New Jersey
Center for Teaching and Learning

Empowering Teachers …Leading Change

www.njctl.org

Robert Goodman, Ed.D

Executive Director

NJ Center for Teaching and Learning

&

Teacher

Bergen County Technical HS – Teterboro, NJ

bob@njctl.org www.njctl.org

My Challenge in 1999

Started public school teaching in 1999.

Launched a pre-engineering program at a new New Jersey vocational-technical high school.

Taught sixteen 9^{th} grade students to begin program.

Told my students had completed Algebra I in 8^{th} grade.

My Challenge in 1999

Only 3 of my 16 students had taken Algebra I, but they were scheduled for Geometry and Biology.

- They weren’t prepared for Geometry.
- Biology wouldn’t help with Algebra or Engineering.

The Solution

Used 2 hours of the vocational time I had with them to create an on-ramp to STEM:

- 40 minutes of Algebra I.
- 40 minutes of mathematically rigorous Algebra-Based Physics.
- 40 minutes of Engineering.

Why Algebra-Based Physics?

- Requirement for almost all STEM career paths, more than any other subject.
- The foundation for science; it makes science make sense.
- Provides a use for math; motivating students.

My Second Challenge

- Textbooks to teach mathematically rigorous Algebra-Based Physics didn't exist.

- In the U.S. mathematically rigorous Physics was taught with Trigonometry or Calculus.

- Books that used just Algebra, were not mathematically rigorous.

The Solution

Wrote a book for mathematically rigorous Algebra-Based Physics.

Topics were chosen to prepare students for Chemistry & AP Physics B.

AP Physics was critical to recognize what these Vo-tech students had achieved.

A Third Challenge

My room had no tables, chairs, blackboard or whiteboard, just computer stations.

I went to:

- The faculty lounge to get a few five foot diameter round tables.
- The cafeteria to get chairs.
- The storage room to get a blackboard on wheels.

Round Tables - a Lucky Break

- These students had not been very successful in science or mathematics.
- But, they liked talking to each other, and working on questions and problems together.
- This led to a pedagogy which was welcoming to all students.

Social Constructivism

- Brief direct instruction.
- Students building mental models by solving increasingly complex problems.
- Working together at round tables.

The Result

Pre-engineering students loved math & science.

- Enjoyed problem-solving with their friends.
- Learned that mathematics is useful.
- Learned that science makes sense, it’s not memorization.

The Result

Students in the other majors petitioned to take Algebra-Based Physics in 9th grade.

- By 2003, all students in the school were taking Physics in 9th grade.
- No tracking, all students in the same course.
- Many went on to AP Physics B.

The Result

By 2005 - 13 times the state rate of students were taking and passing AP Physics B.

- #1 in the state; double the #2 school.
- Became 2006 New Jersey State Teacher of the Year.

Extending the Work

The NJ DOE wanted to build this on-ramp to STEM careers in more NJ schools.

The NJEA formed the NJ Center for Teaching and Learning (CTL) and put me on the board.

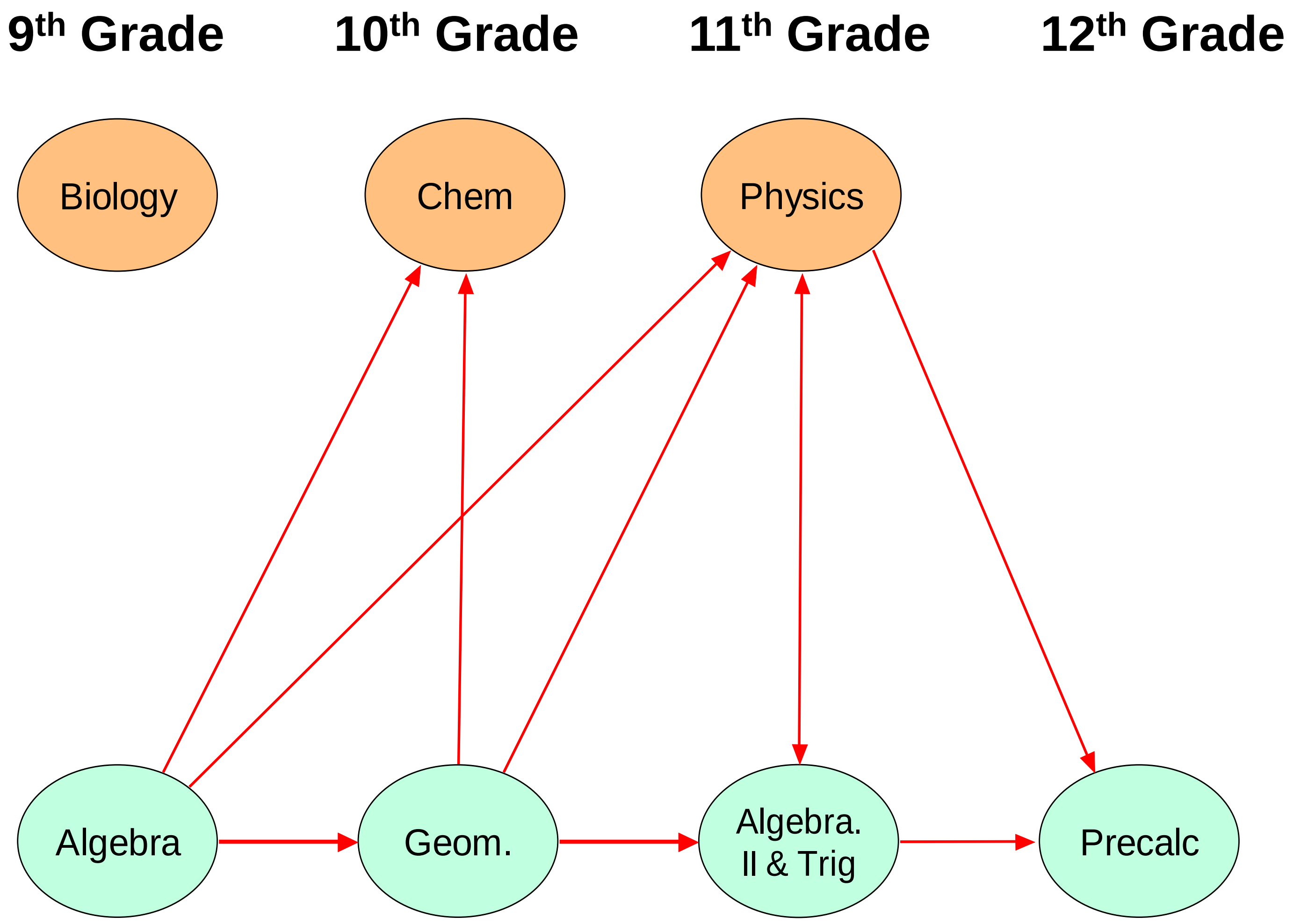
A major goal of CTL became to extend this work.

Our Challenge in 2007

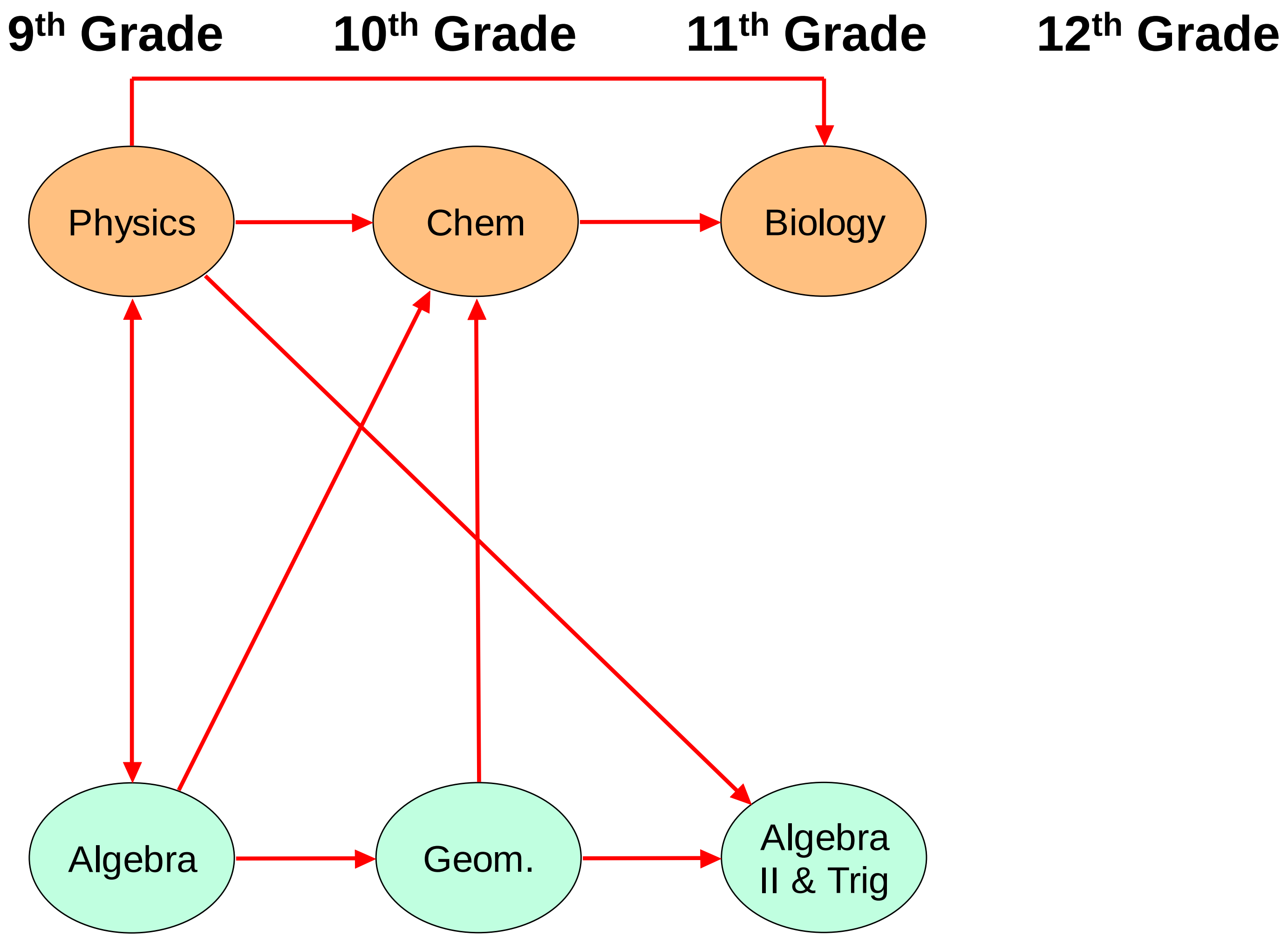
Extending this work broadly required:

- Schools to stop teaching HS science backwards.
- Developing free OER science and mathematics course materials that could be shared and edited.
- Many more Physics teachers.

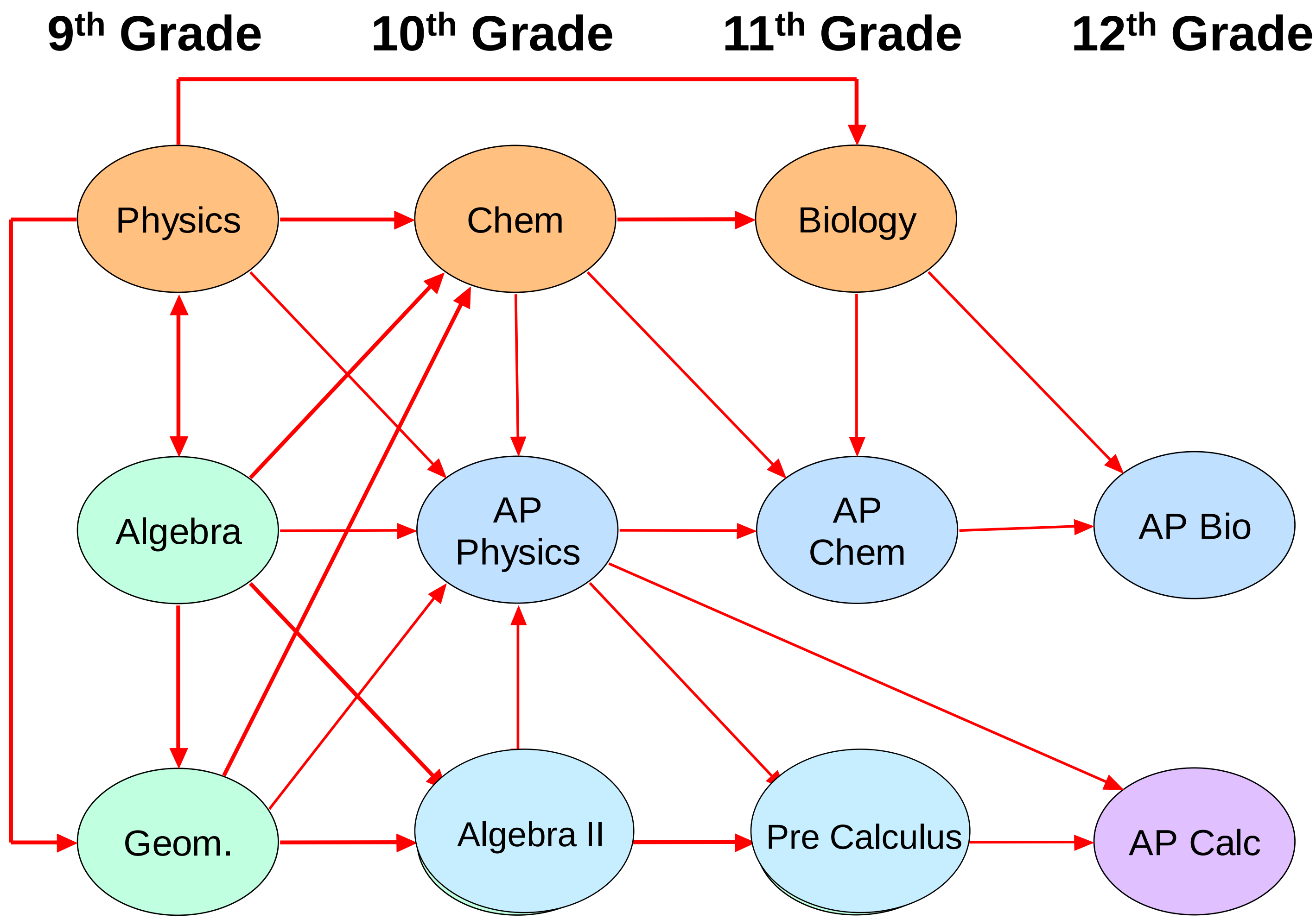
Stop Teaching Science Backwards



Make Science Make Sense



New HS Science Sequence – with APs



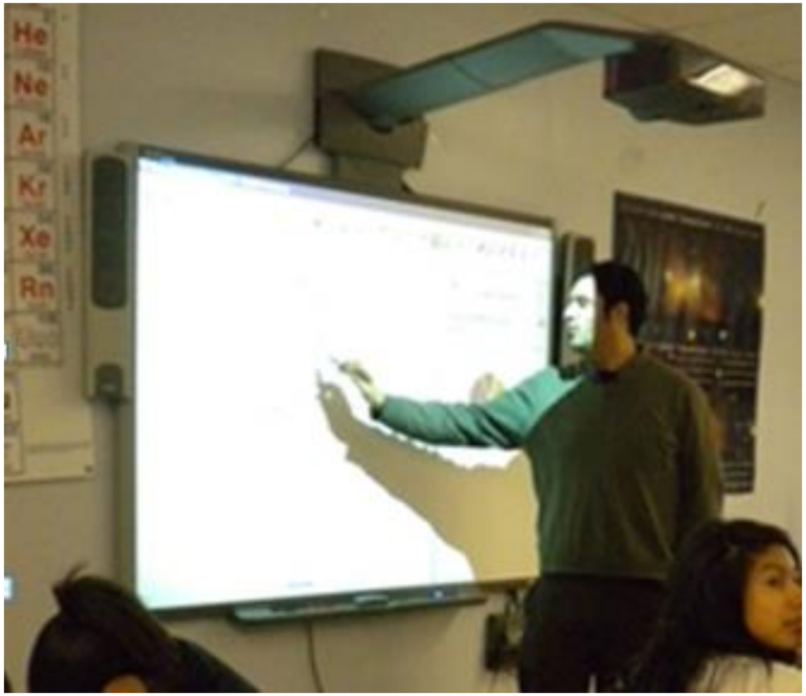
Our Solution for Course Materials

As a STOY, I was given an interactive whiteboard and student polling devices.

We captured our pedagogy and content in SMART Notebooks.

Posted those editable Notebooks on www.njctl.org for the free use of all.

Pedagogy



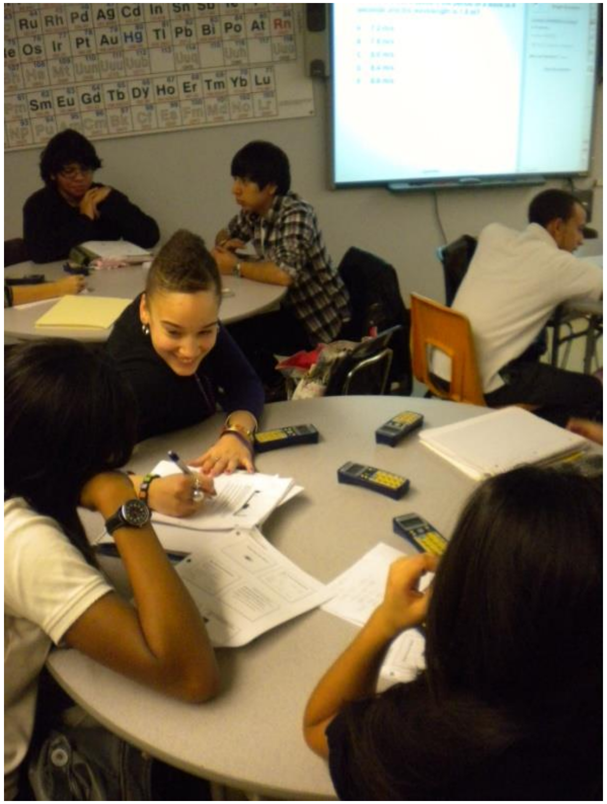
Direct Instruction

- Interactive White Board (IWB) presentation
- Student Response Formative Assessment
- Teacher as part of social group

Pedagogy

Social Constructivism

- Round Tables
- Group Problem Solving
- Heterogeneous Setting



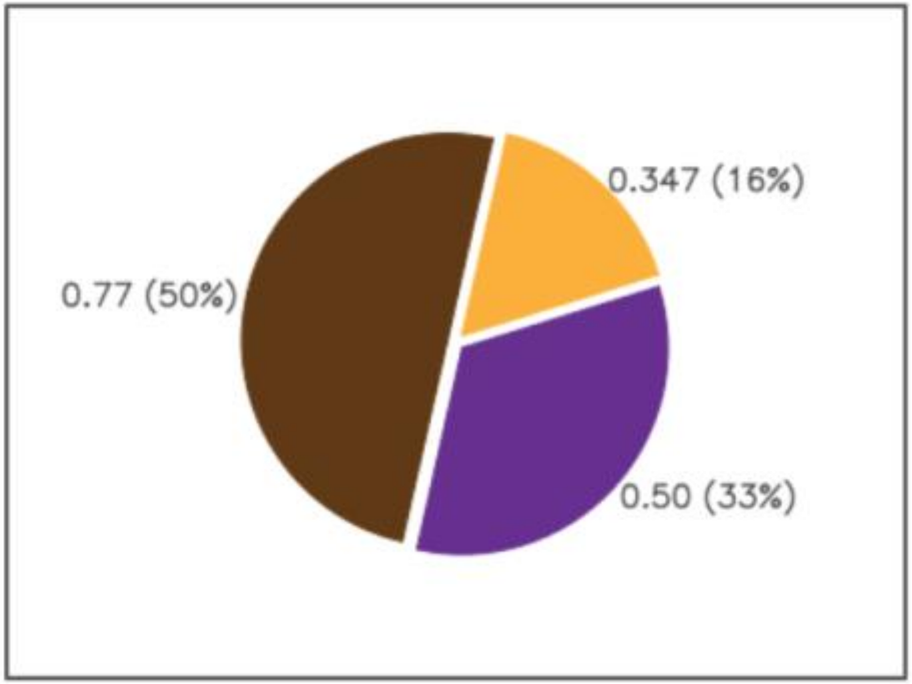
Formative Assessment

Student polling devices connect together direct instruction and social constructivism through the use of real-time formative assessment.

Formative Assessment

1 **Find the sum:**

0.3 + 0.47



The Key: Correct Answer is Hidden

- Students must defend their answers.
- Students focus on short direct instruction.
- Demonstrations and labs extend learning.

Neuroscience, Vygotsky and Video Games

People like to struggle, and then win.

- If there's no struggle, it's boring.
- If there's no win, it's frustrating.

Releases dopamine, resulting in pleasure and memory retention.

Structure of Classroom Learning

Each topic has direct instruction and about 6 formative assessment questions.

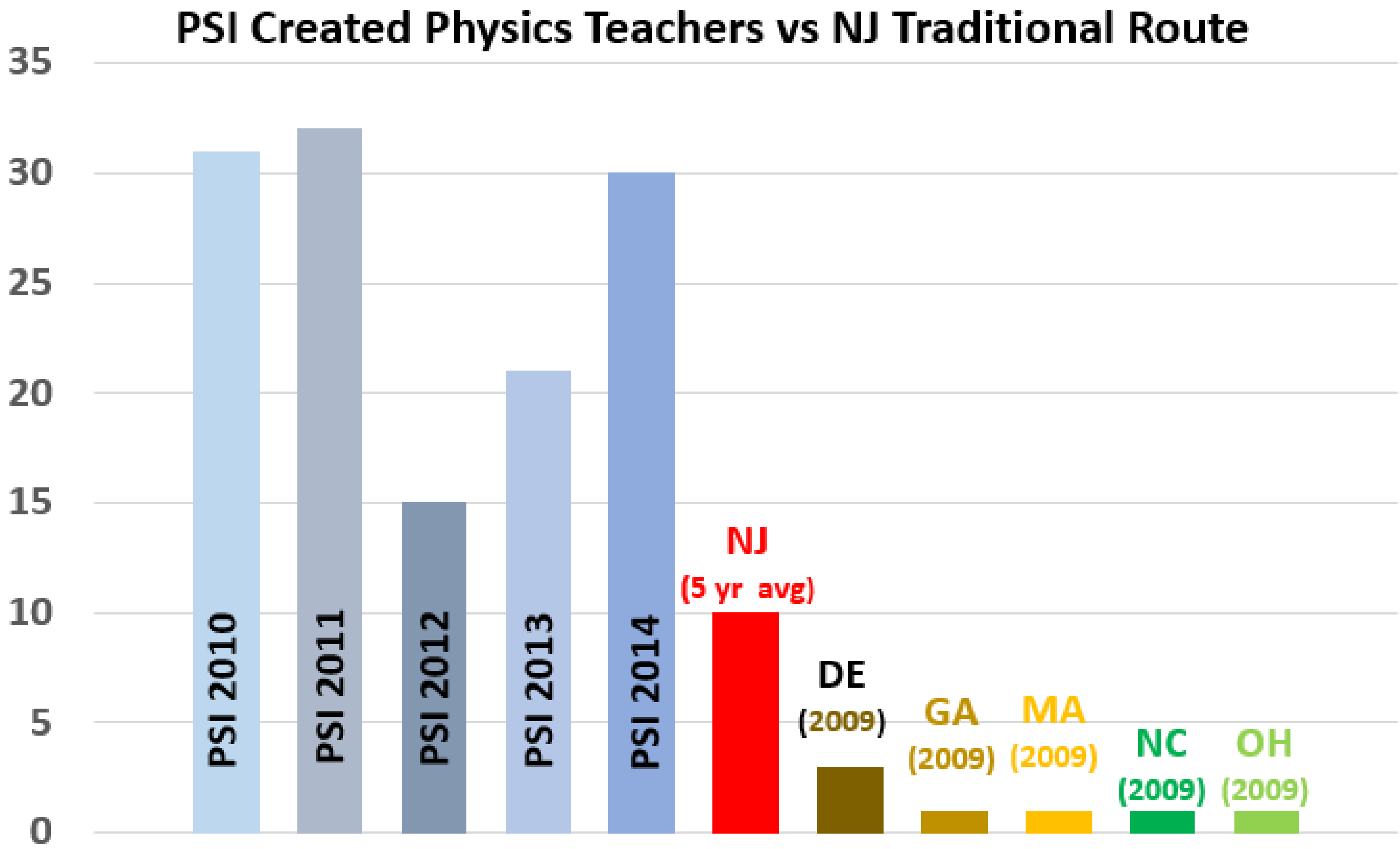
- Topics (with demonstrations) comprise units.
- Units (with labs) comprise courses.
- The sequence of courses comprise education.

Creating Physics Teachers

- **PSI** has shown that all students can learn Physics.
- **PSI** has shown that all teachers can learn Physics.
- **PSI** teaches Physics to skilled teachers.
- Provides teachers the tools to teach Physics.
- To get the best teachers to become the best Physics teachers:

  "Teaching is hard; science is easy"

PSI Creates Physics Teachers



Our Results – Teacher Training

- #1 producer of U.S. Physics teachers.
- Major producer of U.S. Chemistry teachers.
- Trained 1430 teachers in 218 schools in the effective use of our free editable course materials.

Extending beyond HS Science

Approach extended to K-12 mathematics & science

Progressive Science Initiative® (PSI ®): K-12 Science

Progressive Mathematics Initiative ® (PMI ®): K-12 Mathematics

www.njctl.org

Free Editable K-12 Course Content

Created electronic files capturing our course content AND method of teaching, eliminating textbooks.

- 90,000+ slides.
- 3500+ word documents.
- Almost all of K-12 mathematics and science.
- Posted at www.njctl.org.

Our Results: Free Editable K-12 Mathematics & Science Courses

In the last 12 months:

- 3.8 million pageviews.
- 1.6 million file downloads.
- 244,000 unique visitors.
- Used in all 50 states and 180 countries.

Our Results – Geographic Expansion

- Developed in one NJ school: 1999
- Extended to 100+ NJ schools: 2007
- Extended to Argentina: 2010
- Extended to four other U.S. states: 2011
- Extended to West Africa: 2012

Our Results – Student Learning

Eight of the top 20 NJ schools for taking AP Physics B

Students in these PSI schools versus those in these non-PSI schools:

- Economically disadvantaged: 61% versus 9%
- 71% Black/Hispanic 71% versus 11%
- Mostly urban versus mostly suburban

AP Physics B Participation – NJ
2013-14

Rank	School	AP B Participation	Black + Hispanic	Econ. Disadv.
1	BERGEN COUNTY TECHNICAL HIGH SCHOOL - TETERBORO	47.3%	24.4%	11.7%
2	LIBERTY HIGH SCHOOL (JERSEY CITY)	37.6%	77.1%	62.2%
3	GLEN RIDGE HIGH SCHOOL	24.2%	12.0%	0.0%
4	TECHNOLOGY HIGH SCHOOL (NEWARK)	24.2%	89.5%	90.6%
5	BERNARDS HIGH SCHOOL	23.8%	15.8%	8.8%
6	MADISON HIGH SCHOOL	23.8%	11.2%	7.2%
7	CRESSKILL HIGH SCHOOL	23.6%	9.5%	4.2%
8	DR RONALD MCNAIR HIGH SCHOOL (JERSEY CITY)	22.6%	38.2%	47.0%
9	CHATHAM HIGH SCHOOL	22.3%	4.8%	2.2%
10	HIGHLAND PARK HIGH SCHOOL	19.4%	31.7%	33.0%
11	BERGENFIELD HIGH SCHOOL	19.2%	51.6%	35.0%
12	HENRY HUDSON REGIONAL SCHOOL	17.7%	8.3%	26.6%
13	RIDGE HIGH SCHOOL	16.3%	4.3%	1.3%
14	RAMAPO HIGH SCHOOL	15.1%	4.3%	0.4%
15	EAST ORANGE STEM ACADEMY HIGH SCHOOL	14.7%	99.6%	73.6%
16	AMERICAN HISTORY HIGH SCHOOL (NEWARK)	14.2%	96.7%	85.4%
17	MOORESTOWN HIGH SCHOOL	14.2%	11.9%	9.7%
18	PERTH AMBOY HIGH SCHOOL	13.7%	97.4%	84.3%
19	MONTGOMERY HIGH SCHOOL	13.4%	5.7%	3.8%
20	ROBBINSVILLE HIGH SCHOOL	12.6%	7.4%	4.8%

	Black + Hispanic	Econ. Disadv.
PSI	71.8%	61.2%
Non-PSI	10.6%	8.5%

PSI-PMI Paradigm Shift

For what world are we preparing our students?

Not for

Isolated work:

factual recall;

sitting quietly;

transcribing;

accepting

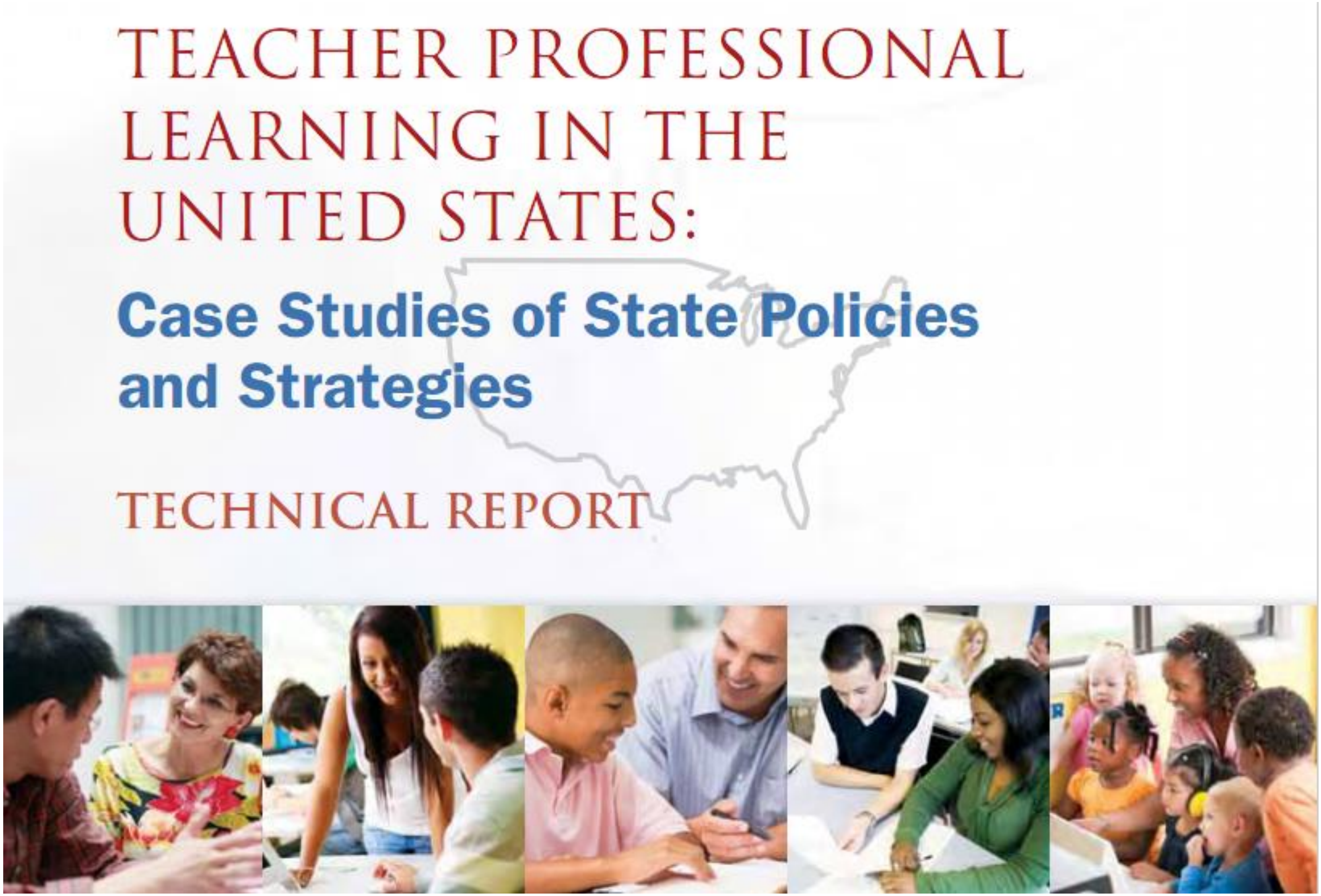
PSI-PMI Paradigm Shift

For what world are we preparing our students?

Rather, for collaborative work:

critical thinking;
problem solving;
talking;
debating;
questioning

Learning Forward – National Report



Learning Forward – National Report

"The New Jersey Center for Teaching and Learning (NJCTL) has been doing **groundbreaking** professional development work in math and science instruction as well…using the innovative curriculum of 2006 New Jersey Teacher of the Year Robert Goodman…to create the Progressive Science Initiative…."

IMS Learning Impact Award

100Kin10 Partner

Accepted, in 2015, by 100Kin10 as one of 236 “best in class” partners working to achieve President Obama’s goal of 100,000 new mathematics and science teachers by 2020.

Dr. Phillip Griffiths

When CTL was vetted to become a 100Kin10 partner reviewers were very positive.

Dr. Phillip Griffiths saw CTL as standing out for its recognition of the unique role of Physics.

Dr. Griffiths is a Fields Medalist and Director Emeritus of the Institute of Advanced Study.

Quote from Dr. Phillip Griffiths

“Physics education is of singular significance. The laws of physics are integral to much of natural science, with applications in chemistry, biology, astronomy, and earth and atmospheric sciences, among other fields. Efforts to solve physics problems spawned the development of calculus in the 17th century, and questions originating from physics permeate mathematics to this day. Problem-solving in the context of conceptual theory, with solutions tested by experiment, is a combination unique to physics.”

The Uniquely Important Role of Physics

Read a university course catalog to find which sciences are required for STEM majors.

For Rutgers,

- 90% require Physics
- 80% require Chemistry
- Fewer than 60% require Biology
- All other sciences are under 10%

The Uniquely Important Role of Physics

The rank of the sciences in importance to STEM majors is:

1. Physics
2. Chemistry
3. Biology
4. Earth, Space and Environmental Science

The Uniquely Important Role of Physics

But what HS students study is the reverse, in order and frequency:

1. Earth, Space and Environmental Science
2. Biology
3. Chemistry
4. Physics

The Challenge in New York City

Less than half of NYC high schools offer physics

Less than 20% of NYC students study physics or chemistry

NYC Students

Students only need to pass one Regents Science Course/Exam to graduate.

So, they take the easiest: The Living Environment

NYC Principals

Administrators only need their students to pass one Regents Science Course.

So, they schedule their students for the easiest:
The Living Environment

NYC Parents

Parents only need their child to pass one test to graduate.

So, they want their child to take the easiest test:
The Living Environment

NYC Teachers

Few teachers are certified to teach physics or chemistry

But, there is no apparent shortage since students, parents and administrators don’t encourage students to take them

So, why go through the process to become certified

Student Unprepared for STEM

As a result, students don’t take physics or chemistry.

They are unprepared for STEM careers

Especially in schools where parents don’t understand the long-term need for those courses

How do we address this tradeoff between the easiest pathway versus the long-term interests of students?

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