New Jersey
Center for Teaching and Learning

Empowering Teachers …Leading Change

www.njctl.org

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&

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My Challenge in 1999

Started public school teaching in 1999.

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

Taught sixteen 9th grade students to begin program.

Told my students had completed Algebra I in 8th 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 DOE wanted to build this on-ramp to STEM careers in more schools.

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

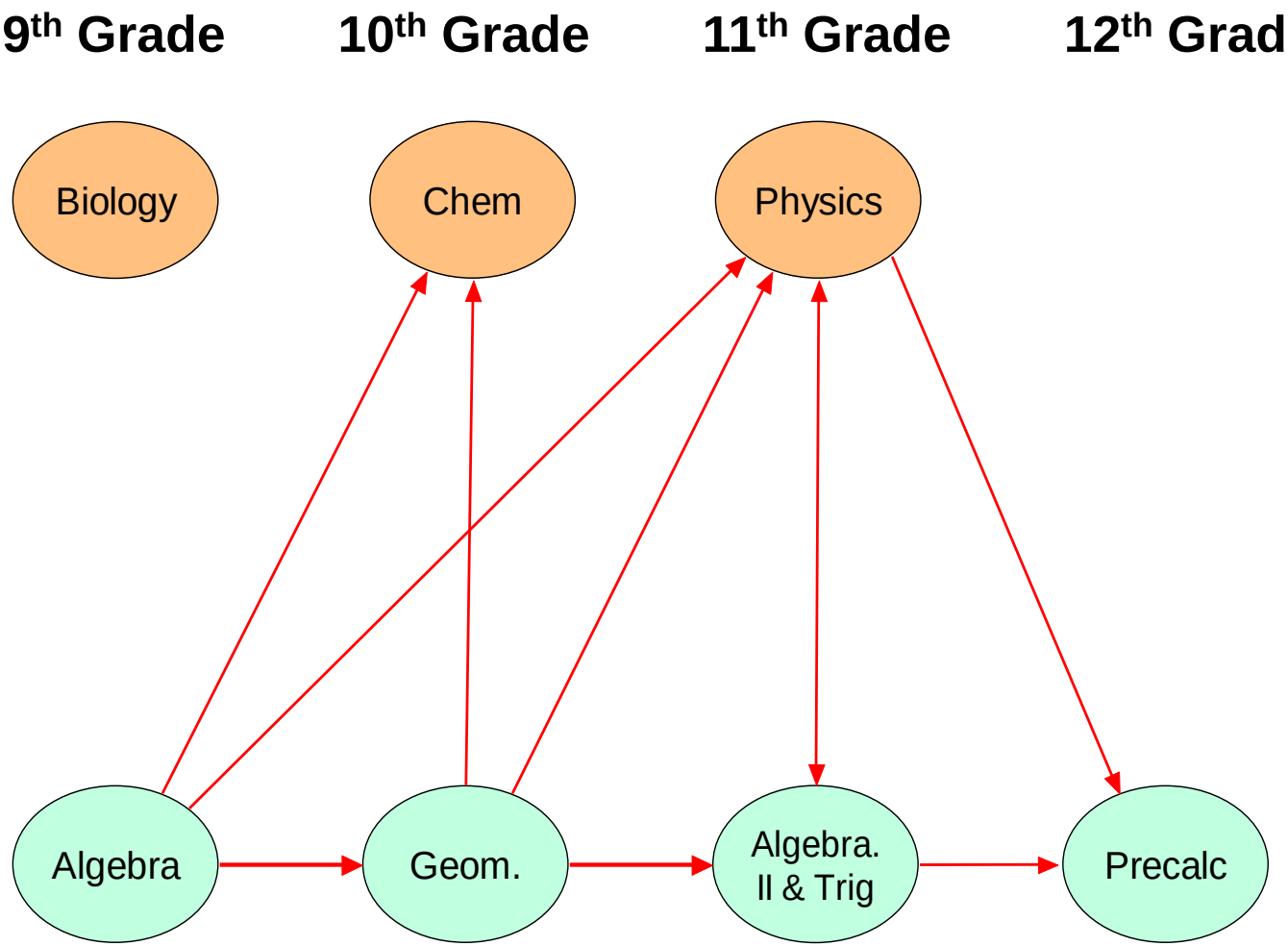
A major goal of CTL became to extend this work.

Our Challenge in 2007

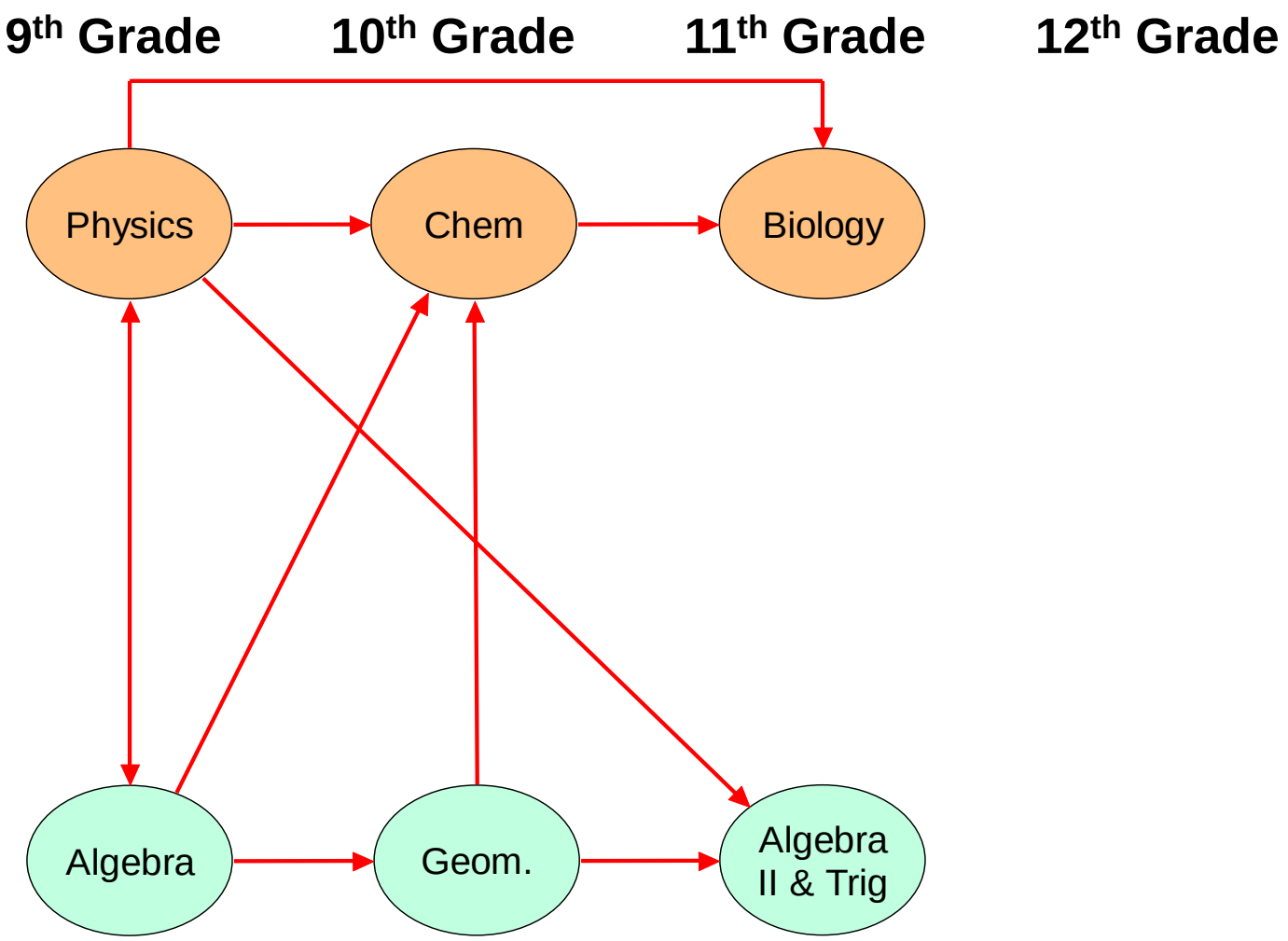
Extending this work broadly required:

- 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.

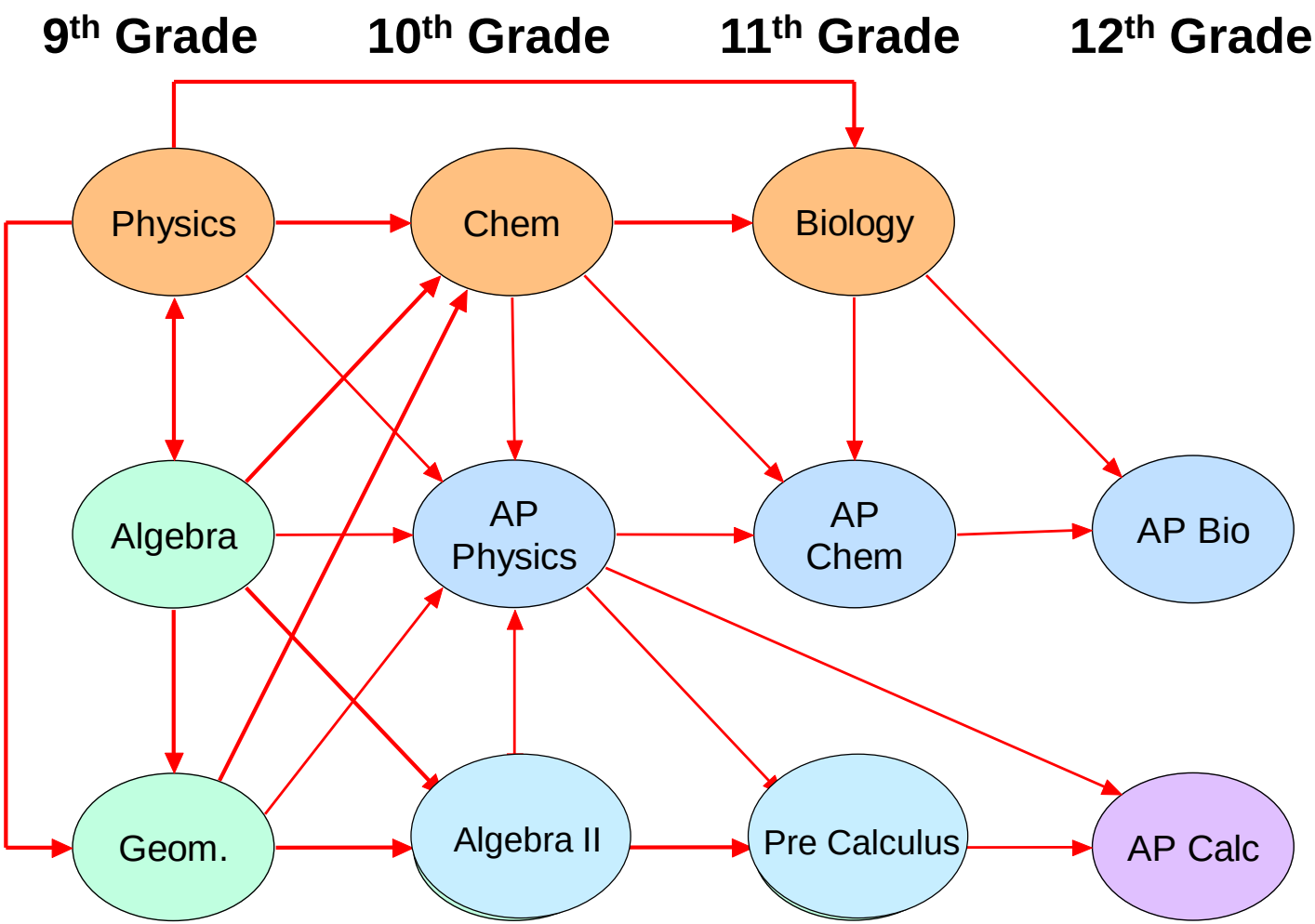
Stop Teaching Science Backwards



Make Science Make Sense



New HS Science Sequence – with APs



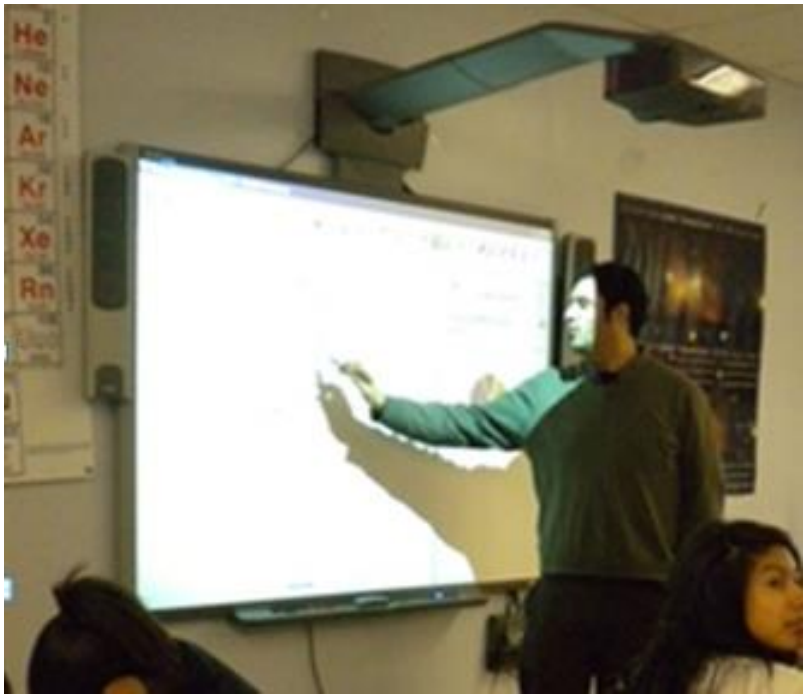
Our Solution for Course Materials

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



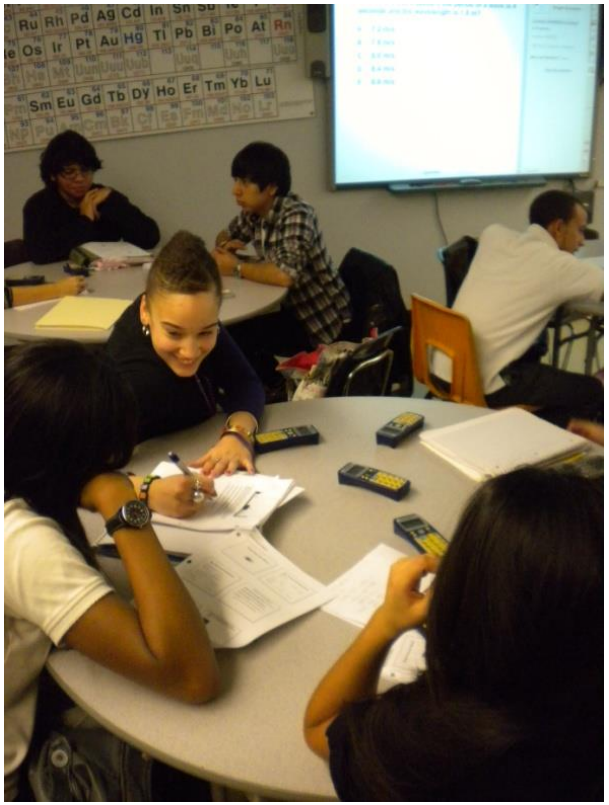
Direct Instruction

- 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



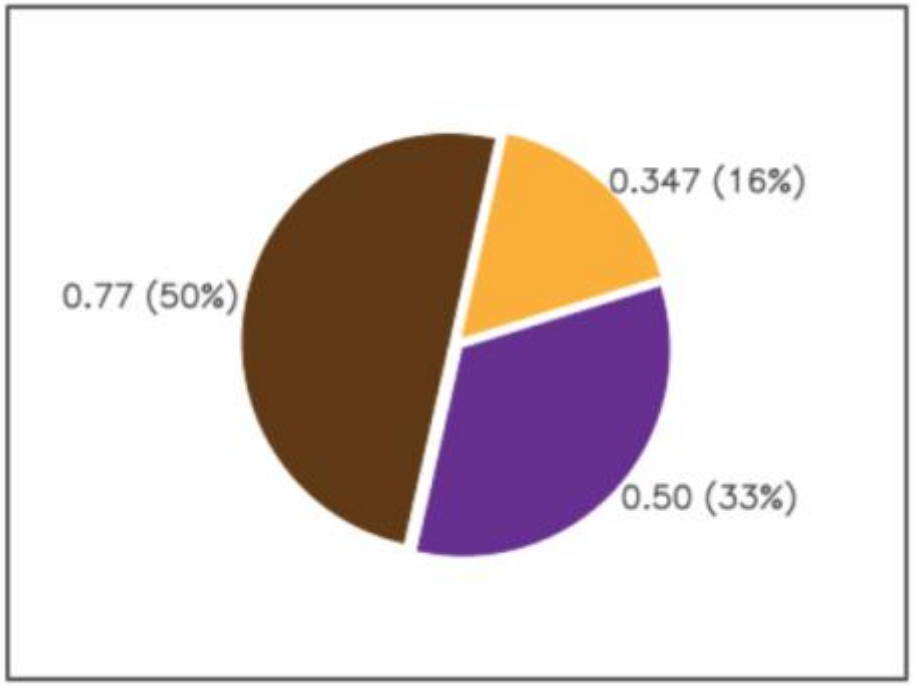
Formative Assessment

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"

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

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What is PSI-PMI?

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NJ Physics Certification

What is PSI-PMI?

Click here to read more or view courses.

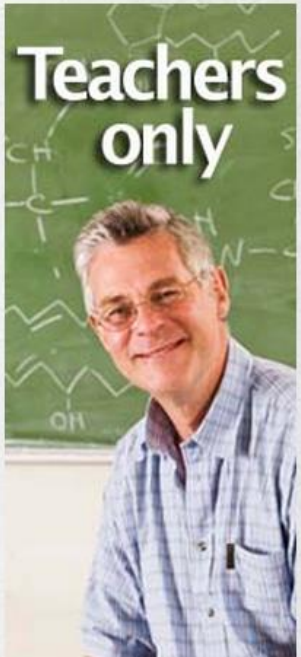
Announcements

Job Posting: Curriculum Writer: K-8 Science
May 20, 2014

CTL is seeking talented teachers to write curriculum for its K-8 science courses. Continue reading →

Trenton Central High Adopts PSI-PMI
May 12, 2014

Sometimes, when the challenges are sharpest, people rise to meet them with surprising clarity and powerful unity. That's what has happened in Trenton, where leaders from the Trenton Education Association (TEA), the Superintendent, Trenton Central High and Dunn Middle Schools' administrators, and the Trenton Board of Education, came together to bring the Progressive Science Initiative® (PSI®) and the Progressive Mathematics



Free Editable K-12 Course Content

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

- 100,000+ 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:

- 3.6 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

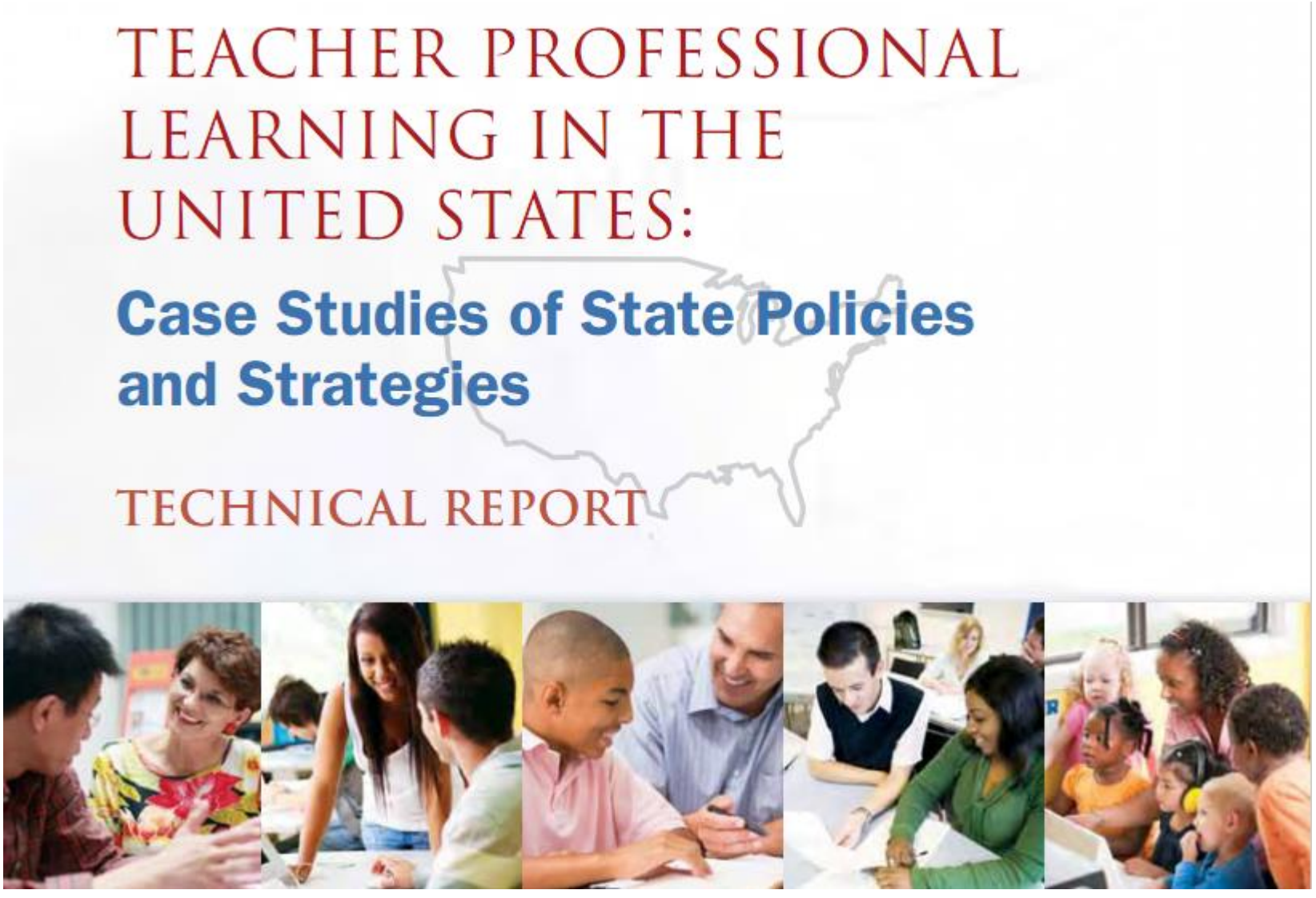
AP Physics B Participation – NJ
2013-14

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%
	PSI	71.8%	61.2%	
	Non-PSI	10.6%	8.5%	

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.

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

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

Next Generation Science Standards (NGSS)

Hired by Achieve to review a draft of the NGSS, and then the final NGSS.

Other people and organizations did similar reviews.

Will cite two of those reviews today.

Reviews of NGSS

American Association of Physics Teachers (AAPT), whose “mission is to enhance the understanding and appreciation of physics through teaching.”

Thomas B. Fordham Institute (TBFI), whose mission is to “be the nation's leader in advancing educational excellence for every child through quality research, analysis, and commentary….”

Reviews of NGSS

All three of us support adoption of the NGSS.

Only NGSS supporters are cited today.

However, we all raised similar concerns that need to be addressed.

STEM College and Career Readiness

NGSS are generally viewed as being a set of standards which, if mastered, would make a student “College and Career Ready.”

They are viewed as being analogous to the Common Core State Standards (CCSS) in mathematics.

Which College? Which Career?

However, that depends on which college or career.

NGSS are **NOT** sufficient to provide the science needed to embark on STEM Career Paths.

This can be corrected by developing curricula which address this deficit.

From the AAPT Report on NGSS

"Minimum Standards. We emphasize again that the NGSS document should state very clearly that the performance standards put forward in the document are minimum standards."

"Teachers can and should go beyond these performance expectations for most students. Students expecting to pursue STEM-related majors or careers will need more depth."

From NGSS Documents

"It would certainly be recommended that students, especially those considering careers in a STEM-related field, would go beyond these courses to take science, technology, engineering, and mathematics courses that would enhance their preparation."

From NGSS Documents

"The NGSS do not define advanced work in the sciences. Based on review from college and career faculty and staff, the NGSS form a foundation for advanced work, but students wishing to move into STEM fields should be encouraged to follow their interest with additional coursework."

From the Fordham Institute NGSS Report

"More problematic, however, is that the content of NGSS itself fails to ensure that *all* students will be equipped with sufficient content to make real the option of taking more advanced courses in the core STEM disciplines. This is particularly egregious in physics and chemistry, where our reviewers found that…"

From the Fordham Institute NGSS Report

"…the physical science standards fail to lay the foundation for advanced study in high school and beyond, and there is so little advanced content that it would be impossible to derive a high school physics or chemistry course from the content included in the NGSS."

From the Fordham Institute NGSS Report

“Recommended ‘practices’ dominated the NGSS, relegating essential knowledge—which should be the ultimate goal of science education—to secondary status.”

From the Fordham Institute NGSS Report

"…[the NGSS] conferred primacy on practices and paid too little attention to the knowledge base that makes those practices both feasible and worthwhile."

"Unfortunately, the NGSS suffer from the belief—widespread among educators—that practices are more important than content."

From the Fordham Institute NGSS Report

"…factual knowledge [actually] enhances cognitive processes like problem solving and reasoning. The richer the knowledge base, the more smoothly and effectively these cognitive processes—the very ones that teachers target—operate. So, the more knowledge students accumulate, the smarter they become."

- Daniel Willingham

From the AAPT Report on NGSS

"As mentioned previously, the AAPT group is profoundly disappointed with the current formulation of NGSS and we believe that in fact, that formulation undermines the national science education standards effort."

From the AAPT Letter on NGSS

"We emphasize, however, that the Science Standards are not meant to be a guide for curriculum development."

From the Fordham Institute NGSS Report

"In reality, there is virtually no mathematics, even at the high school level, where it is essential to the learning of physics and chemistry. Rather, the standards seem to assiduously dodge the mathematical demands inherent in the subjects covered. There is math available in the Common Core that could be used to enhance the science of the NGSS. No advantage is taken of this."

From the AAPT Report on NGSS

"We find an under-emphasis on using quantitative techniques…."

"Compared with the Common Core State Standards for Mathematics at middle school level, the Physical Science PEs undervalue the use of mathematics in science."

From the AAPT Report on NGSS

"We find…a lack of emphasis on construction and interpretation of graphs at middle school and high school levels. Graphical presentation of information is ubiquitous in society, cutting across many professions and occupations. We want students to be able to deal with both qualitative, graphical and age-appropriate quantitative information and models."

NGSS Appendix L

The authors of NGSS realized that they had a mathematics deficit.

So, they created Appendix L to address this deficit.

Appendix L proved insufficient, since the NGSS themselves were left unchanged.

From the Fordham Institute Report on Appendix L

“This failure to include essential math content is particularly troubling in light of statements by the authors of the NGSS that they intended to integrate mathematics into their new science expectations.”

From the Fordham Institute Report on Appendix L

“Johns Hopkins mathematician and veteran Fordham reviewer W. Stephen Wilson” found the following three major weaknesses in the mathematical alignment of NGSS to CCSS.

From the Fordham Institute Report on Appendix L

"1. In several cases where NGSS expectations require math in order to fully understand the science content, that math goes well beyond what students would have learned in classrooms aligned to the Common Core. In other words, the math in the NGSS and the math in the CCSSM are *not* fully aligned."

From the Fordham Institute Report on Appendix L

“2. Appendix L misses several opportunities to build important links between grade-appropriate math and required science content.”

From the Fordham Institute Report on Appendix L

“3. Appendix L too often makes “superficial connections,” in which grade-appropriate math is presented in ways that do little to enhance science learning.”

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

NGSS and Physics

NGSS weights these science about equally.

This under-emphasizes Physics and Chemistry.

And overemphasizes Biology, Earth and Environmental Science.

Improving NGSS and CCSS

A K-12 Physics thread would wed NGSS to CCSS, benefiting both.

But, this solution requires a pedagogy which is welcoming to all students.

This would build an on-ramp to STEM career paths for all students.

Access to STEM Career Paths

In the past, there were jobs for people without the mental tools of mathematics and science.

Those jobs are shrinking in number.

We can no longer accept students leaving school unprepared for the jobs that are open and desirable.

STEM Career Paths

Social justice and international competitiveness are two sides of the same coin.

A society which is just provides equal opportunity to all its citizens.

A society which is internationally competitive realizes the potential of all of its citizens.

STEM Career Paths

All students need not pursue a STEM Career Path.

But, all students must have a K-12 education that gives them that choice…that opportunity.

Using Physics to connect CCSS and NGSS would provide all students that opportunity.

Your Help Is Needed

Please work with CTL to:

Identify key experiments and problems that tie the NGSS to the CCSS Math in each grade

Develop materials making those experiments accessible to all K-8 students and teachers.

The Goal:

Access for All to STEM Career Paths

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