Teaching Physics in Alabama High School Classrooms

Alliance for Physics Excellence (APEX)
Physics Teaching Research Program (PTR)

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Physics Teachers Nationally

- There is a national need for quality physics teachers and high school physics offerings to effect a quality STEM workforce.
- 27,000 teachers taught at least one physics course in 2009 in U.S. high schools up from 23,000 in 2005
- Most physics teachers have undergraduate majors in other disciplines, often biology (White & Tesfaye, 2010) with only a minority majoring in physics or physics education (Hodapp, Hehn, & Hein, 2009),

- In 2013, 20% of 472 physics teachers in a national sample had undergraduate majors in physics. (Banilower, 2014)
- The annual growth rate was and continues below that of students wanting to take physics courses. (Hodapp, Hehn, & Hein, 2009).
- During the 2012-13 school year 1,4 million students took physics, 1.35 million in 2008-09 – a 2% growth. At the same time high school graduates dropped 1%. 39% of graduates took at least one physics class. Up from 37% in 2009. (Physics Teacher, 52, 2014)

Purpose

- Before we can effectively apply interventions or evaluate the efforts to improve the quantity and quality of physics teaching through professional development, it is important to determine what is occurring in our high school physics classrooms.

- *The Alliance for Physics Excellence* (APEX) goal was to integrate research-based teaching practices into physics classrooms via in-service teacher education, and evaluate the impact on teachers and their students.

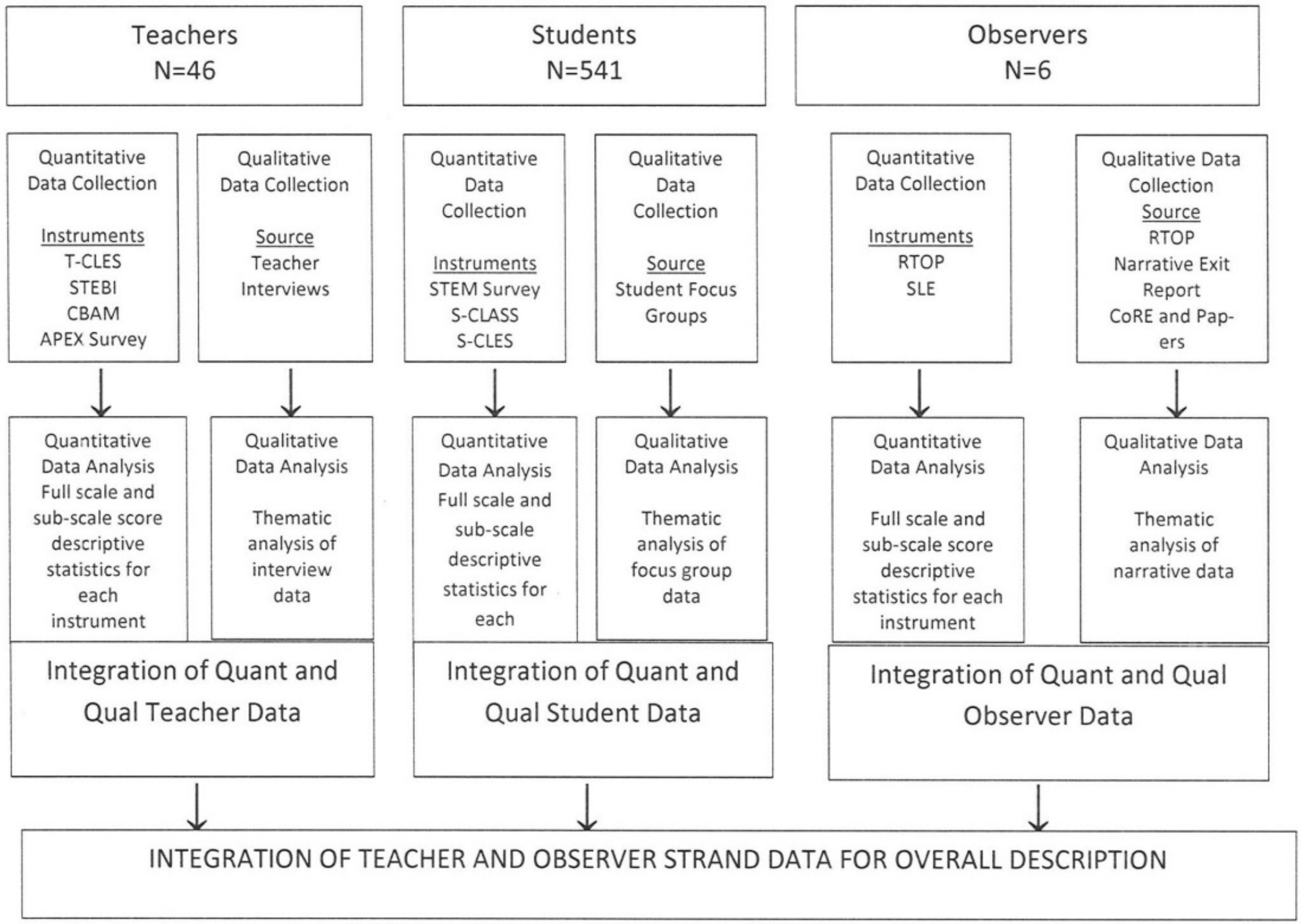
Question to begin with

What is the nature of the secondary physics classroom in Alabama as it exists today?

Variables:

- who is teaching physics?
- what is the classroom context?
- what physics teaching is occurring?
- what are the students doing during a lesson?
- what impact is the physics instruction having on students from a statewide population?

Convergent Parallel Research Design



Instruments

Teacher Perspectives Instruments

1. *Classroom Learning Environments Survey* (CLES) (Teacher version) ((Taylor, Fraser, & Fisher, 1997)
2. *Science Teaching Efficacy and Beliefs* (STEBI) (Riggs & Enochs, 1990; Enochs & Riggs, 1990)
3. *Concerns-Based Adoption Model* (*CBAM-TPACK*) Moertsch, C. (1998) and Hall, G. & Hord, S. (1987)
4. *Teacher Interview Protocol* (TIP)
5. *Content Representation* (CoRe) (Loughran, Mulhall, & Berry, 2004)

Student Perspectives Instruments

1. *Classroom Learning Environments Survey* (CLES) (Student Version) (Taylor, Fraser, & Fisher, 1997)
2. *Colorado Learning Attitudes about Science Survey* (CLASS) (Adams et al., 2006)
3. *STEM Career Preferences Survey* (STEM)
4. *Student Focus Group Interview Protocol* on physics lessons (SFGIP)

Observer Perspective Instruments

1 &2. *Reformed Teaching Observation Protocol* (RTOP) (Sawada & Pilburn, 2000; Sawada et al., 2002) rating teacher-student interactions and classroom context including detailed observational narrative section

3. *Pedagogical and Professional experience Repertoires* (PaP-ers) (Loughran, Mulhall, & Berry, 2004)

4. *Student Learning Engagement* (SLE)

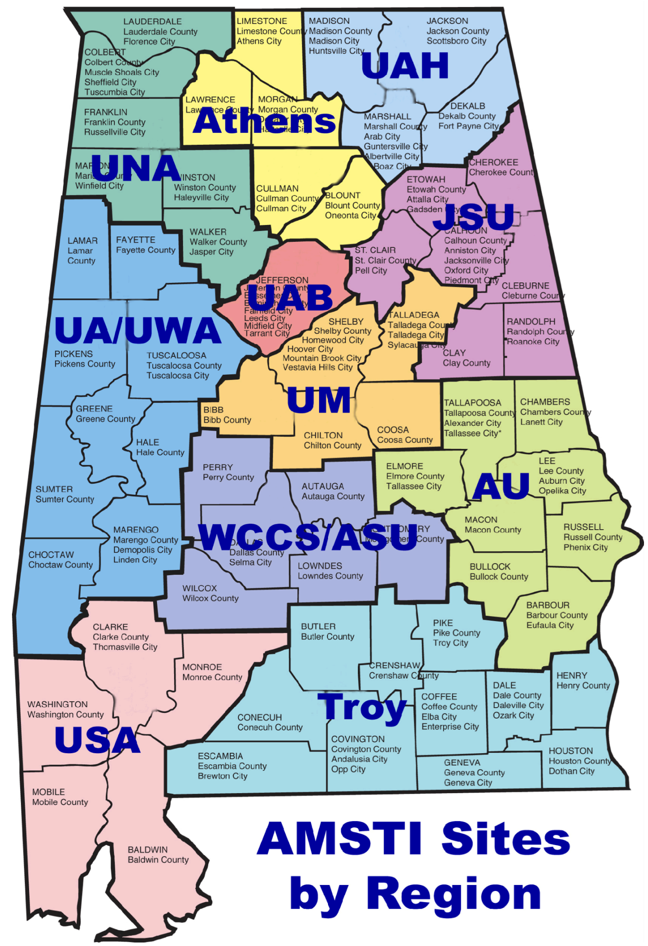
Procedure

- **Population:** rural & urban high schools in state
- **Sample:** 76 teachers, 847 students,

  8 yrs teaching science (11,8,6) & 6 (6,4,12) yrs physics; 61% female & 39% male; 26% AP & 74% other
- **On-site visits** (2 consecutive days)
- Pre-visit: teachers completed 3 surveys
- During visit: interviews with teacher & student focus groups; observations of physics lessons, laboratories, and student discussions.
- Post-visit: students completed 3 surveys

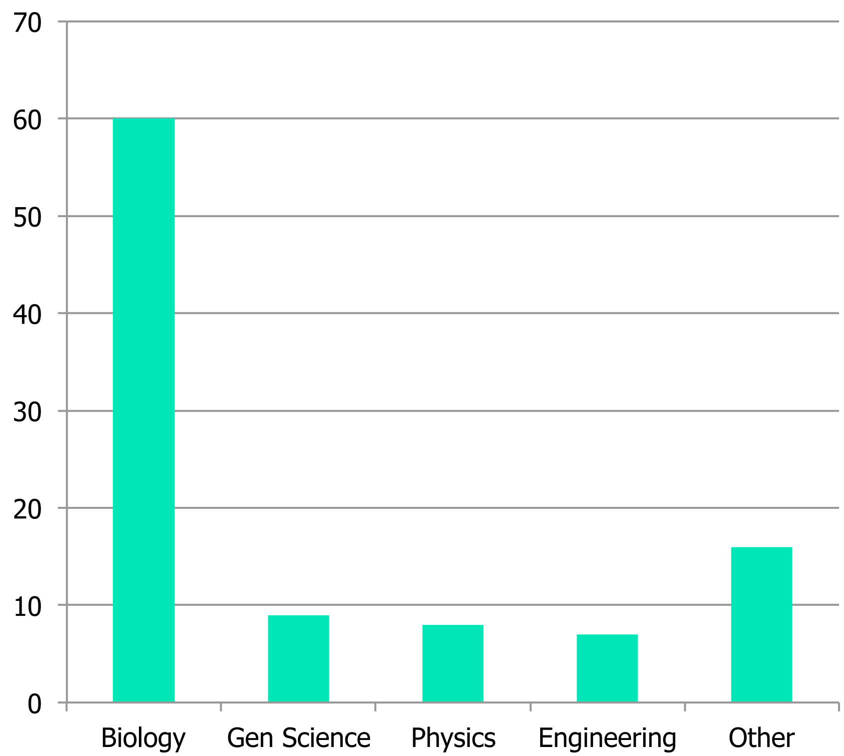
Selected APEX Sample

- Seventy seven physics teachers were selected from 11 of Alabama Inservice AMSTI/ ASIM Centers



AMSTI Sites by Region

Teacher Perspective - Quantitative Results



Undergraduate College Major

- Biology = 60%
- General Science = 09%
- Physics = 08%
- Engineering = 07%
- Other = 16%

  (Earth Science, Math, Chemistry, other)

Teacher Perspective - Quantitative Results

- **Teacher certification**
  - 90% General science/biology
  - 09% Physics
  - 01% Chemistry

College/University degree

Bachelors = 58.5%

Masters = 35.6%

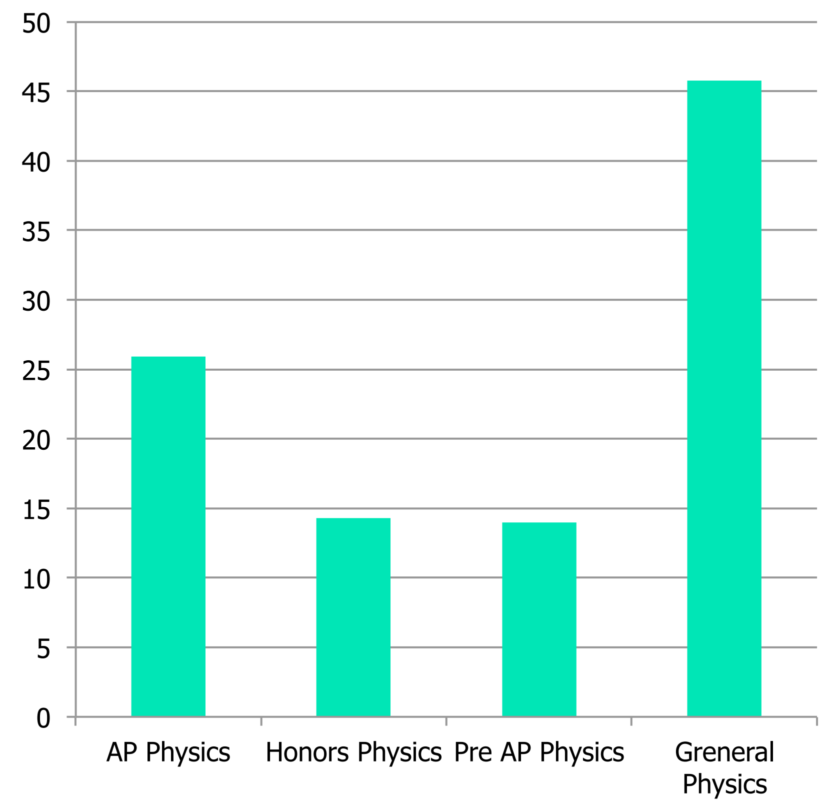
Ph.D. = 03%

Other = 03%

Teacher Perspective - Quantitative Results

Types of physics courses

25.9% AP Physics
14.3% Honors physics
14% Pre AP
45.8% “General” Physics



Teacher Perspective - Quantitative Results

Number of physics classes per day per teacher

- Average =1.87 classes
- Medium =1 class (46%)
- Range = 1-6 classes

Years Teaching

Range = 1-28 yrs

Physics teaching = 6.2 yrs

Science teaching = 11.03 yrs

Important content in physics to cover (Non-AP courses)

- 40% to 70% of course -Force and Motion (Newton's Laws)
- 20%- Electricity & Magnetism 20%
- 10%- Light, Sound, Waves, modern physics

Teacher Perspective - Quantitative Results

Mean	**Mean**
T-CLES (class environment) Year 0	**T-CLES (class environment)**
All Cohorts= 61.7	Cohort 1 Year 0= 94.4
Cohort 1= 94.4	Cohort 1 Year 2= 88.8
Cohort 2= 58.1	
Cohort 3= 54.0	
Sig. difference 1 & 2,3	*No sig. difference

Teacher Perspective - Quantitative Results

Learning Environment (CLES) Sub-score ratings (Maximum =25), **Cohort 2, Year 0**

T0 – S0

- 58.1-85.9* - Total CLES
- 11.0-17.9* - Learning about the world (relevance)
- 13.1-16.7* - Learning about science
- 11.8-18.0* - Learning to speak out
- 12.6-13.8 - Learning to learn
- 09.6-20.9* - Learning to communicate

Teacher Perspective - Quantitative Results

Learning Environment (CLES) Sub-score ratings (Maximum =25), **Cohort 1, Year 0 & 2 (matched)**

T0 – T2

- 19.7-19.6 - Learning about the world (relevance)
- 17.7-16.7 - Learning about science
- 18.9-18.0 - Learning to speak out
- 16.4-12.4*- Learning to learn
- 21.6-21.9 - Learning to communicate

Teacher Perspective - Quantitative Results

	Mean
TSTEBI (Efficacy)	
All Cohorts= 85.5	
Cohort 1 = 97.6*	
Cohort 2 = 78.1	
Cohort 3 = 89.7	

*Sig. difference 1 & 2

	Mean
TSTEBI (Efficacy)	
Cohort 1 Year 0= 97.6	
Cohort 1 Year 2= 88.5	

*No sig. difference

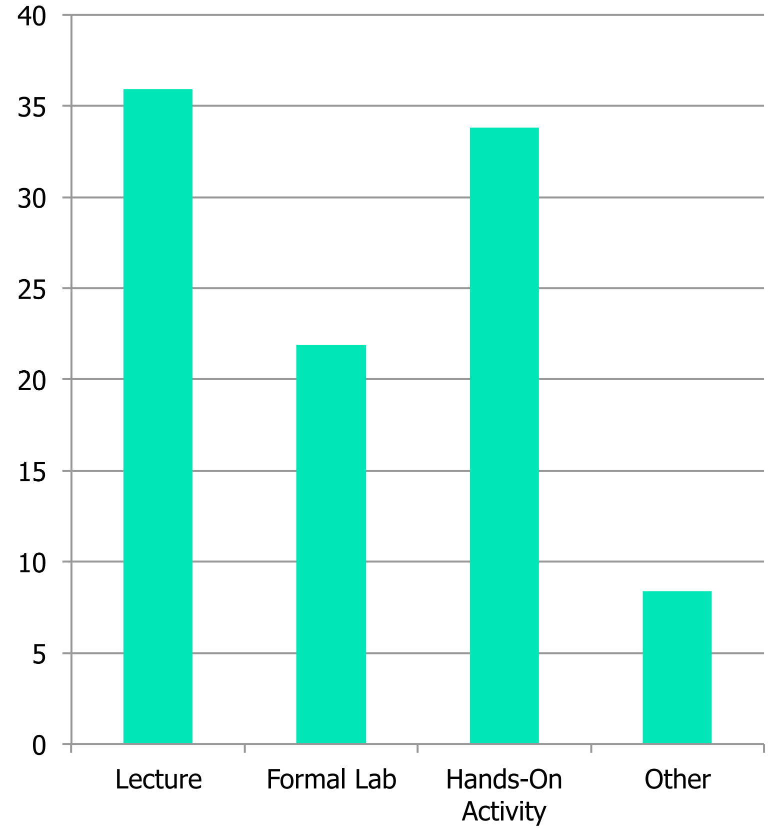
Teacher Perspective - Quantitative Results

Mean	Mean
Efficacy-Teaching Ability	**Efficacy- Expectancy Outcome**
All Cohorts= 89.5	All Cohorts= 81.2
Cohort 1 = 103.7*	Cohort 1 = 91.0*
Cohort 2 = 82.1	Cohort 2 = 73.2
Cohort 3 = 92.2*	Cohort 3 = 86.2*
*Sig. difference 1-2-3	*Sig. difference 1,2-3

Teacher Perspective - Qualitative Results

Physics teaching preferences

- 35.9% lecture
- 21.9% formal lab
- 33.8% hands-on activity
- 8.4% other (individual work & problems)



Teacher Perspective - Qualitative Results

Best way to teach physics

- All referred to different descriptions of "hands-on approaches" =
  - Activities at desks
  - Teacher guided labs
  - Solving problems

- Inquiry
- Experience
- Discovery
- Hands-on

Take a Break
What do you think?

- **How would you summarize teachers' perspectives on teaching physics in Alabama?**

Teacher Perspectives – Qualitative Themes Summary

1. Deficit in Understanding of Aspects of Physics Content.
2. Lack of Understanding of Inquiry Teaching and Inquiry Learning
3. Understanding of Content as Related to Teachers' Understanding of Inquiry Teaching in Physics
4. Content Knowledge (Math or Physics) vs. Ability to Teach - Three Constructs Noted
5. Teachers Cared for Student Learning
6. Difficulties with Professional Development in Physics
7. Difficulty in Implementing Differentiated Instruction
8. Isolation from Other Physics Teachers

Teacher Perspectives – Qualitative Themes Summary

9. Awareness of Prior Knowledge
10. Student Engagement
11. Assessing Active or Inquiry Learning
12. Lack of Efficacy: Two Constructs Noted
13. Understanding of Physics Teaching Interpreted Through Biological Science View
14. Use of Outside resources
15. Physics Seen as a Support Course, Not a Major
16. Critical Barriers to Planning and Teaching Physics

Take a Break
What do you think?

- **Which items appear most accurate in describing teachers' perspectives on teaching physics in Alabama? Recognize that this summary represents over 70 Alabama Physics teachers.**
- **What is missing?**

Student Perspective - Quantitative Results

Mean	Mean
S-CLES (class environment) Yr 0	**S-CLES (class environment)**
All Cohorts= 87.5	**Cohort 1 Year 0 = 83.9**
Cohort 1 = 83.9	
Cohort 2 = 85.9	**Cohort 1 Year 2 = 90.4**
Cohort 3 = 91.5	
*No sig. differences	*No sig. difference

Student Perspective - Quantitative Results

Learning Environment (CLES) Sub-score ratings (Maximum =25), **Cohort 1, Year 0 & 2**

S0 – S2

- 14.1-18.9 - Learning about the world (relevance)
- 15.6-17.0 - Learning about science
- 17.2-18.6 - Learning to speak out
- 18.9-12.9 - Learning to learn
- 20.3-21.1 - Learning to communicate

Student Perspective - Quantitative Results

Mean	Mean
S-STEM (Physics Related Career)	**S=STEM (Physics Related Career)**
Cohort 1 = 80.0	**Cohort 1 Year 0** 80.0
Cohort 2 = 75.8	**Cohort 1 Year 2** 121.4
Cohort 3 = 130.8*	
Maximum score= 175	Significant Difference = .000

Take a Break
What do you think?

- **How would you summarize students' perspectives on learning physics in Alabama?**

Student Perspectives – Qualitative Themes Summary

1. Teachers struggled with content knowledge
2. Teachers struggled with helping students think more critically and problem solve
3. Good physics teaching related to teacher confidence
4. Students' foundation in math contributes/hinders physics problem solving and attitudes
5. Labs and demonstrations helped students engage with the material
6. Interest increased with relevant applications
7. Teacher dedication was important
8. Working in groups and technology contributed to learning physics
9. Creative approaches produced positive attitudes

Take a Break
What do you think?

- **Which items appear most accurate in describing students' perspectives on learning physics in Alabama? Recognize that this summary represents over 70 Alabama Physics classrooms.**
- **What needs to be added?**

Observer Perspective -
APEX Cohort 1, 2, 3 Baseline, Year 0

Reformed Teaching Observation Protocol (RTOP) for 72 physics teachers

- Maximum rating possible = 100
- **Mean rating= 49.4 -before PTI started**
- Range = 11.5 - 97

65 = moderate level of classroom reform (innovation)

50 = presence of some reform characteristics

20= low level of reform, very traditional teaching

(MacIsaac & Falconer, 2002)

Observer Perspective - APEX Cohort 1, 2, 3 Baseline, Year 0

	Mean	SD
RTOP		
Total 1,2,3 =	49.4	18.4
Cohort 1 =	57.6	31.5
Cohort 2 =	50.2	16.9
Cohort 3 =	46.2	14.7

Significant Difference

= .031

Observer Perspective - APEX Cohort 1, Year 0

Reformed Teaching Observation Protocol (RTOP) for 8 physics teachers

- Maximum rating possible = 100
- **Mean rating= 57.6** **-baseline, before PTI started**
- Range = 11.5 – 97

65 = moderate level of classroom reform (innovation)

50 = presence of some reform characteristics

20= low level of reform, very traditional teaching

(MacIsaac & Falconer, 2002)

Observer Perspective - APEX Cohort 1, Year 2

Reformed Teaching Observation Protocol (RTOP) for 8 physics teachers

- Maximum rating possible = 100
- **Mean rating= 66.1** **- after PTI Year 2**
- Range = 43 – 93

65 = moderate level of classroom reform (innovation)

50 = presence of some reform characteristics

20= low level of reform, very traditional teaching

(MacIsaac & Falconer, 2002)

Observer Perspective - APEX Cohort 1, Year 0 & Year 2

Reformed Teaching Observation Protocol (RTOP) for 8 physics teachers

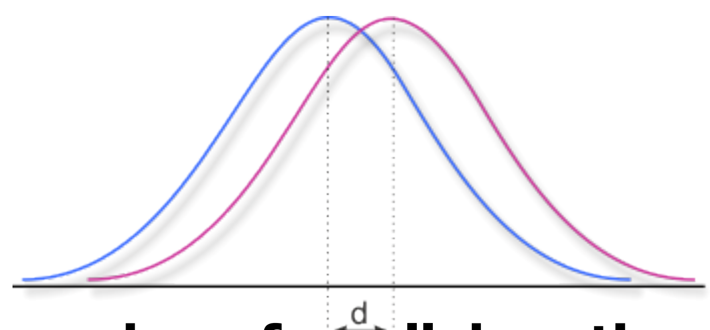
- **Mean rating= 57.6 -baseline,**
- **Mean rating= 66.10 -after PTI Year 2**
- **Effect Size = 0.174 or Percentile gain = 7.0 %**

0.10 = Small Effect size

0.30 = Medium Effect size

0.50 = Large Effect size

Jacob Cohen, 1988, Hedges & Olkin, 1985



What do the results mean to you as a member of a collaborative group of physics teachers?

Observer Perspective - APEX All Cohorts, Year 0 & Cohort 1, Year 2

Reformed Teaching Observation Protocol (RTOP) for 8 physics teachers

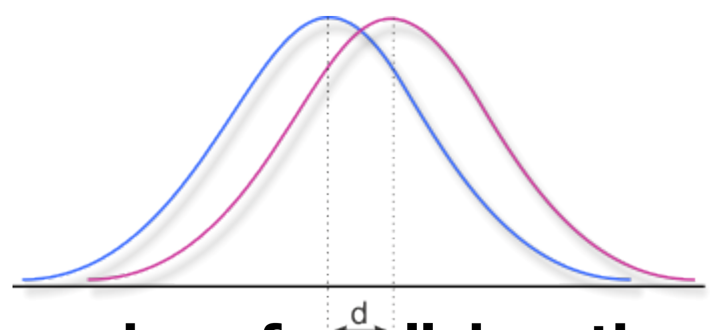
- **Mean rating all Cohorts = 57.6 - baseline, Year 0**
- **Mean rating Cohort 1 = 66.1 - after PTI Year 2**
- **Effect Size = 0.974 Percentile Difference= 33.5 %**

0.10 = Small Effect size

o.30 = Medium Effect size

0.50 = Large Effect size

Jacob Cohen, 1988, Hedges & Olkin, 1985



What do the results mean to you as a member of a collaborative group of physics teachers?

Observer Perspective - APEX Cohort 1, Year 2 (Year 0)

Reformed Teaching Observation Protocol (RTOP) for 8 physics teachers

Observation Sub-score rating. Maximum=20

Yr 2 Yr 0

- 12.6 (?) -Lesson Design & Implementation
- 14.1 (?) -Propositional Knowledge
- 12.9 -Procedural Knowledge
- 13.0 -Communicative Interactions
- 10.5 -Student/Teacher Relationships

What do the results mean to you as a member of a collaborative group of physics teachers?

Observer Perspective - APEX Cohort 1, Year 0

Pedagogical Content Knowledge -

Content Representation (CoRe) and Pedagogical and Professional experience Repertoires (PaP-ers)

Physics PCK Level*

- **04% Advanced**
- **28% Proficient**
- **67% Novice or Emergent**

* Turner & Sunal, 2014

Take a Break
What do you think?

- **How would you summarize observers' perspective on teaching physics in Alabama classrooms?**

Observer Perspectives – Qualitative Themes Summary

1. Lack of content and pedagogical content knowledge in both physics and math
2. Physics was seen as easy or intimidating to teachers and students. Teachers were not meeting the goals they set
3. Regularly observed a lack of understanding and practice of "inquiry teaching and learning"
4. Teachers did not use an organized approach when trying new methods, e.g. classroom action research
5. Teachers used general science teaching methods in physics
6. Appropriate assessment or cooperative learning techniques were not commonly seen in lessons
7. Student use of technology or social technology applications in lessons was not commonly seen
8. Teachers lacked collegial and mentor support/experience in teaching physics

Take a Break What do you think?

- **Which items appear most accurate in describing observers' perspectives on teaching physics in Alabama classrooms? Recognize that this summary represents over 70 Alabama Physics classrooms.**
- **What is missing?**

Take a Break
What do you think?

- **How would you summarize the three strand perspectives on teaching physics in Alabama?**

Cross-Strand Integration of Results– *Summary Themes*

1. Teaching of physics was not based on the specific nature of the discipline (e.g. use of mathematical modeling).
2. Understanding through inquiry learning and the using the strategy of teaching, learning, and assessment focused on inquiry rather than exposition with more student control of learning was not commonly observed.
3. Teachers demonstrated a dedication to promoting student learning.
4. Social networking among physics teachers to facilitate change and provide collegial support occurred through AMSTI/ASIM, more needed.
5. Expand teaching through classroom technology with modeling and social technology applications

Cross-Strand Integration of Results– *Discussion*

The results of this study underscore the prevalence of an expository teacher centered approach to teaching physics that was repeated with each viewpoint found in the parallel studies.

Conclusion 1:

Teachers and students perceive physics as important for college and career paths.

However, physics teaching often did not focus on the problem solving or critical thinking teachers had identified as so important for being successful, nor was the nature of physics as a discipline of knowledge acknowledged.

e.g. Nature of physics as a discipline of knowledge includes

Graphical Analysis & Mathematical Function

- Constant
- Proportional
- Linear x or y intercept
- Square function
- Simple inverse
- Inverse square
- Complex inverse
- Logarithmic/exponential
- Multivariable

- **Free-body diagramming**
- **Energy charts**
- **Four step analysis**
- **Etc. including use of differential calculas in AP courses**

Cross-Strand Integration of Results– *Discussion*

Conclusion 2:

Most students did not experience a reform approach with inquiry-based reform characteristics.

Teachers' lacked physics knowledge and physics pedagogical content knowledge needed to fully develop, teach, and assess inquiry lessons.

Conclusion 3:

Although most students seemed to have a scientific interest, they considered future careers to be in areas other than physics. Existing physics courses did not heighten student interest in taking physics as a high school course choice.

Take a Break
What do you think?

- **Which items appear most accurate in describing the cross strand perspectives on teaching physics in over 70 Alabama classrooms?**
- **What is missing?**

Take a Break
What do you think?

- **What do the benchmark measures mean to you as a member of a collaborative group of physics teachers?**

Study Implications

Using the baseline data gathered, three key components for professional development can be identified. Teachers must be provided with

1. opportunities to develop their physics content knowledge (CK).
2. in-depth pedagogical content knowledge (PCK) for all major physics concept areas, e.g. expert use of Diagnoser.
3. local peer networks to decrease isolation and action research strategies to create continuous self-professional development.

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