Teaching APEX Physics in High School Classrooms: What have we learned?

Alliance for Physics Excellence (APEX)

Physics Teaching Research Program (PTR)

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APEX PTI Cohort 3 Weekend Workshop 2, March 23-24, 2018

Alliance for Physics Excellence

The goal of the *Alliance for Physics Excellence* (APEX) program is to integrate research-based teaching practices into Alabama physics classrooms via in-service teacher education, and evaluate the impact on physics teachers and their students in the state's school systems.

APEX Cohort 3: Action Research Activity with Units during the Fall 2017 to Spring 2018 Academic Year

Complete Survey Individually

1. Unit described 1) Force and Motion (FCI), 2) Electricity (CEEC) 3) Sound and Waves (SWCI)

2. Teaching strategies used in Unit not identified on checklist

3. **What did you learn from action research** activities you completed in the APEX professional development program? (What role did it play?)

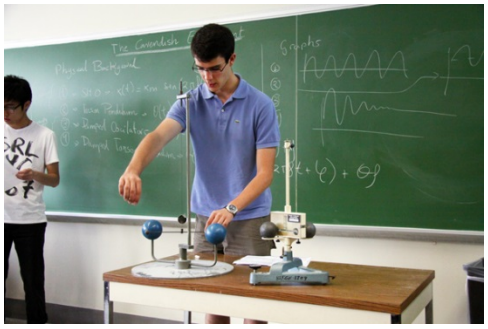
Action Research Facilitates Change in Beliefs

- Over the last three years we said……
  - ***All teachers have beliefs which guide their teaching.***
  - ***Beliefs are constructions of reality.***
  - ***Can you determine which of your beliefs are "truthful" or "misconceptions"?***
  - ***The process of changing is the process of changing beliefs.***
  - ***<u>How do you change beliefs?</u>***
  - ***<u>How can you change your beliefs about physics teaching?</u>***

Teacher Action Research

Action Research is the only strategy for <u>extending</u> APEX professional development and <u>facilitating and sustaining change</u> this year and in the future.

There are several forms, we all use one.



Professional Development through Teacher Action Research

A data driven evaluation process you must use to monitor your progress in using the APEX PTI information and understandings?

- **How can a classroom action research study add to your understanding of teaching and learning?**
- **What different kinds of evidence are you using to answer your action research question?** Three sources are needed to give you confidence and understand the result in action (practitioner) research.

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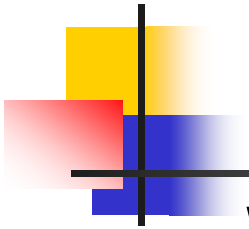


What happens in our APEX classrooms?

- How have teaching practices changed?
- What teacher characteristics were related to the implementation of reform practice?

What changes did we make in our physics classroom to get to APEX?

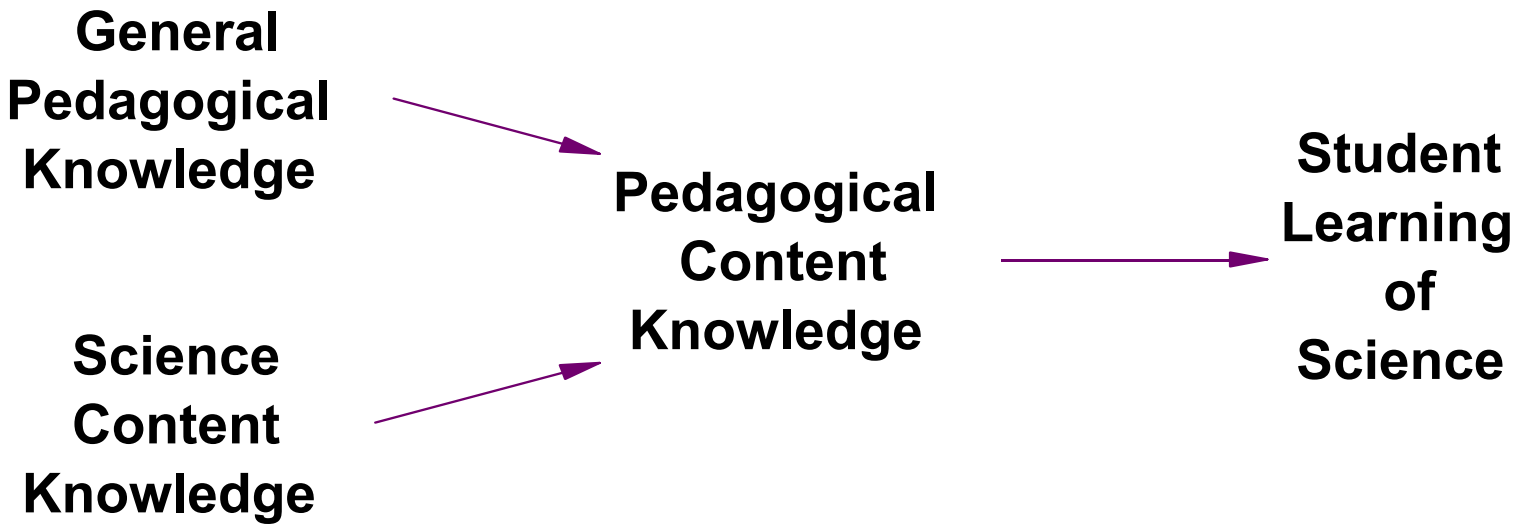
- What effect did APEX reformed classroom practices have on student learning
- How has the classroom learning environment changed?

How do we sustain, improve, and disseminate what we learned?

APEX In-service Perspective

The APEX focus was on professional development and teacher knowledge. These were related in developing effective physics classroom reform. (pedagogical knowledge, pedagogical content knowledge, and discipline content knowledge)

Teacher Knowledge and Skills



Problem Addressed

- In studies of typical in-service teacher professional development, researchers note the desired integration of subject matter and pedagogy has not been accomplished.
- Learning in pre-service undergraduate (physics) courses and in-service professional development programs is typically only content oriented, which reinforces, and does not challenge teachers' physics fragmented knowledge and relative inability to apply that knowledge within the context of teaching.
- APEX focused on the development of reform, using integration, in high school physics classrooms.

Sequence of Data Collection During APEX Professional Development

Year 0 Year 1 Year 2 Year 3

1) Classroom Observation Measures (2 days each)

Baseline Mid End

2) Student Achievement Measures

1 2 3

Who are Sample Teachers?
Baseline, Year 0

Rating of Classroom Reform at Year 0

Reformed Teaching Observation Protocol (RTOP)

Year	N	Min Score	Max Score	Mean	SE
0	72	11.5	97	50.23	2.06

65 = moderate level of classroom reform (innovation)

50 = presence of some reform characteristics

20= low level of reform, very traditional teaching

(*MacIsaac & Falconer, 2002)

How have teaching practices changed?
RTOP Rating–Baseline (Yr 0) to (Yr 2)

Reformed Teaching Observation Protocol (RTOP)

Year	N	Min Score	Max Score	Mean	SE
0	55	11.5	97	50.36	2.76
2	55	36.5	91	64.67	2.78

Significant difference between overall RTOP scores between Year 0 and Year 2,

ANOVA $F(1,108) = 15.35$, $\alpha < .01$

How have teaching practices changed?
RTOP Rating–Baseline (Yr 0) to (Yr 2)

Reformed Teaching Observation Protocol (RTOP)

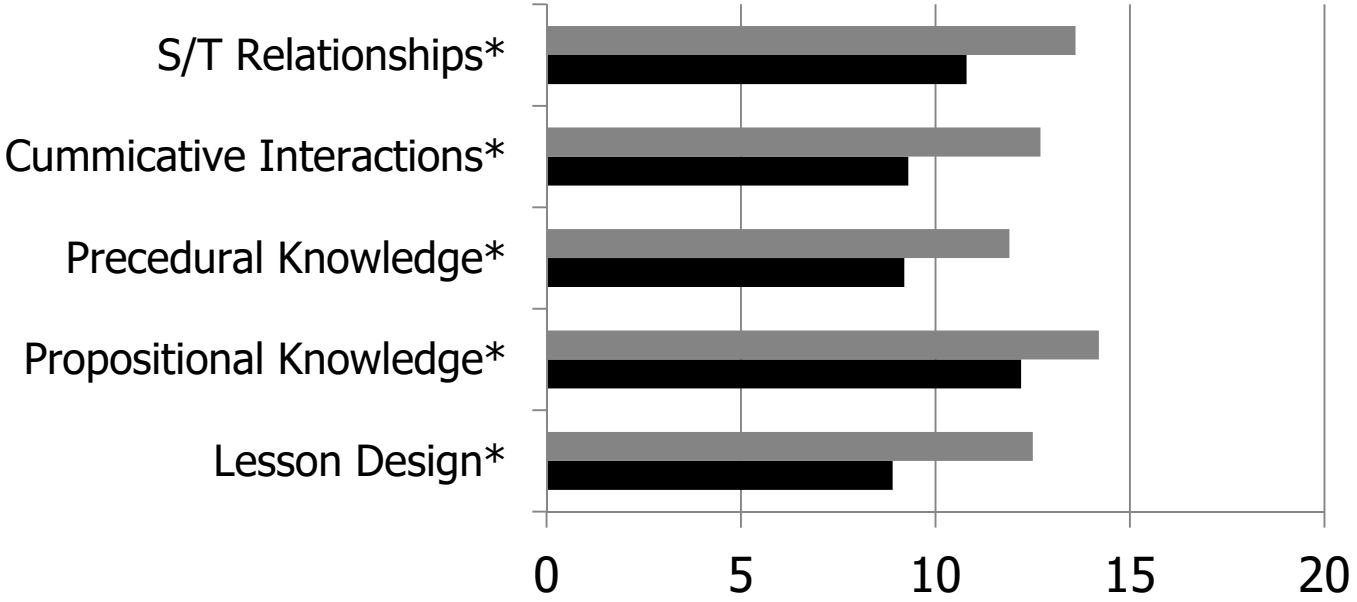
Observation Sub-score rating. Maximum=20 each

Yr0	Yr2	Sub-score section
08.9	12.5	-Lesson Design & Implementation*
12.2	14.2	-Propositional Knowledge*
09.2	11.9	-Procedural Knowledge*
09.3	12.7	-Communicative Interactions*
10.8	13.6	-Student/Teacher Relationships*

* significant difference at $p<.01$

How have teaching practices changed?
RTOP Rating–Baseline (Yr 0) to (Yr 2)

Reformed Teaching Observation Protocol (RTOP) Observation Sub-score rating. Maximum=20 each



* significant difference at p<.01

How have teaching practices changed?
RTOP Rating–Baseline (Yr 0) to (Yr 2)

Reformed Teaching Observation Protocol (RTOP)

Teachers RTOP Total Reform Rating Results Based on Level of Performance

RTOP Level	Traditional (0-30)	Beginning (30-50)	Moderate (50-70)_	High (70-100)
Year 0 - Pre PD Intervention	7	22	14	12
Year 2 – During PD Intervention	1	14	12	28

What teacher characteristics were related to the implementation of reform practice?

Baseline (Yr 0) to (Yr 2)

Year 0

- Inquiry Teaching incorrectly defined as “hands on”, “activities” “labs” “problem-solving”
- Teachers lectured most of the time.
- Most teachers wanted students to be prepared for post-secondary education and see the practical application of physics concepts

My goal is that they can apply physics to their everyday life and understand the concept.

- Apex Teacher (Teacher Interview)

I want to prepare them for calculus based physics in college and provide a solid foundation

Apex Teacher (Teacher Interview)

What teacher characteristics were related to the implementation of reform practice?

Baseline (Yr 0) to (Yr 2)

Year 2

- More evidence of Inquiry Teaching
- Increased student engagement
- Use of APEX professional development strategies

I incorporated various short clips of rollercoaster rides that illustrate well the transfer of energy from Gravitational Potential Energy to Kinetic Energy. Knowing that students have experienced this, and that roller coasters are fun, is a good starting point for this idea.

Apex Teacher (Teacher interview)

…..he recognizes that everyone thinks differently and that as long as your way to get there is logical, than you can tell

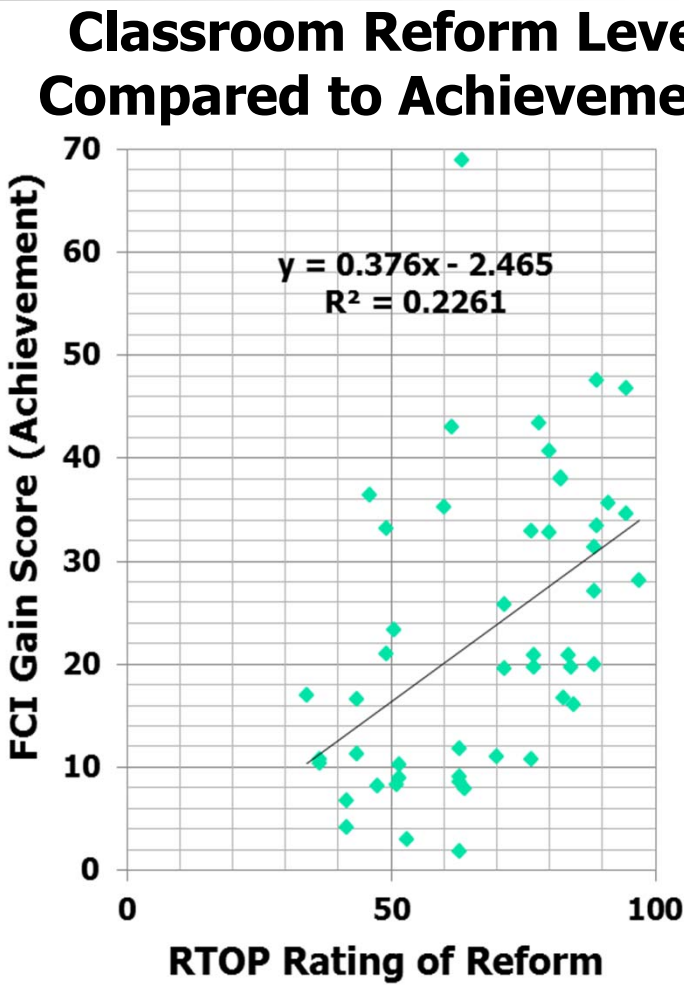
Student Focus Group Participant

How have teaching practices changed?
RTOP Rating–Baseline (Yr 0) to (Yr 2)

RTOP rating of classroom reform changed for sample teachers. This reform was related to student achievement gains.

Gains from pre-post FCI tests on teachers' Force & Motion Unit were used.

Sample classroom reform: RTOP ratings; Mean=65 Range=37-91 compared with FCI N-gain; Mean=22% Range=2%-69%



How has the classroom learning environment changed?

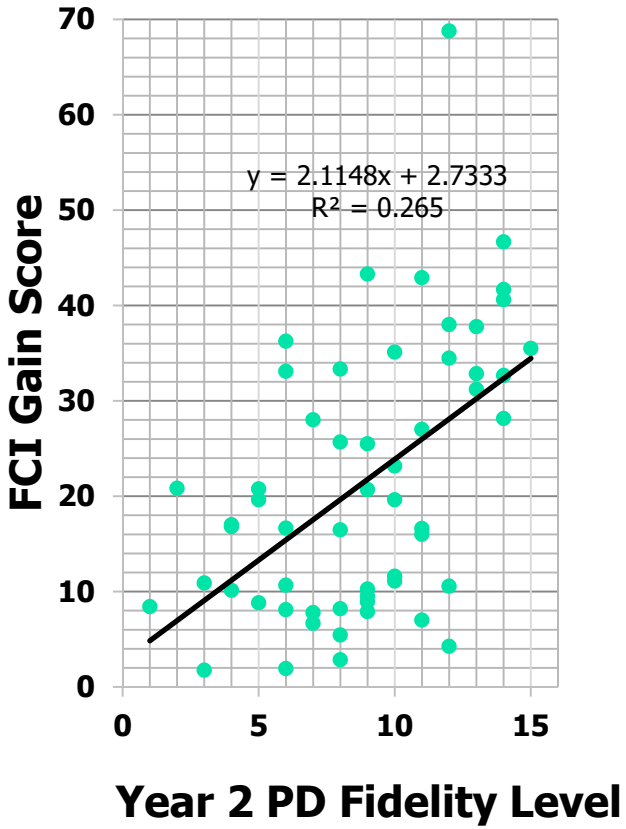
Baseline (Yr 0) to (Yr 2)

Fidelity of use of APEX (PCK) PD practices were related to student achievement gains.

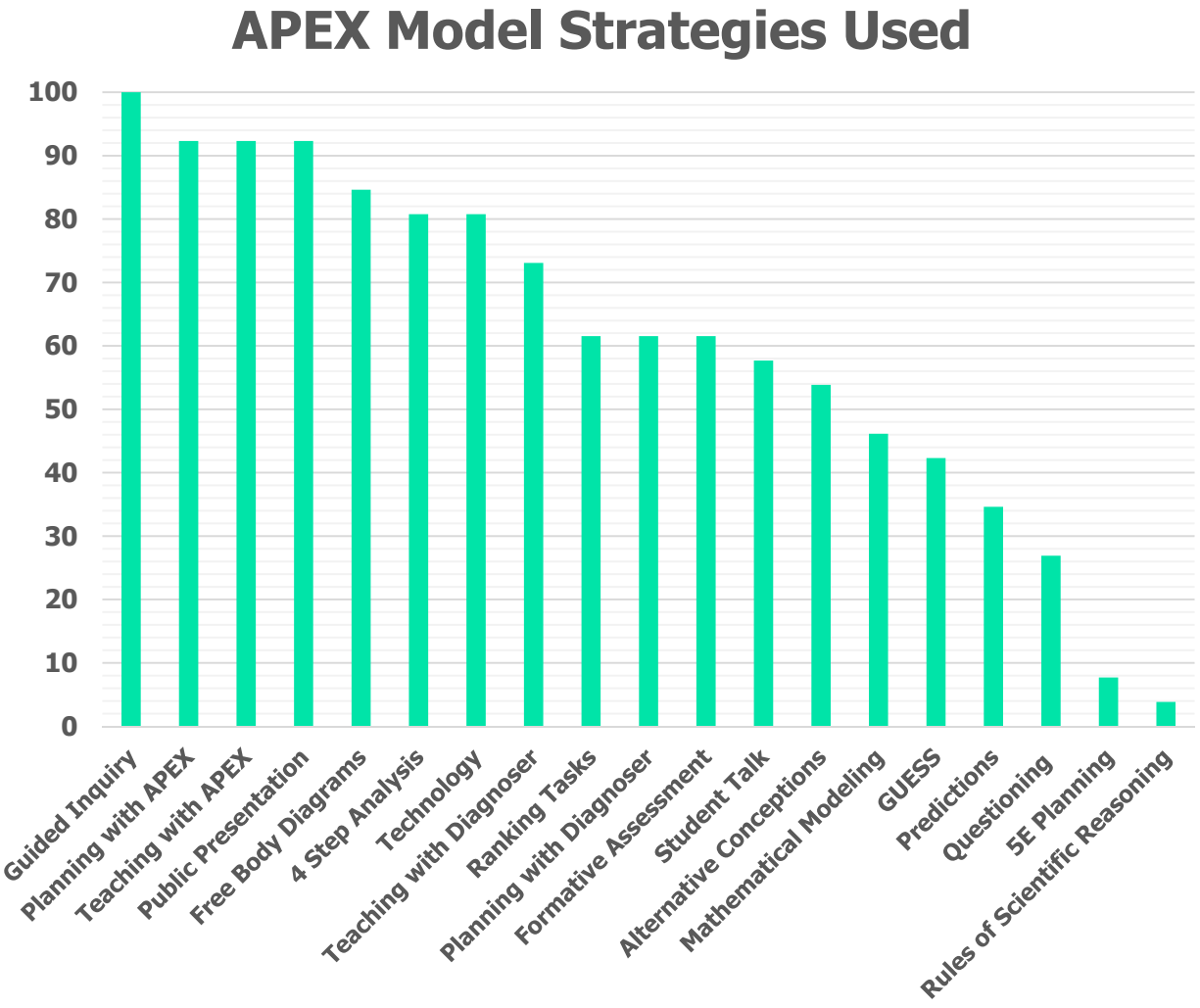
Fidelity indicators were rated PD practices found in Force Motion Unit materials.

Sample classroom reform PD Fidelity level; Mean=8.5 Range=1-15 compared with FCI gain; Mean=22% Range=2%-69%.

Classroom PD Fidelity Level Compared to Achievement



How has the classroom learning environment changed?



How has the classroom learning environment changed?
Baseline (Yr 0) to (Yr 2)

PD Teacher Actions Related to Higher Student Achievement

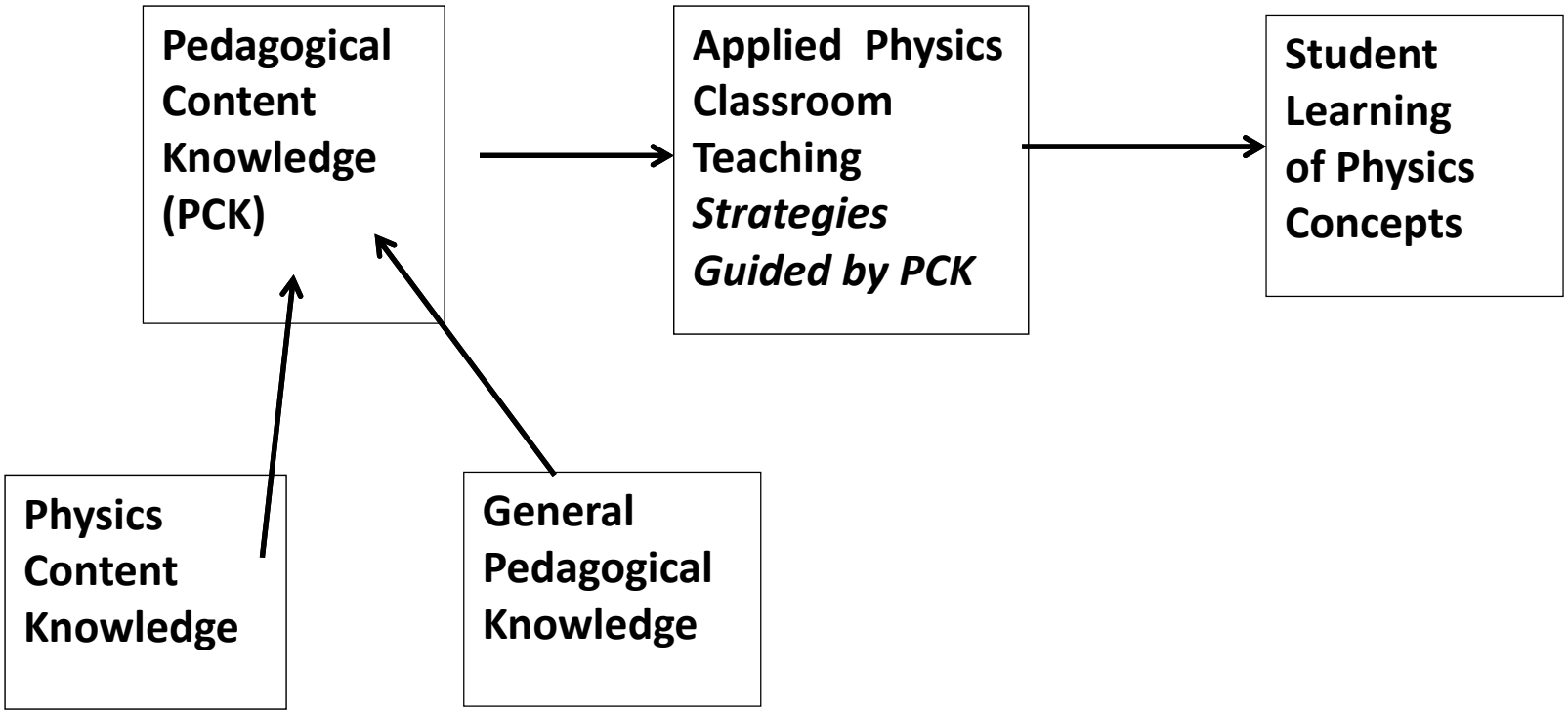
12 Indicators of successful teacher PD performance during force and motion units were found to be common in classes where students scored above the FCI Gain mean were

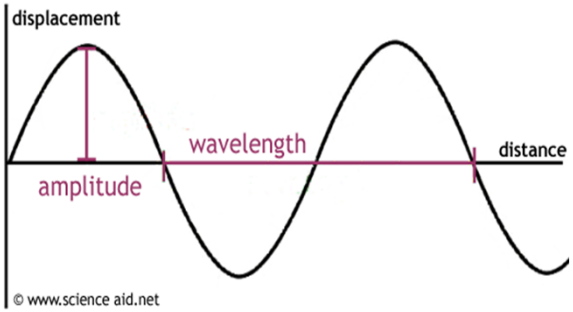
- **Guided inquiry** laboratory activities
- **APEX/PTRA and other professional development** lesson materials and teaching used
- **Public presentations and argumentation** with students explaining and defending results
- **Free body diagrams** used
- **Graphical analysis of data** in a 4 step analysis & mathematical modeling
- **Use of Technology** to facilitate learning
- **Planning/teaching with Diagnoser (alternative conceptions)**
- **Ranking Tasks**
- **Formative Assessment**
- **Increased student talk** and control of learning during lessons

Summary

- Classroom level of reform increased with APEX model PD experience and classroom practice.
- Teachers use of action research during PD fostered deeper classroom reform.
- Student achievement gains were related to RTOP rating of classroom reform.
- Student achievement gains were related to fidelity of use of APEX (PCK) practices.
- Regression analysis indicated that variance in achievement gain scores could be predicted from increased used use of APEX PD practices, class type, and RTOP rating of classroom reform.
- Together these variables accounted for 54.1% of the variance in achievement gain scores.

Knowledge Guiding Teachers in the Physics Classroom





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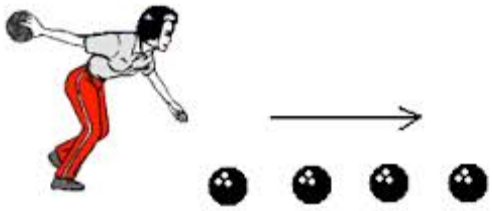
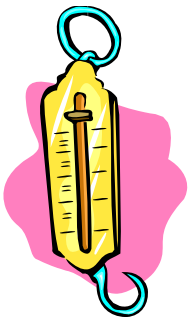
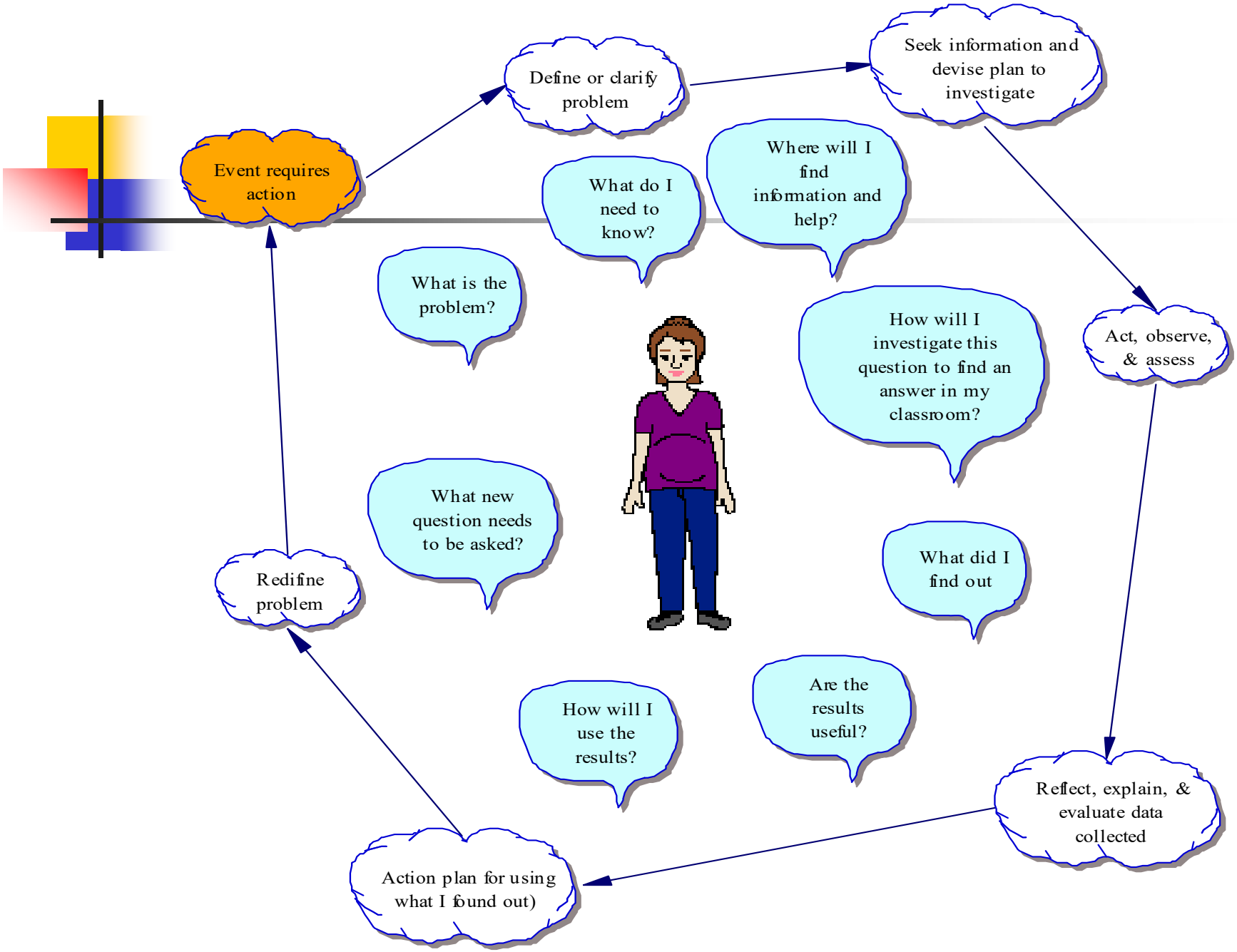
What did you learn?






Event requires action
Define or clarify problem
Seek information and devise plan to investigate
What do I need to know?
Where will I find information and help?
What is the problem?
How will I investigate this question to find an answer in my classroom?
Act, observe, & assess
What new question needs to be asked?
What did I find out
Redifine problem
How will I use the results?
Are the results useful?
Reflect, explain, & evaluate data collected
Action plan for using what I found out)

Ongoing Action Research Model
(perhaps several cycles for a complex innovation)

A Spiraling Process:

- revise focus (**define** and later **redefine problem**)
- new hypotheses of modify original (**plan**)
- leading to new actions and new data analysis (**act, observe & assess**)
- revise previous conclusions (**reflect, explain & evaluate**)
- redevelop grounded theory (**understand**)
- etc... a continuous spiral leading to self- professional development & change leading to expertise

Take a Break
What do you think?

- **How would you summarize results from classroom action research reports on teaching physics in Alabama?**

Inquiry Teacher's Actions and Students' Responses

Essential Features of Classroom Inquiry and Their Variations

Essential Features of Inquiry	1 Full Inquiry Teaching (Can Use Learning Cycle)	2 Coupled Inquiry (Can Use Learning Cycle)	3 Guided Inquiry	4 Directed Inquiry	5 Verification	6 Expository

More <_____ Amount of Learner Self-Direction _____> Less

Less <_____Amount of Direction from Teacher or Material _____> More

Essential Features of Inquiry	1 Full Inquiry Teaching (Can Use Learning Cycle)	2 Coupled Inquiry (Can Use Learning Cycle)	3 Guided Inquiry	4 Directed Inquiry	5 Verification	6 Expository
1. Learner engages in scientifically oriented questions	Learner poses a question	Learner selects among questions, poses new questions	Learner sharpens or clarifies question provided by teacher, materials, or other source	Learner engages in question provided by teacher, materials, or other source	Learner engages in question that replicates one provided by teacher, materials, or other source	Learner engages in no question to investigate
2. Learner gives priority to evidence in responding to questions	Learner determines what constitutes evidence and collects it	Learner directed to collect certain data	Learner given data and asked to analyze	Learner given data and told how to analyze	Learner given data and told how to analyze that replicates one provided	Learner given no data just conclusions
3. Learner formulates explanations from evidence	Learner formulates explanation after summarizing evidence	Learner guided in process of formulating explanations from evidence	Learner given possible ways to use evidence to formulate explanation	Learner provided with evidence	Learner provided with evidence that replicates conclusions already given	Learner provided with no evidence, only conclusions
4. Learner connects explanations to scientific knowledge	Learner independently examines other resources and forms the links to explanations	Learner directed toward areas and sources of scientific knowledge	Learner given possible connections	Learner provided with connections	Learner provided with connections that replicates one provided	Teacher reports connections
5. Learner communicates and justifies explanations	Learner forms reasonable and logical argument to communicate explanations	Learner coached in development of communication	Learner provided broad guidelines to sharpen communication	Learner given steps and procedures for communication	Learner reports how close to the textbook the conclusions were	Learner reports no conclusions

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