EFFECTIVE COMPONENTS OF A PHYSICS TEACHER PREPARATION PROGRAM

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National Science Foundation
WHERE DISCOVERIES BEGIN

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Presentation Overview

- Teacher Attrition
- Teacher Preparation Program
- Why Inquiry?
- Physics By Inquiry Course
- Impact of course on pre-service teachers
- Outcomes

Teacher Attrition

"…teaching is becoming…a career of 'movement in and out' and the 'out' may be permanent"

Skilbeck & Connell, 2003, p. 32-33

Teacher Attrition

- Urban centers like Houston and Philadelphia lose 50%-70% of beginning teachers in 4-6 years
- Baby boomer teachers are retiring earlier than anticipated
- One-third of those teachers remaining in the workforce plan to leave soon
- Cost is 2.2 billion dollars per year with over 800 million in Texas
- The present-day population mix in Texas resembles the U.S. in 2040

Craig, 2014

By the Numbers: Houston and Texas

80%	• teachers with five years or less experience in HISD
50%	• principals with five years or less experience in HISD
>30 %	• middle school math and science teaching out of field in TX
13.3%	• high school math teaching out of field in TX
28.7%	• high school physics teachers teaching out of field in TX
~75%	• Student (80% are minorities) in HISD are economically disadvantaged

Craig, 2014

How do address these attrition rates?

- Produce more qualified Physics teachers at the secondary level
  - *Nationwide - 47% of high school physics teachers have a degree in physics),* compared with 73% of biology classes and about 80% for humanities courses (**U.S. Physics Teacher Shortage and the Need for PhysTEC Report - https://www.phystec.org/webdocs/shortage.cfm**).
  - Texas - ~1600 science teachers certified/year and less than 2% certified in physics/math and only 1-10% have science composite certification (Texas Education Agency – Educator Reports and Data from 2014-2017).

- How do we meet the needs of
  - students enrolled in physics courses
  - students interested in teaching physics
  - students who may not know they will be teaching physics?

Solution: *teach*HOUSTON

Collaboration

- NSM and COE
- Faculty, Master Teachers, Mentor Teachers

Research Based Approaches to Teaching

- Inquiry-based Learning
- Technology
- Project Based Learning
- Early and Intensive Field Experiences

Degree Plans

- NSM Major
- teachHOUSTON Minor
- Complete in Four Years

Other Benefits

- Internships
- Scholarships
- Professional Develop
- Both Formal and Informal Learning Opportunities

***teach*HOUSTON** (2007): First Replication Site of UTeach

Physics/teachHOUSTON Collaboration (2009)

- Developed degree plans for physics majors/minor to facilitate completion of the BS/certification in 4 years.

BS IN PHYSICS COURSE FLOWCHART w/teachHOUSTON

Freshman

Fall (15 hrs)

ENGL 1303
Fr. Comp. I (See course placement criteria web page)

Social and Bahavioral Sciences *(See core approved web page)*** 3 hours*

CHEM 1331
Fund. Of Chem. I
(MATH 1310 & HS Chemistry or CHEM 1301)

CHEM 1111
Fund. of Chem. Lab I
(Credit or concurrent enrollment in CHEM 1331)

MATH 1431
Calculus I (MPE score of 65 or MATH 1330 or See course placement criteria web page)

CUIN 1101 *STEP 1*

Spring (16 hrs)

ENGL 1304
Fr. Comp. II
(ENGL 1303 or equiv)

CHEM 1332
Fund. of Chem. II
(CHEM 1331)

CHEM 1112
Fund. Of Chem. Lab II
(Credit or concurrent enrollment in CHEM 1332)

MATH 1432
Calculus II
(MATH 1431)

PHYS 1321
Univ. Physics I
(Credit or concurrent enrollment in MATH 1432)

PHYS 1121
Physics Lab I
(Credit or concurrent enrollment in PHYS 1321)

CUIN 1102
STEP 2

Sophomore

Fall (17 hrs)

HIST 1377
US Hist. I
(No Prerequisite)

MATH 2331
Linear Algebra
(Credit or concurrent enrollment in MATH 1432)

MATH 2433
Calculus III
(MATH 1432)

PHYS 1322
Univ. of Physics II
(Credit or concurrent enrollment in MATH 2433)

PHYS 1122
Physics Lab II
(Credit or concurrent enrollment in PHYS 1322)

CUIN 3350
Knowing & Learning

Spring (16 hrs)

HIST 1378
US Hist. II
(No Prerequisite)

MATH 3331
Differential Eqn.
(MATH 2433 & MATH 2331)

PHYS 3110
Adv. Lab. Analysis
(PHYS 1122 & PHYS 1322)
Spring and Fall

PHYS 3315
Modern Physics
(PHYS 1301 and 1302, or PHYS 1322, and credit or concurrent enrollment in MATH 3331)
Spring and Fall

PHYS 3313
Adv. Lab I
(PHYS 1122, PHYS 1322, and credit or concurrent enrollment in PHYS 3315 and 3110)
Spring and Fall
**** Satisfies WID Requirement***

CUIN 3351
Classroom Interactions

Summer (6 hrs)

Life and Physical Sciences *(See your advisor)** 3 hours*

Life and Physical Sciences *(See your advisor)** 3 hours*

Junior

Fall (15 hrs)

POLS 1336
US & TX Politics
(No Prerequisite)

MATH 3364
Complex Analysis
(MATH 2433) Spring and Fall ***OR***
Math 4397 Math Methods in Physics Fall Only

PHYS 3316
Quantum Mechanics (PHYS 3315) ***Fall and Spring***

PHYS 3214
Adv. Lab II (PHYS 1122, PHYS 1322, 3315, and credit or concurrent enrollment in PHYS 3110)
Spring and Fall

PHYS 3309
Intermediate Mech.
(MATH 3331 & PHYS 1322)
Fall and Spring

Spring (18 hrs)

POLS 1337
US Gov't (No Prerequisite)

PHYS 4342
Physics By Inquiry
3 hours

MATH 3363
Intro. PDE
(MATH 2433 & either MATH 3321 or MATH 3331)

PHYS 3327
Thermal Physics (PHYS 3309) Fall and ***Spring***

Creative Arts *(See core approved web page)*** 3 hours*

CUIN 3352
Perspectives

Senior

Fall (16 hrs)

PHYS 4340
Research Methods

Language, Phil and Culture *(See core approved web page)*** 3 hours*

PHYS 4321
Inter. Elec. Theory I
(PHYS 1322 and MATH 3363)
Fall Only

PHYS 3312 **&**
PHYS 3112
Modern Optics and Lab
(PHYS 1322 or, with consent of instructor, PHYS 1302 & MATH 2433) (Credit or concurrent enrollment in PHYS 3110 & PHYS 3312) ***SpringOnly***
OR
PHYS 4421
Elect. Devices & App.
(PHYS 1122)
Fall Only

CUIN 4350
Multiple Teaching Strategies

Spring (9 hrs)

ELED 4314
Student Teaching

ELED 4315
Student Teaching Seminar

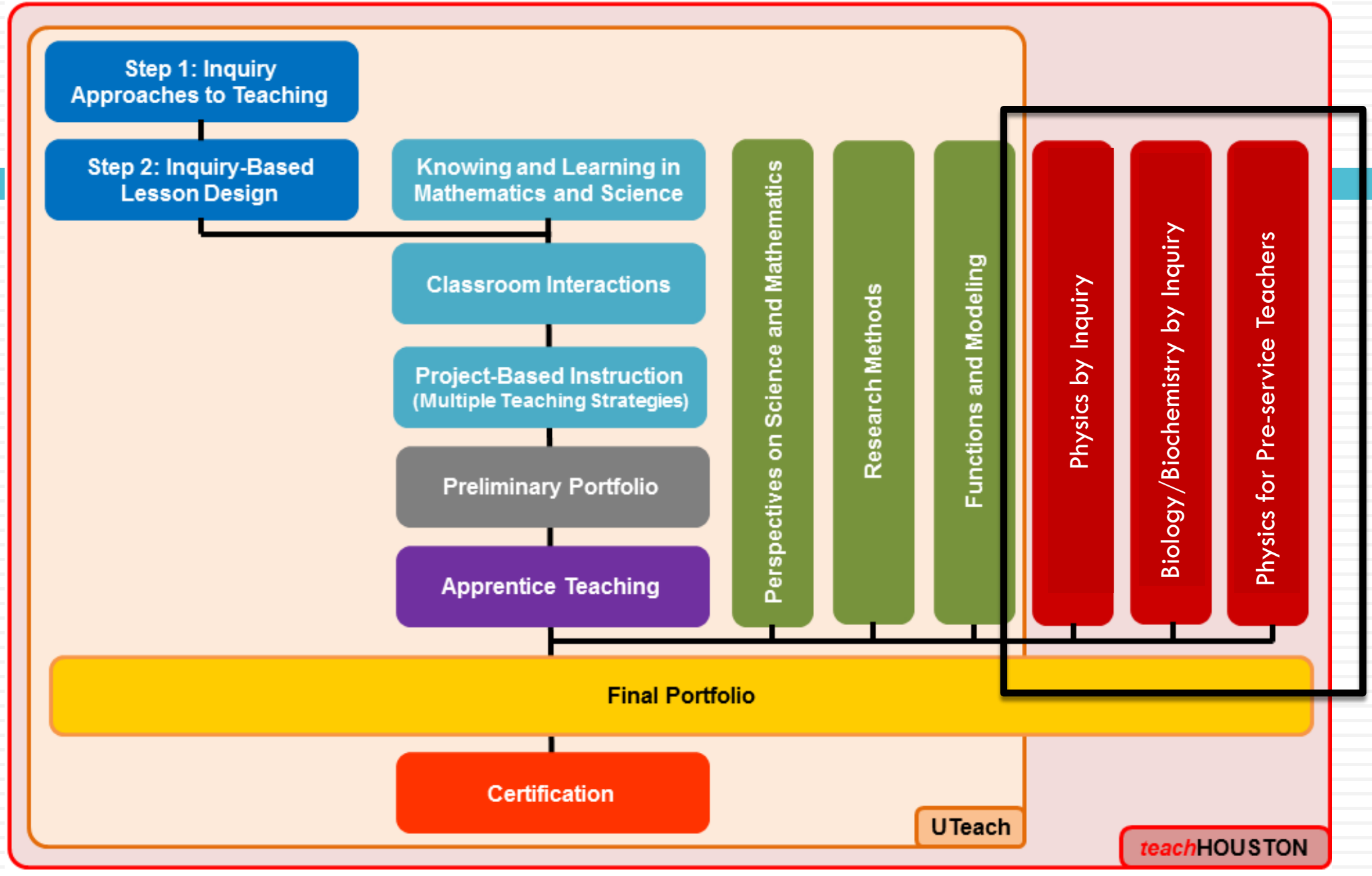
PHYS 4322
Inter. Elec. Theory II
(PHYS 1322 & MATH 3363)
Spring Only

*** Approved Core *** http://www.uh.edu/academics/corecurriculum/index.html
*** Course Placement Criteria*** www.usd.uh.edu/usdforms/placrit.htm
** FYI ** Math Minor complete with 3 hours of a 4000 level MATH course (Satisfies NSM Capstone)
* Computer classes recommended
* Meet with your advisor before registering for all classes
* Must have 6 hours of 2000 level or above in one foreign language
* Meet with your advisor before registering for all classes

* 127 total hours/ 36 advanced hours
*42 Physics hours (34 advanced Physics hours)
* 2.0 Cumulative GPA, 2.0 Major GPA, and 2.0 Minor GPA
* Last 30 hours must be taken at U of H
* No more than 6 hrs in major course work below a C-
* Last 30 hours must be taken at U of H
* No more than 6 hrs in major course work below a C-

Physics/teachHOUSTON Collaboration (2009)

- Developed degree plans for physics majors/minor to facilitate completion of the BS/certification in 4 years.
- NSF Noyce Award (2012) – Offer Scholarships for physics/chemistry majors/minors
  - Internship through summer camp experiences
  - Mentoring and advising through Physics and *teach*HOUSTON
  - **Developed Physics by Inquiry course utilizing best practices for teaching physics to better train pre-service teachers.**


Step 1: Inquiry Approaches to Teaching
Step 2: Inquiry-Based Lesson Design
Knowing and Learning in Mathematics and Science
Classroom Interactions
Project-Based Instruction (Multiple Teaching Strategies)
Preliminary Portfolio
Apprentice Teaching
Perspectives on Science and Mathematics
Research Methods
Functions and Modeling
Physics by Inquiry
Biology/Biochemistry by Inquiry
Physics for Pre-service Teachers
Final Portfolio
Certification
UTeach
teachHOUSTON

Why Inquiry?

John Dewey

- Learning is deep-rooted in experiences
- Knowledge arises through the process of inquiry
- Inquiry occurs with a community of learners
- One must rely on past experiences
- Advocated an experimental approach to science teaching

Joseph Schwab

- Students learn scientific concepts through inquiry
- Students should learn science similar to the way scientists construct their research

Fencl & Scheel

- Inquiry teaching methods correlate with how well students learn STEM content

Why Inquiry?

- Inquiry – around for many decades
- Teaching science through inquiry - recommended
  - American Association for the Advancement of Science, 1993
  - National Academy of Sciences, 2007
  - National Research Council [NRC], 2000, 2005
- Excellent choice for science teaching
  - Preparation for Pre-service science teacher
  - Training for in-service science teacher

Why Physics by Inquiry?

- Physics Education Research (PER)
  - Improve student learning gains over traditional style teaching and is key for promoting student success in Physics

Majority of teachers fail to employ inquiry teaching methods in their classrooms. Why?

Teaching through Inquiry

"Teachers tend to teach as they were taught. If they were taught through lecture, they are likely to lecture, even if such instruction is inappropriate for their students"

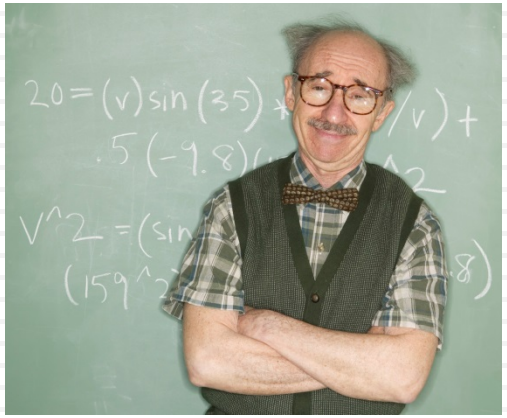
(McDermott, Shaffer, & Constantinou, 2000, p. 412).

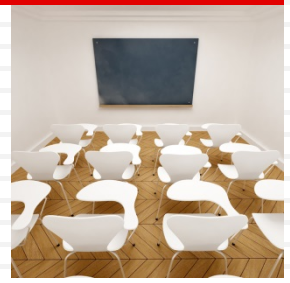
"If teachers are willing to "re-culture" these kinds of classrooms, their first obstacle is the influence of their own personal histories as learners"

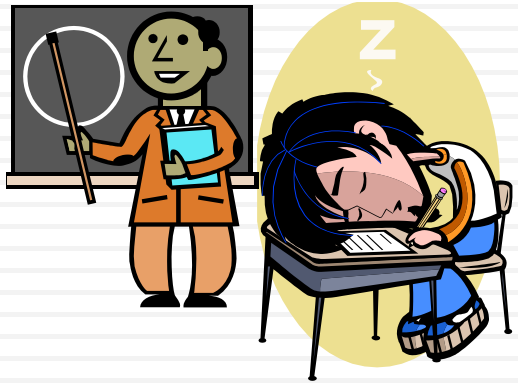
(Windschitl, 2002).

Pioneering Change through a **Physics By Inquiry Course**

Traditional

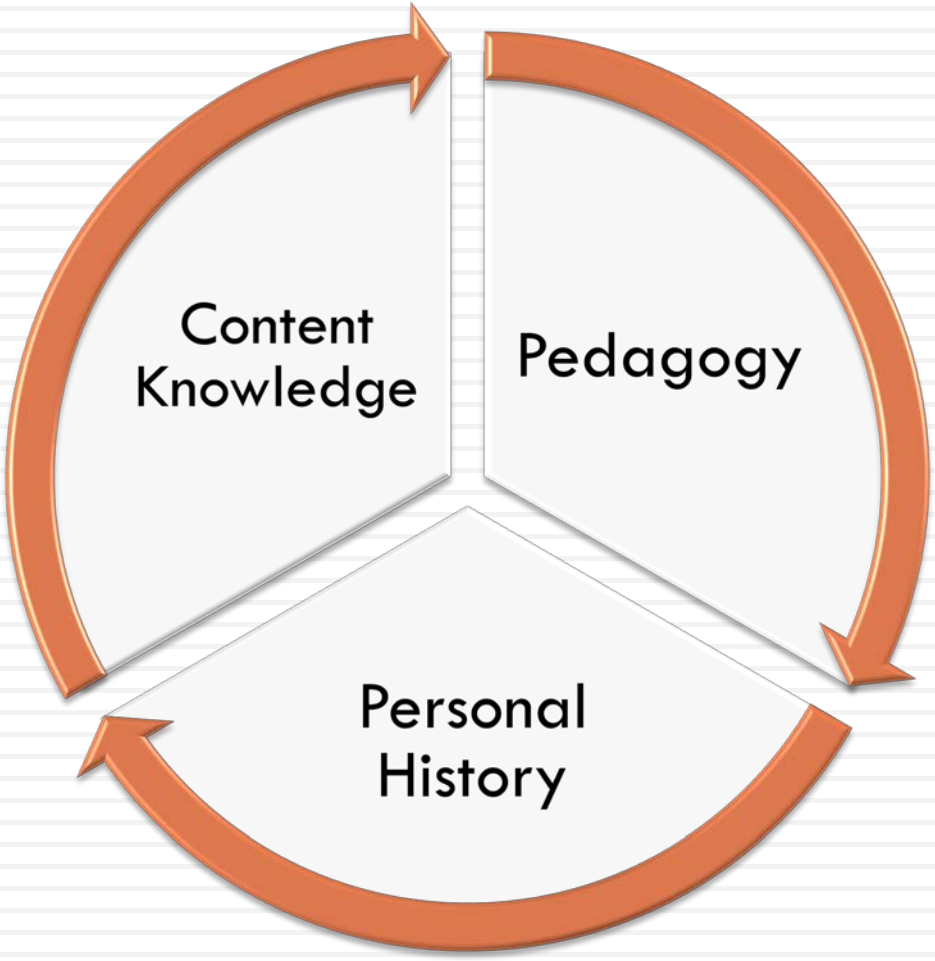






Innovative = *teach*HOUSTON

Physics Inquiry Course



Motivation

- Increase number of qualified physics teachers (majors and minors)
  - **Past decade – zero secondary teachers with physics major or minor produced at UH**
- Increase physics content level of pre-service teachers who will be physics certified or composite certified teaching physics (teachers assigned out-of-field)

Who takes the course?

- *teach*HOUSTON Students
  - Physics majors
  - Physics minors
  - Any *teach*Houston student who wants to strengthen their physics knowledge or needs an upper level science credit
    - Many of our biology majors teach physics with composite certification

- Non-*teach*HOUSTON NSM students
  - Biology Honors Students (used as second semester of algebra based physics course where curriculum development based assignments are replaced with problem solving/critical thinking assignments)

Description of Course

Physics 4342 (offered Fall and Spring semesters)

- Can be used for credit toward the BS/BA Physics degree or minor as an advance physics elective AND can be used toward the teacher certification
- Based on:
  - ✓ McDermott's Physics by Inquiry (McDermott, 1996)
  - ✓ PhET simulations (University of Colorado)
  - ✓ One engineering design challenge
  - ✓ Faculty/instructor developed resources/materials

Types of Inquiry-Based Teaching/Learning

Confirmation Inquiry —Students are given a question, answer and the guidelines on finding the answer with the idea of the student building investigative and critical-thinking skills.

Structured Inquiry — Students are given an open-ended question and a method to finding the solution using their knowledge and scientific evidence to support their conclusion.

Guided Inquiry — Students are given an open question, typically in groups, where they are tasked with designing a method of investigation to reach a conclusion.

Open Inquiry —Students are given extended time and support to compose an original questions for which they will investigate through their own methods. Students will then discuss and expand on their results/conclusions.

Some Inquiry Practices

- Project or Problem Based Learning - students use real world situations to stimulate learning before have been taught the relevant knowledge. By engaging with the problem first, learners define problems determine what is needed to evaluate the situation.

- Case Studies - engage students in analysis of real-world examples. Students interact and work in groups to build their knowledge as it relates to the problem. The instructor facilitator as student work together to address the problems and come up with a solution

- Meta-Questions- questions designed to structure student work over a term on a focused investigation. Students chose resources and devise a plan to support their ideas about the question. Daily discussions and assignments are completed to invoke inquiry, and at the end of the term students produce a comprehensive response to the Meta-question.

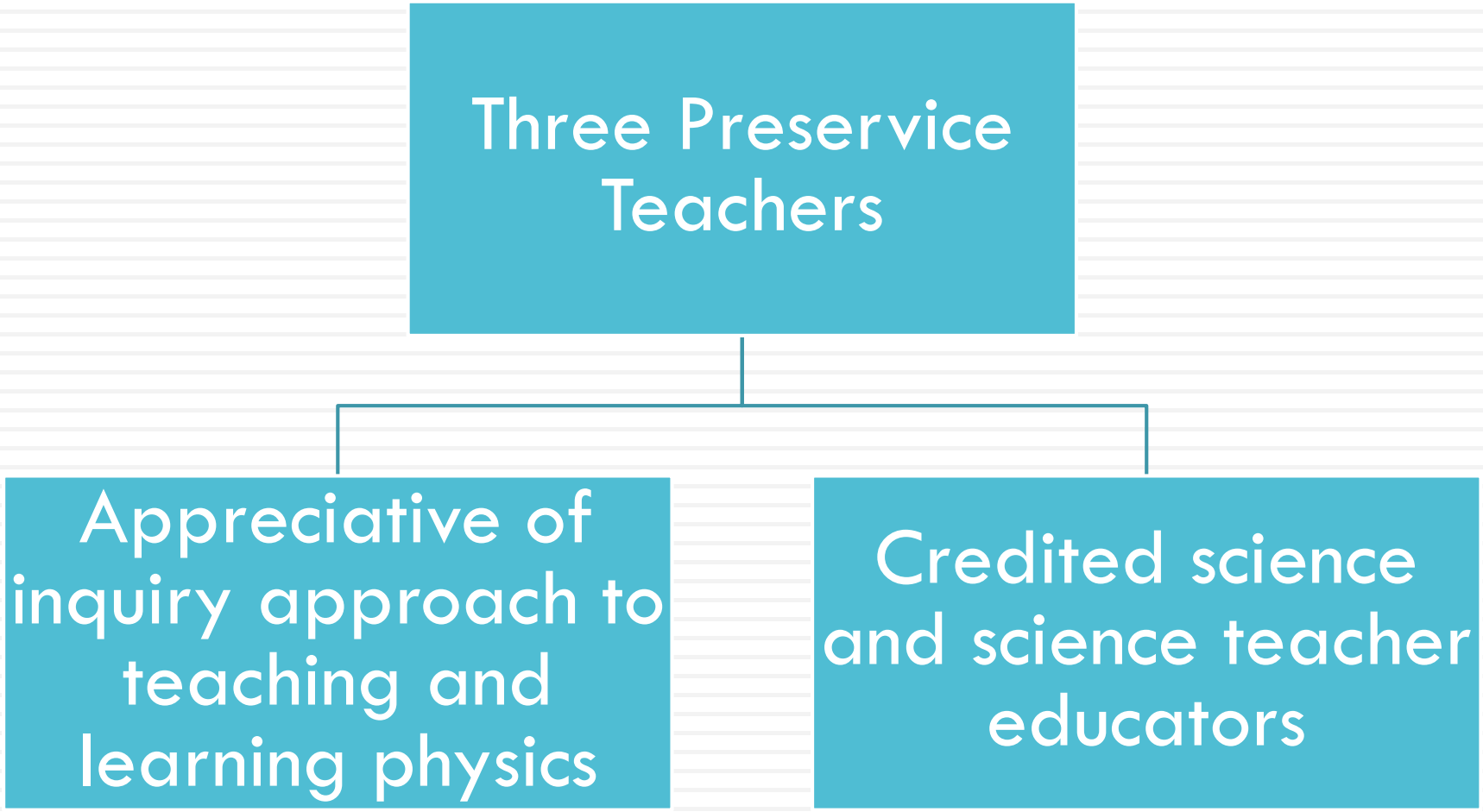
- Field Experience

Impact on Pre-service teachers
Research Questions

1. How does learning through inquiry impact the pre-service teachers' conceptions of inquiry-based learning?
2. How does learning science content through inquiry impact the attitudes that pre-service teachers have toward teaching through inquiry?
3. Are student teachers more apt to employ inquiry-based learning subsequent to learning science as inquiry?
4. What are some of the roadblocks student teachers encounter in their experiences of teaching science as inquiry?

***Inquiry-Based Instruction Pre/Post-Surveys, Teacher Interest Pre/Post-Surveys (based on Teachers' Sense of Efficacy Scale created by Tschannen-Moran and Woolfolk Hoy (2001)) and interviews**

Analyses and Findings



Katrina

- Instructors would guide us and scaffold us – but would not tell us the answer
- Never direct teaching
- Appreciated the approach
- Would try to mimic it in her own teaching as well

Ryan

Discerned differences between physics taught as theory in high school and physics taught as inquiry class at the university

Theoretically – the words are just words dancing around in your head…that may or may not mean something to you

Physics as inquiry – you come to knowledge on your own…it comes from inside of you and grows to be solid and a part of you

Teacher educators put him into the flight zone

Ryan

There's something amazing about seeing a student learn through inquiry…It just gives me the chills….It's very freeing…the Eureka moment. It lifts you up and you feel your whole body come alive. It's tingly and you want to learn and teach that way again and again and again. You want to start that fire again…and you want to keep fanning the flames…

Jason

"experience [needs to] come in the front door and theory [needs to] come through the back door."

Results: Common Themes – RQ1

1. How does learning through inquiry impact the pre-service teachers' conceptions of inquiry-based learning?

   - Results of learning science as inquiry as a student
   - Understand inquiry-based learning vs. hands-on learning
   - Improved confidence
   - Ability to re-enact inquiry model using different science concepts (more difficult)
   - Students drives the learning process

Results: Common Themes – RQ2

2. How does learning science content through inquiry impact the attitudes that pre-service teachers have toward teaching through inquiry?

- Changed my belief in method – worked for me as a student
- Truly understood content
- Understand better how this may work in a classroom

Results: Common Themes – RQ2

"This is the only course in which I experienced real inquiry-based instruction, rather than occasional model lessons in other courses" (participant).

Results: Common Themes – RQ2

"This was the first time during my teacher training that I was put in the seat of one of my pupils, experiencing the struggles that they may face during inquiry-based education. This granted me an excellent view into the mindset of a student of science, working hard and often failing to tease apart the complexities of a concept I don't fully understand. This has helped me to empathize with my students and to encourage them during the process of learning in a meaningful and personal way" (participant).

Results: Common Themes – RQ3

3. Are student teachers more apt to employ inquiry-based learning subsequent to learning science as inquiry?

- Those that took the course created more inquiry-based lessons and expressed that they would be employing inquiry methods in the classroom
- Enacting inquiry-based lessons was dependent on Milieus (personal backgrounds, experiences and environment)

Results: Common Themes – RQ4

4. What are some of the roadblocks student teachers encounter in their experiences of teaching science as inquiry?

- Cooperating Teachers
- Time
- Materials
- Accountability: “Dragon in Backyard”

"When you work in a school and there is a dragon in your backyard, you had better prepare for the dragon. The dragon, of course, is the accountability system . . ." (Craig, 2004,p. 1230).

Results: Common Themes – RQ4

"Inquiry-based teaching is, on my campus, considered at best a novelty and at worst a myth, and so I have struggled to weave my own methods through the fabric of the pre-existent status-quo. In other words, my greatest barrier to the implementation of the teaching style in which I believe and in which I am trained is simply inertia. That's plainly not the way science is taught here, and therefore it will not be taught that way. This is not to say that my students don't experience hands-on learning in my classroom, but simply that they don't experience ***inquiry*** *learning. There is a stark difference" (participant).*

Impact of Physics By Inquiry Course

Self-Efficacy/Confidence

- ✓ Augment the physics content knowledge
- ✓ Pedagogy (employing inquiry)
  - ❖ Professional development to
    - assist teachers in transitioning from cookbook lessons to inquiry which allowed for more practice writing inquiry-based lessons
    - discuss barriers to classroom implementation and how to overcome them
- ✓ Allow pre-service teachers to experience the process of inquiry learning
- ✓ Learn science as a scientist
- ✓ Change mental model of classroom prior to student teaching

May lead to improvement in teacher retention/attrition rates

Key Outcomes

- **11 qualified physics since 2014 (average ~2/year)**
- **All are still teaching in the Houston area**
- 115 students enrolled and successfully completed the Physics By Inquiry Course
  - Biology majors that end up teaching physics will be better prepared to do so
- Similar courses were created
  - Physics for pre-service teachers (for middle school teachers)
  - Biology/Biochemistry By Inquiry

Alumni Joshua Kehr

Physics

Physics Teacher: Spring Branch ISD

"Physics is the study of what makes the physical universe tick. I hope to leave UH with as much of a mastery of physics as possible and a solid foundation in teaching methodology which will benefit my future students. I encourage other students to definitely consider a STEM degree. The understanding of how we think the universe works and how to apply that knowledge is one of the greatest gifts of a STEM degree. The world literally becomes a big opportunity for you."

Alumni Geoffrey Hart

Math/Physics minor

Physics Teacher: Fort Bend ISD

"Math is the tool of all science, and physics is the most direct science that pulls the resources acquired from mathematics and puts them into applicable scenarios. It's what keeps this world running. Ever since I took my first high school physics course, I believed it was the most ideal science course I'd ever taken. I was finally able to apply my knowledge in math to real life. To me, it's the easiest science to demonstrate and describe concepts."

2017 PhysTEC Local Teacher of the Year

Digital Story: A Snapshot of the course

https://drive.google.com/file/d/0B58LhruXdJk_dTJOWTV6LUhnN1k/edit

Thank you!!

Questions?