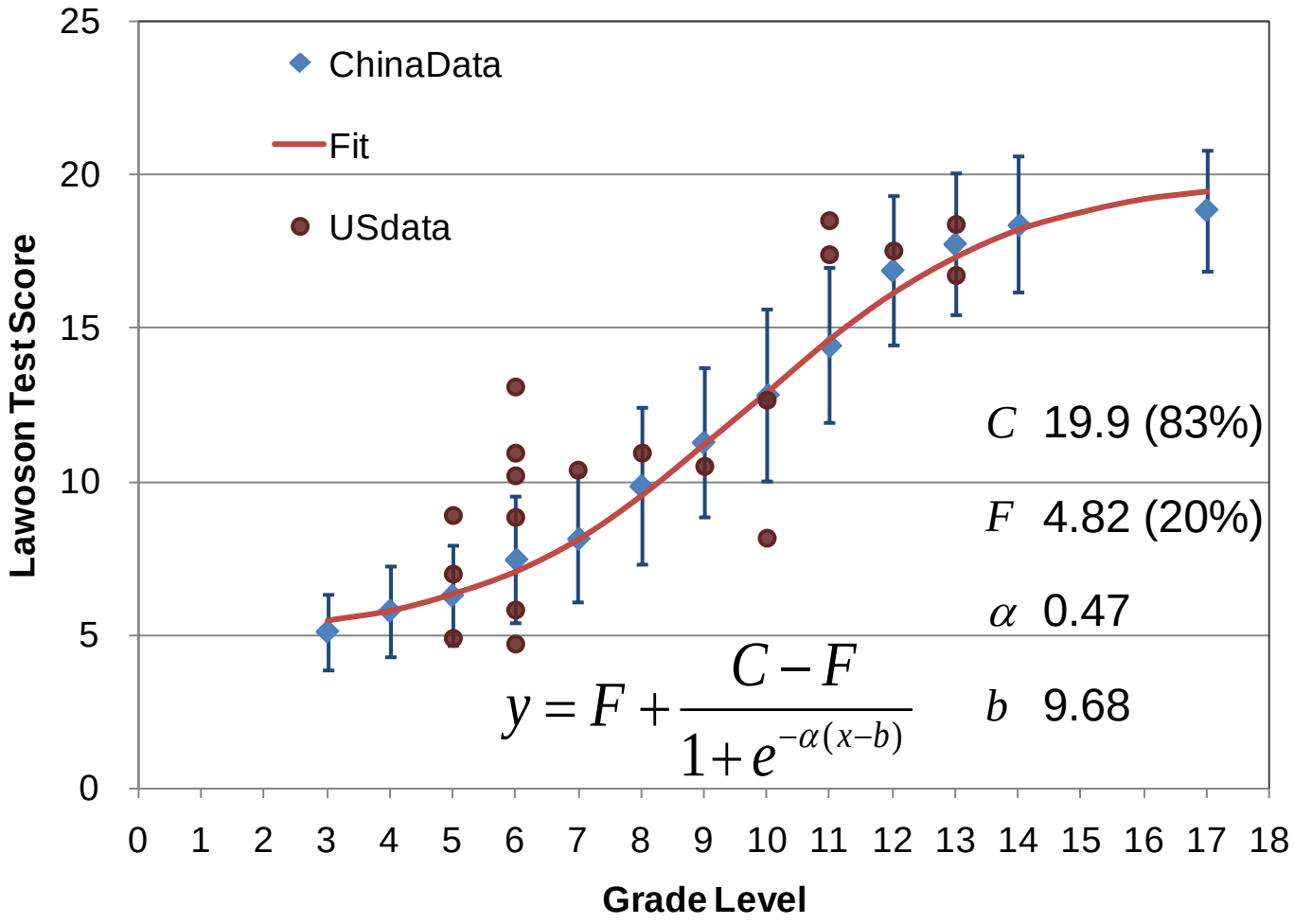
Populations	Sites	N_{Total}	Mean	SD
US (11+12)	11	402	15.4	3.9
CN (11+12)	39	1786	15.1	3.7
US (U. 1st)	7	1061	17.8	4.3
CN (U. 1st)	5	369	17.9	3.8

The Developmental Scale of Scientific Reasoning

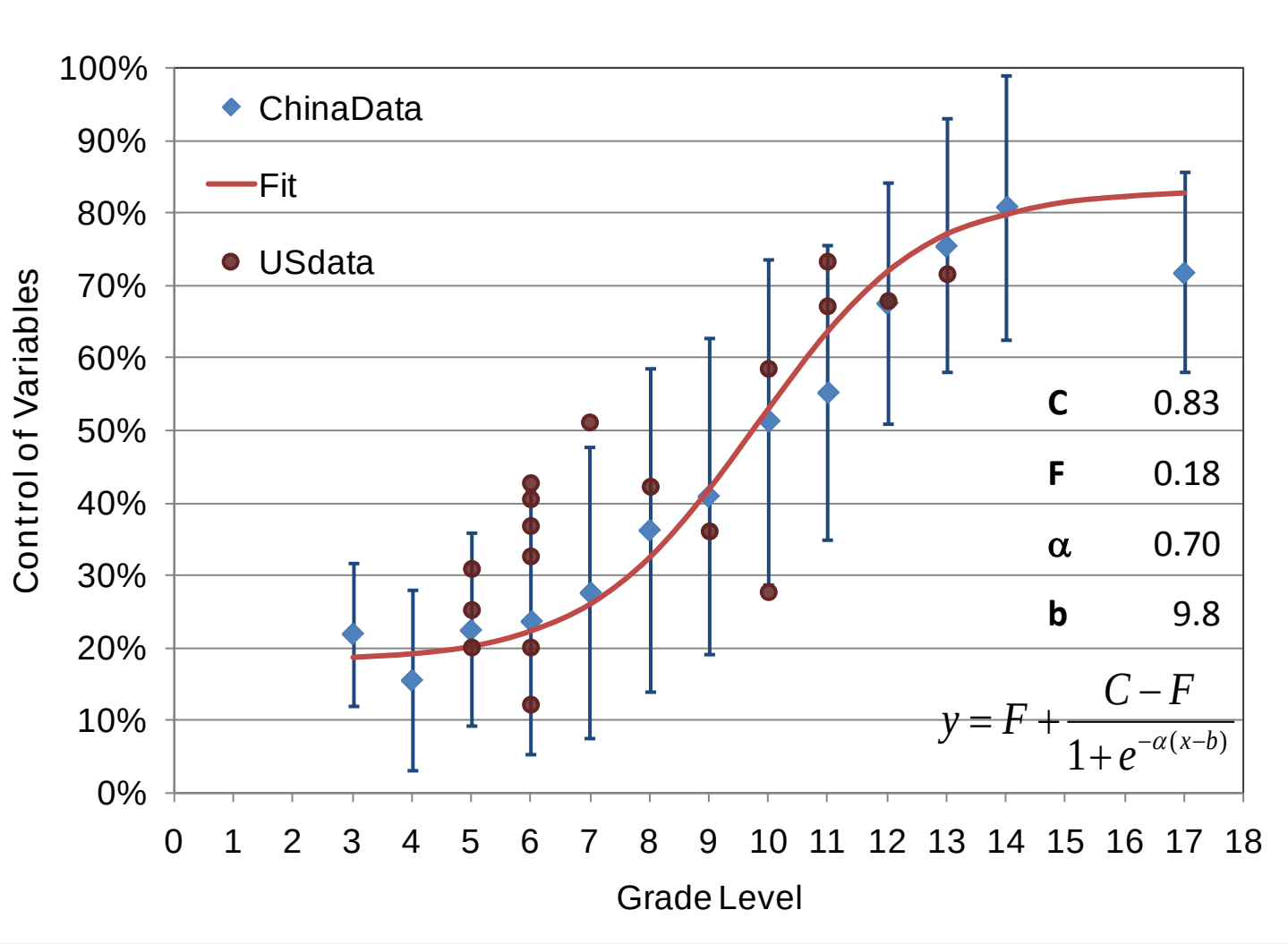
Measure and obtain a developmental metric of Lawson's test results for K-17 students.

- Over 10,000 data points from China
- ~3,000 from US college students
- ~2,500 from US K-12 students.

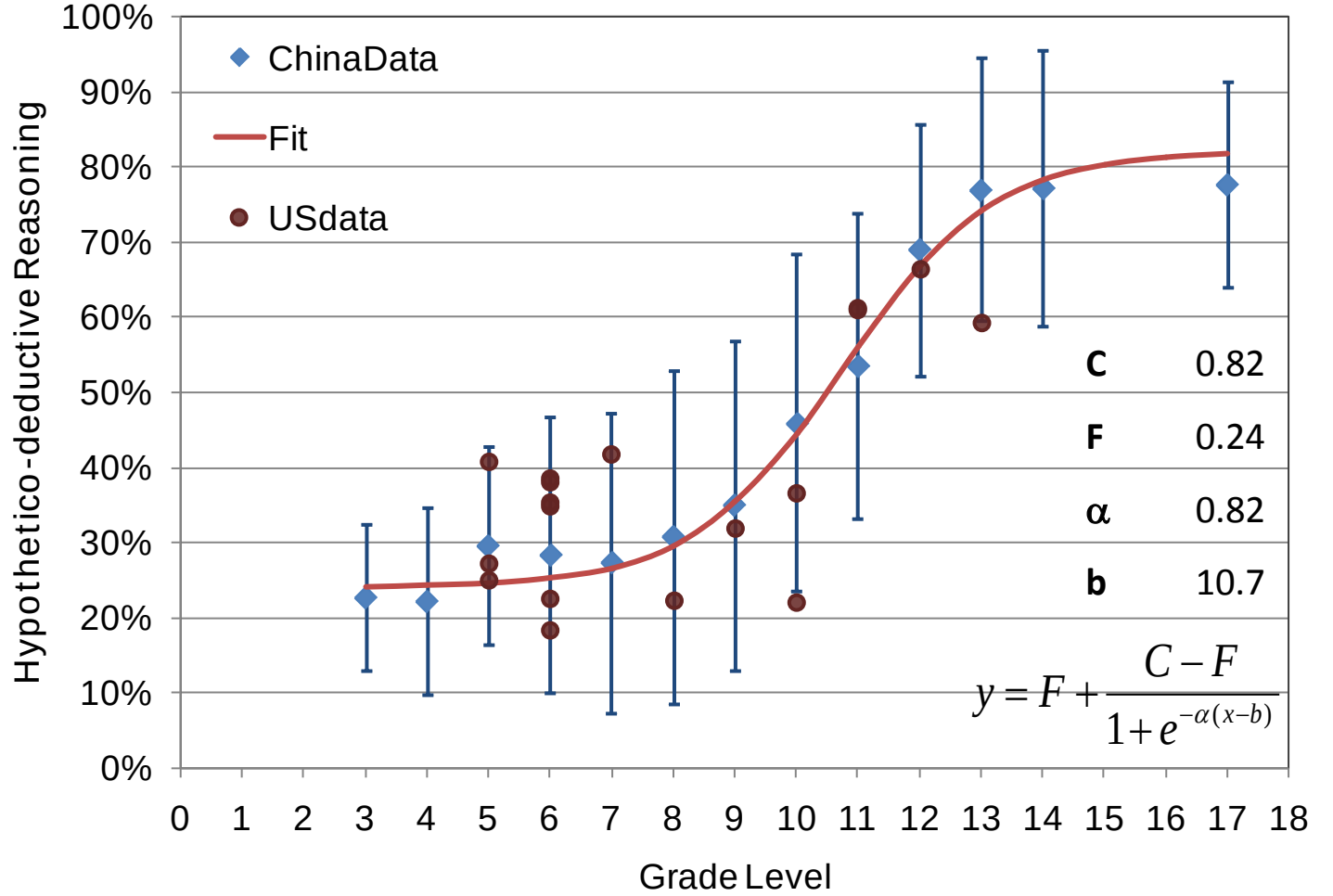
Learning Evolution Index (LEI) Curve



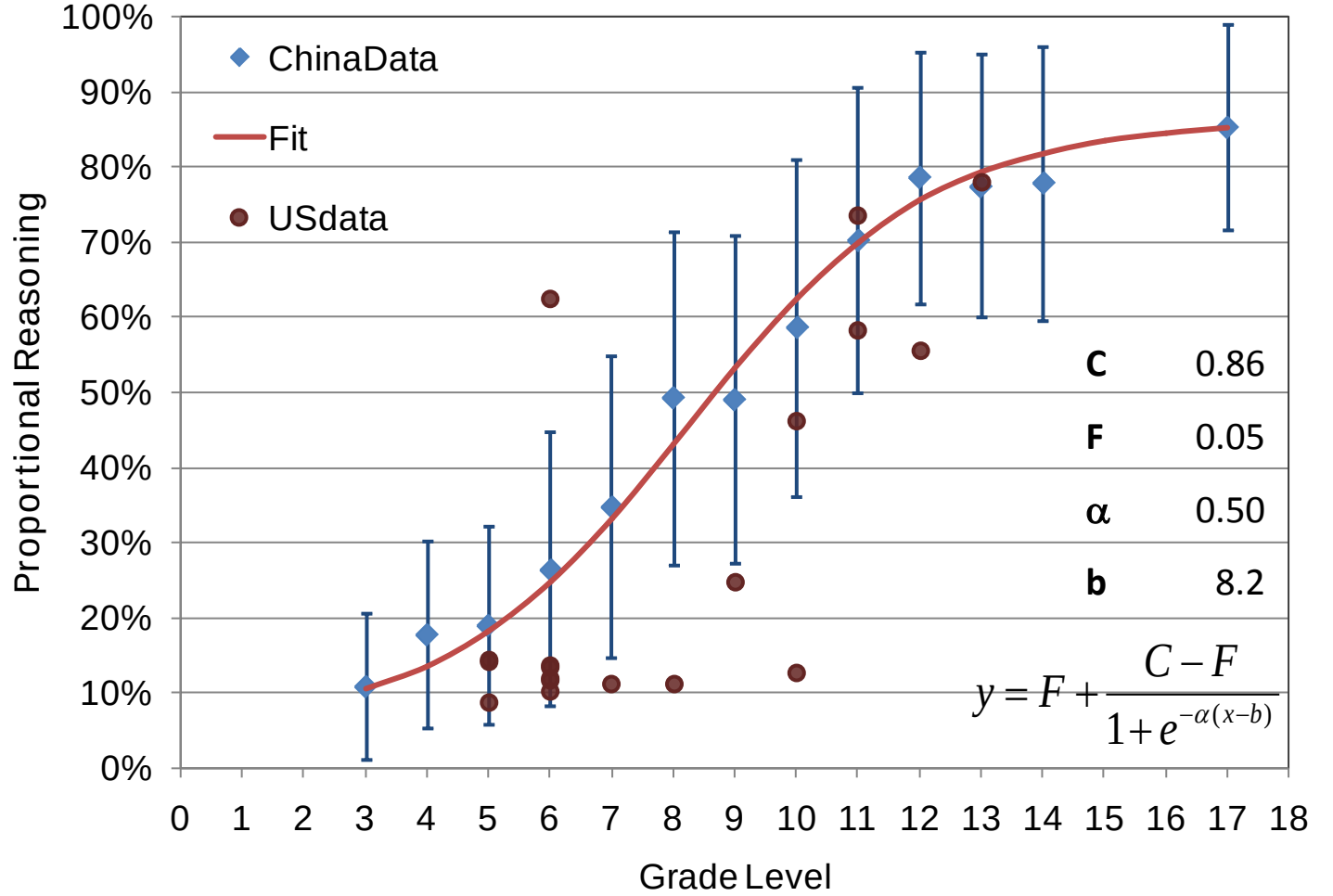
LEI Curve for “Control of Variables”



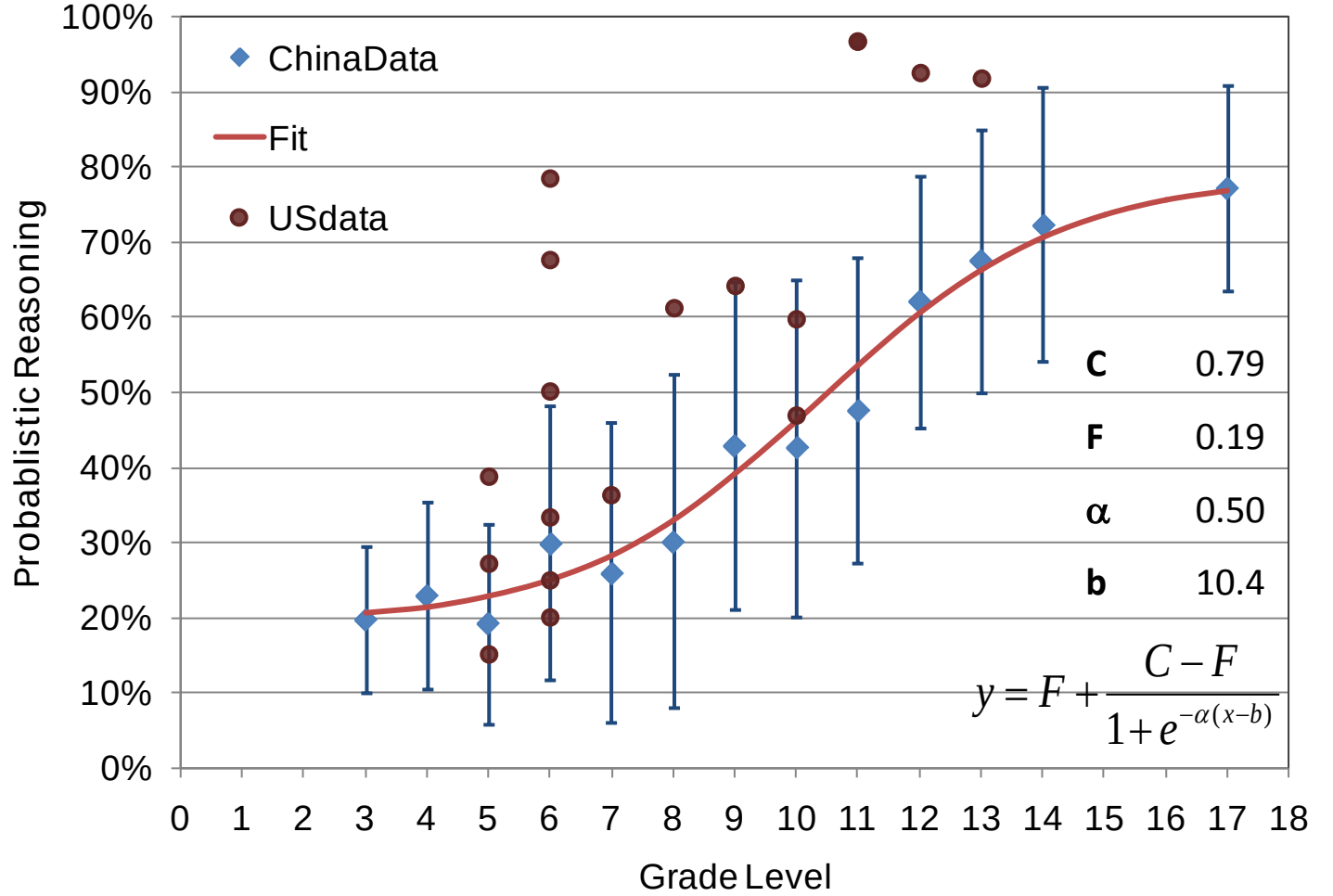
LEI Curve for “Hypothetical-Deductive”



LEI Curve for “Proportional Reasoning”



LEI Curve for “Probabilistic Thinking”



What methods are effective in developing Scientific Reasoning abilities?

Under current education settings the learning of content knowledge doesn't seem to have an obvious effect on the development of general scientific reasoning abilities.

- Regular intro courses has no effect (effect size~0.1).
- Inquiry-based courses changes Lawson pre-post (effect size=0.4~1).

	Course A			Course B		
	N	Mean	SD	N	Mean	SD
Pre-Test	205	60.5%	19.3%	58	58.1%	17.3%
Post-Test	197	61.5%	19.9%	58	66.1%	16.0%
Pre-Post Difference	1.0%			8.0%		
Pre-Post Effect Size	0.05			0.47		

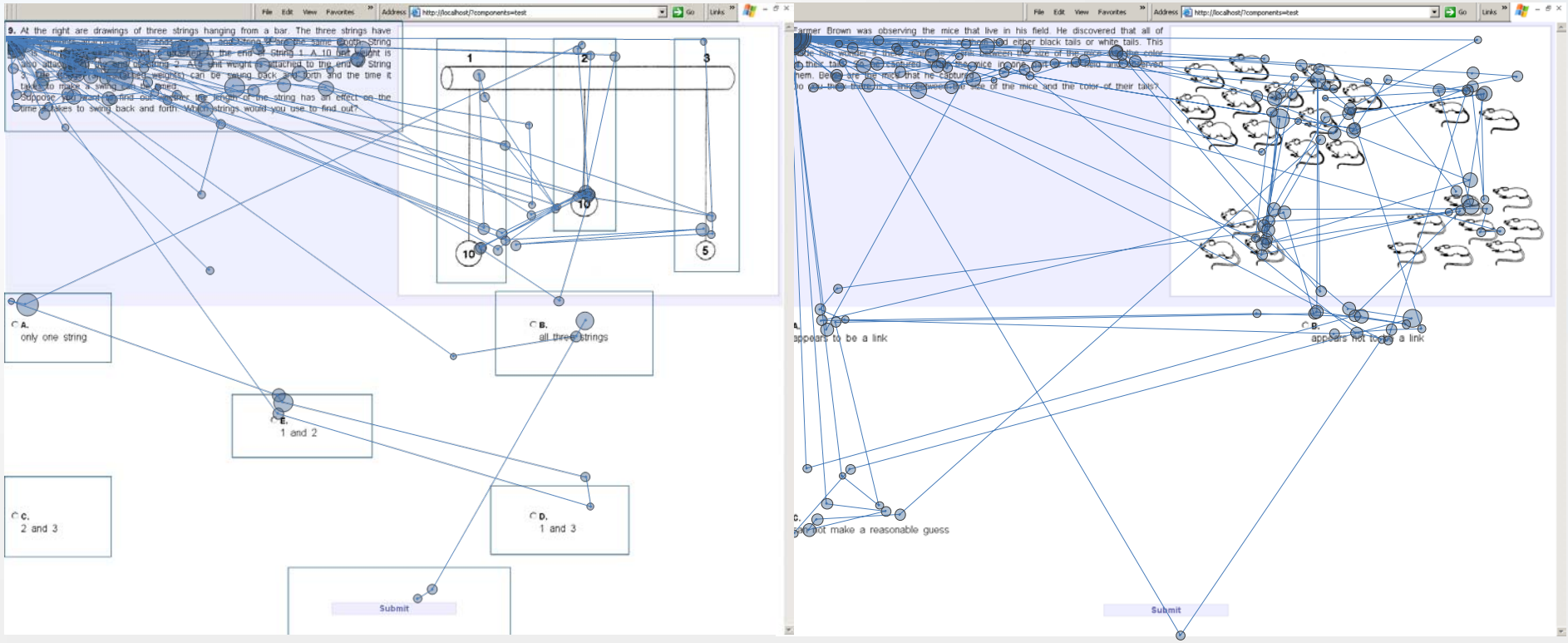
It is not what we teach but how we teach that matters!

Current Research

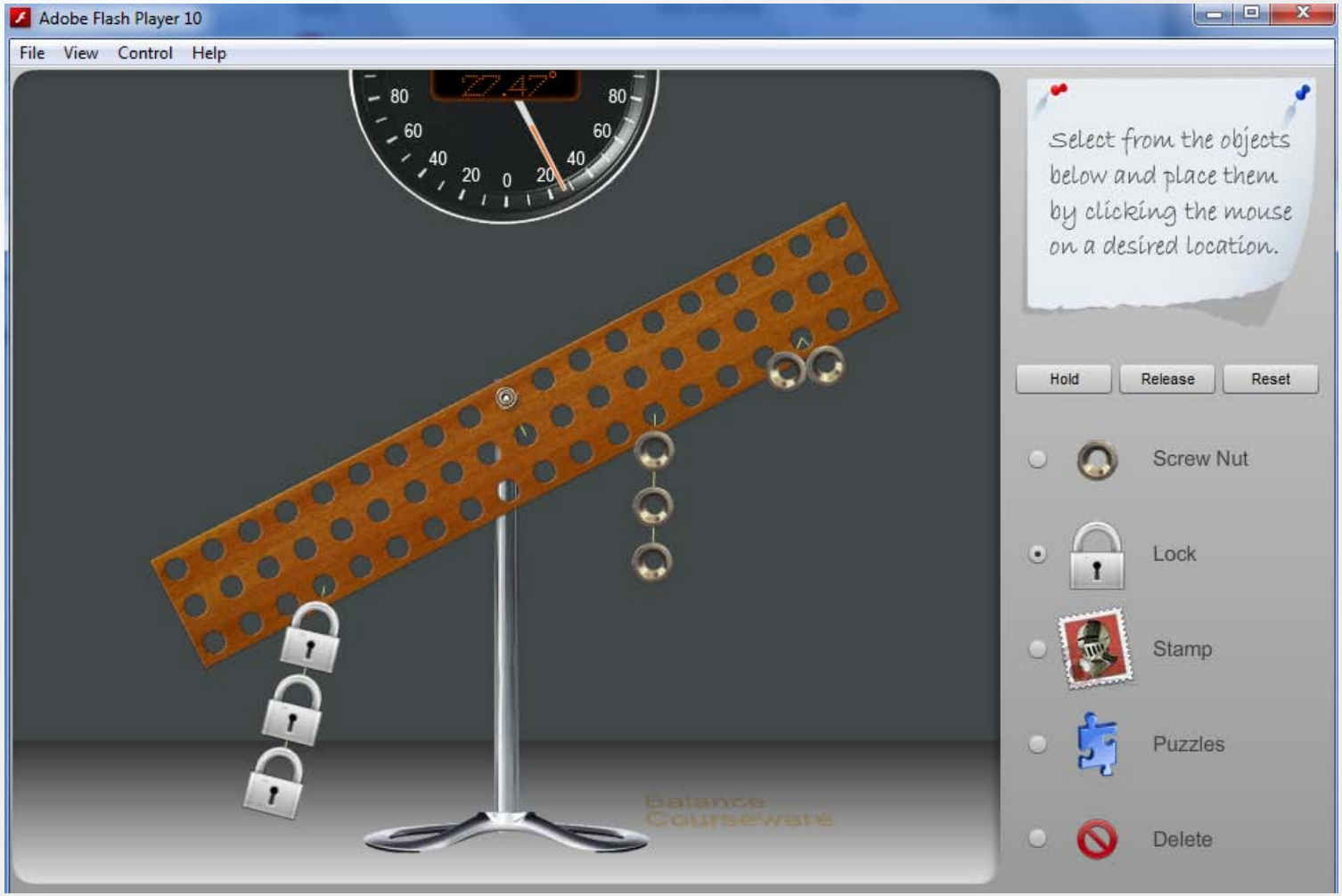
- Develop a valid and easy-to-use assessment tool (a test bank of 300+ questions).
- Develop curriculum.
- Evaluate the effectiveness of several education programs.
- Develop a large scale national and international quantitative assessment database.
- Develop a community of users and researchers.

(*NIH STEM Edu*)

Eye-tracking Measurement



Virtual Experiment for Inquiry Learning



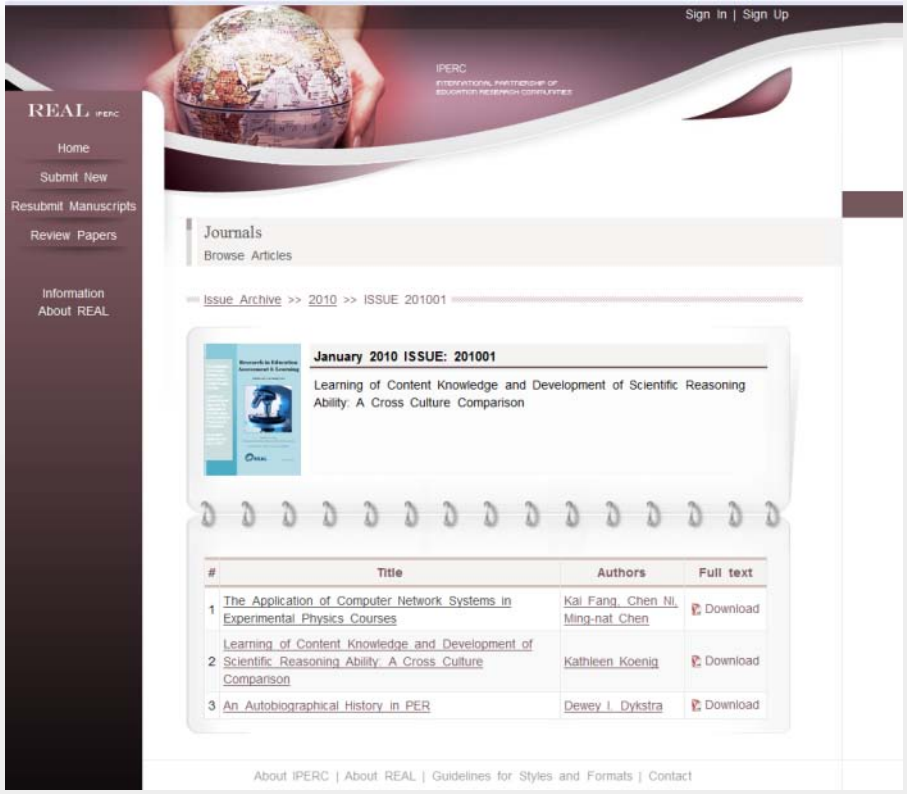
Sustained Development: community building

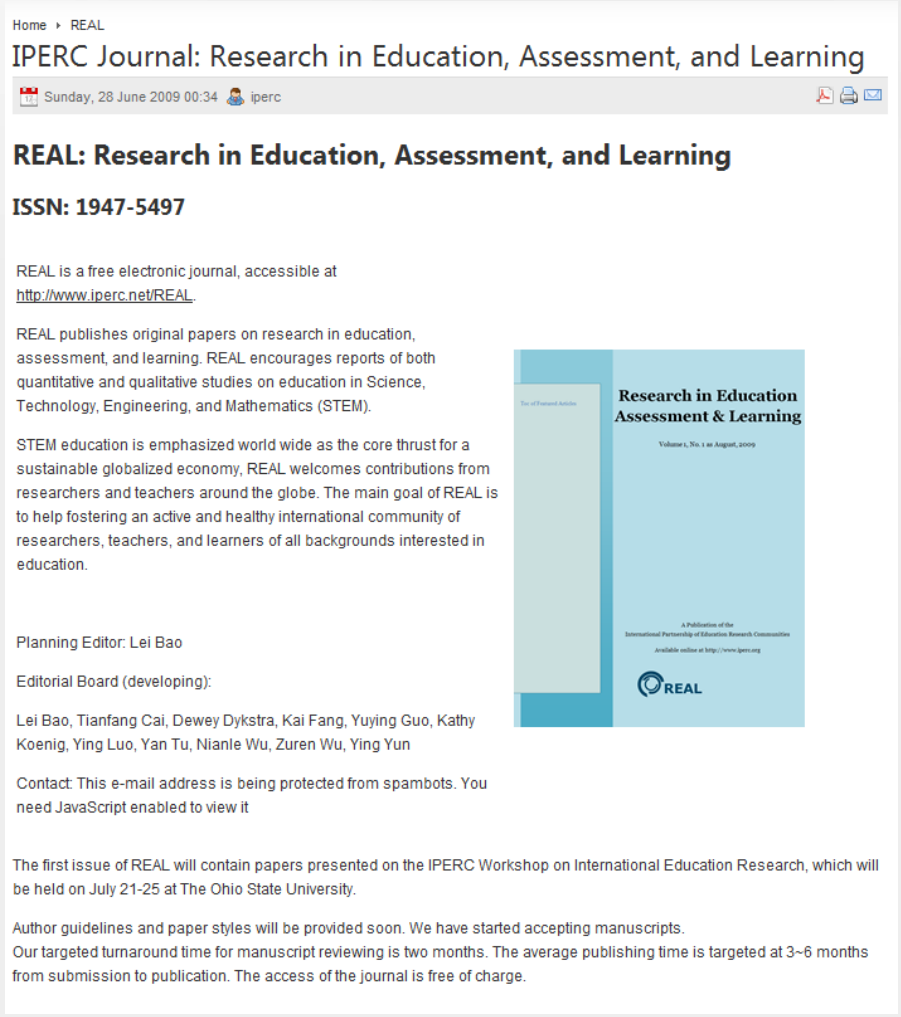
- About 12 Universities and 50 schools in China
- About 8 Universities and 30 schools in USA
- Additional Countries: Germany, India, Israel, Japan, South Africa, South Korean, Thailand

Community Building

Journal: Research in Education Assessment and Learning

www.iperc.org/REAL





Community Building

IPERC Summer 2009

International Physics Education Research Conference

AAPT International Education Committee
The Ohio State University

Featured Presentations

Developing Self-Learning Ability in a Bilingual College Physics Course

Ying Yun
Department of Physics, SouthEast University, Nanjing, China
Chief Editor of "International Physics Education Research Communications"
Former Director of the Chinese Physical Society International Physics Education Information Center.

When freshman students enter university from high school, they immediately encounter many changes and challenges, especially in the ways of teaching and learning. They are not used to the learning styles in the university, which are more flexible and very different from what they have experienced in high school. It's important for the teachers to help students develop the ability to conduct self-motivated and controlled learning. We have been working on this goal in our physics courses for the past 10 years. In this talk, we introduce the new development in a Bilingual Physics course that uses both Chinese and English to teach physics. We describe the teaching methods designed to foster students' self-learning ability and discuss the results and implications of this new course format.

'It's Important to Ask Students To Do Some Work on Their Own'

A Brief History of Physics Education and Physics Education Research
子曰、溫故而知新、可以为师矣。

E. Leonard Jossem
Department of Physics The Ohio State University.
Past-President of the American Association of Physics Teachers,
Consultant for the World Bank-Chinese University Development Project in China.
Honorary Professorships in Physics at Beijing Normal University,
at Beijing Teachers College, and at Southeast University in Nanjing, China.

The idea that the past has its uses, and that reviewing the past may help in planning for the future, has appeared in all ages and in all societies. Here we will take a brief overview of the development of physics education and physics education research on an international scale.

Targeting Scientific Reasoning Skill and Student Retention in an Innovative College Science Course*

Kathy Koenig
Department of Physics
Wright State University

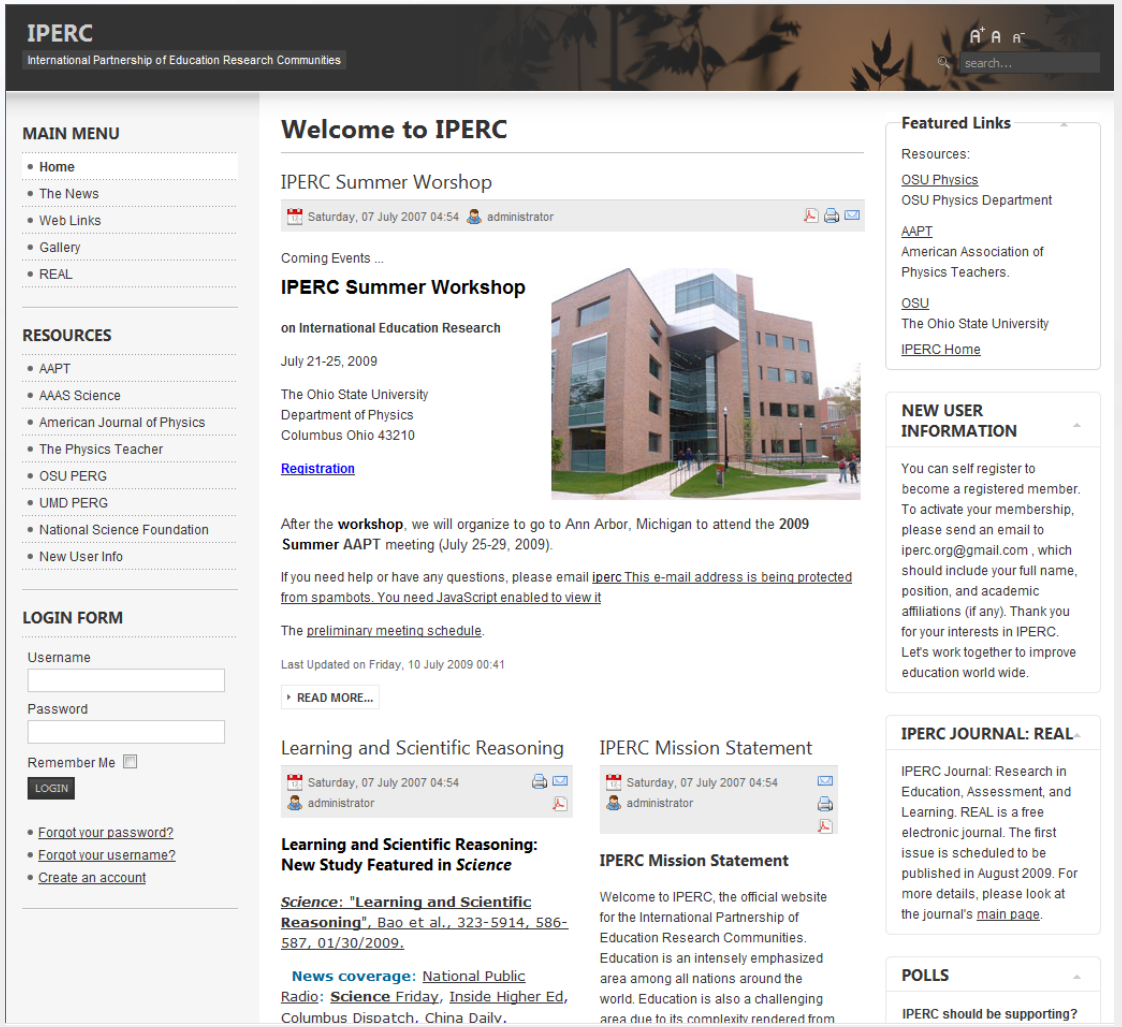
Students interested in majoring in science but who lack competency-based scientific and mathematical skills typically have low retention rates. An innovative course, SM 101, was created to address this problem and better retain "not-yet-ready" students. The presentation will describe the SM 101 curriculum which employs direct scientific reasoning training, and skills developed early on are repeatedly practiced in other multidisciplinary science contexts throughout the course. Sample activities will be described in the context of the targeted reasoning skills. Evaluation of the curriculum indicates that student scientific reasoning ability, as measured by the Lawson Classroom Test of Scientific Reasoning, significantly improves during the course and modest increases in student Fall-to-Fall retention has been observed. The need for department buy-in, offering the course for general education credit, and automatic enrollment of "not-yet-ready" students will also be discussed along with plans to incorporate the curriculum in courses at other colleges and high schools. The course, including pilots, has now been offered during six quarters to roughly 230 students.

A New Methodology for Using clicker in Physics Lectures

Bill Reay
Department of Physics The Ohio State University.

Passive lectures can be converted into active learning environments if students are able to electronically answer questions using clickers. Active learning is stimulated not by clickers, but rather by creating properly designed questions that generate discussions both during the answering period and after seeing anonymous answer summaries. Based on the hypothesis that learning is content dependent, we have replaced single questions with sequences of questions. Each question in a sequence contains the same underlying concept but has different surface features. Question sequences also are able to furnish both students and lecturers with multiple formative assessments.

A project to create a sufficient number of question sequences to populate an entire year of introductory physics is nearing completion. All sequences have been created, validated both by experts and students, and have been used multiple times in actual lecture classrooms. Learning gains have been measured by comparing otherwise identical lecture sections that use, or do not use, clickers to enhance conceptual learning. We will provide a brief overview of this project.



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Coming Events ...

IPERC Summer Workshop

on International Education Research

July 21-25, 2009

The Ohio State University
Department of Physics
Columbus Ohio 43210

Registration

After the **workshop**, we will organize to go to Ann Arbor, Michigan to attend the **2009 Summer AAPT** meeting (July 25-29, 2009).

If you need help or have any questions, please email iperc This e-mail address is being protected from spambots. You need JavaScript enabled to view it

The preliminary meeting schedule.

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Learning and Scientific Reasoning: New Study Featured in *Science*

***Science*: "Learning and Scientific Reasoning", Bao et al., 323-5914, 586-587, 01/30/2009.**

News coverage: National Public Radio: **Science** Friday, Inside Higher Ed, Columbus Dispatch, China Daily,

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Welcome to IPERC, the official website for the International Partnership of Education Research Communities. Education is an intensely emphasized area among all nations around the world. Education is also a challenging area due to its complexity rendered from

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IPERC JOURNAL: REAL

IPERC Journal: Research in Education, Assessment, and Learning. REAL is a free electronic journal. The first issue is scheduled to be published in August 2009. For more details, please look at the journal's main page.

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