Producing More and Better Prepared Middle School Science Teachers in Indiana

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HASTI
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The Problem

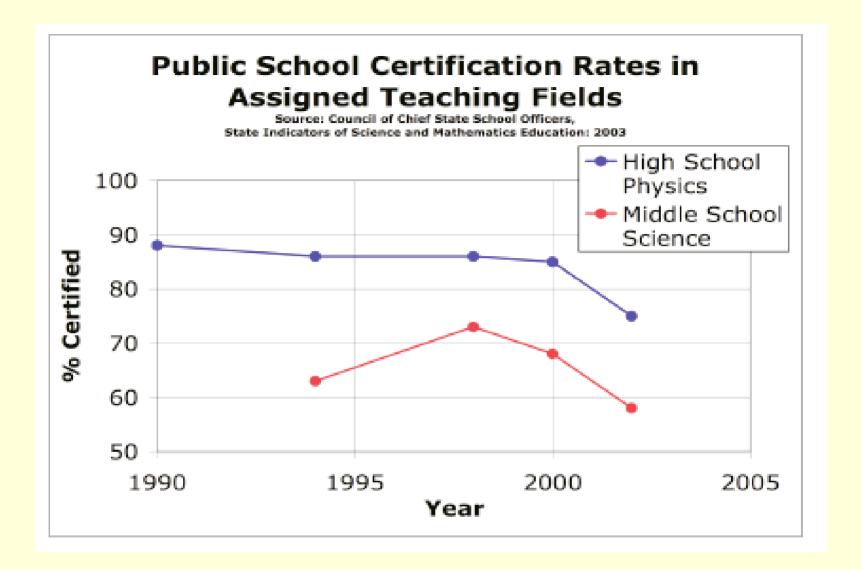
- Our nation is losing its new teachers at an alarming rate
- The sciences, and particularly physics, are at great risk for shortages
- Over 39% of all teachers will have left the teaching profession by the end of their fifth year of teaching
- At Ball State University approximately 30% of all pre-service teachers never enter the teaching profession at all

National Educator Demand

(2004 Executive Summary for the American Association for Employment in Education)

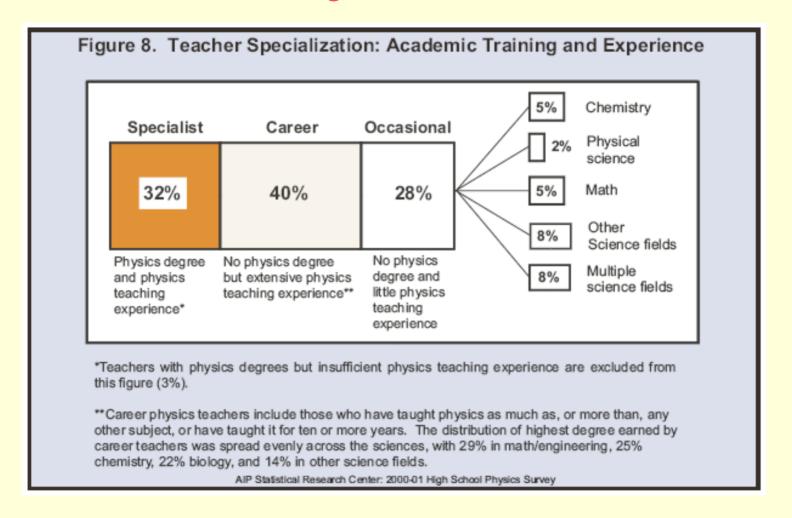
Relative Demand by Field	
Fields with Considerable Shortage (5.00 - 4.21)	
Severe/Profound Disabilities (Spec. Ed.)	4.42
Multicategorical (Spec. Ed.)	4.36
Emotional/Behavioral Disorders (Spec. Ed.)	4.32
Mild/Moderate Disabilities	4.32
Physics	4.31
Mental Retardation (Spec. Ed.)	4.23
Learning Disability (Spec. Ed.)	4.22
Mathematics Education	4.21
Fields with Some Shortage (4.20 - 3.41)	
Visually Impaired	4.20
Chemistry	4.16
Dual Certificate (Gen./Spec.)	4.14
Bilingual Education	4.12
Hearing Impaired	4.11
Early Childhood Special Education	4.08
Speech Pathologist	3.95
Biology	3.88
Earth/Physical	3.88
Languages - Spanish	3.86
General Science	3.85
English as a Second Language	3.82
Technology Education	3.74

http://www.aaee.org/pdf/2004_s_d-execsummary.pdf



Observe decrease in numbers of certified high school physics and middle school science teachers

Problem: Quality of Teachers



2000-2001 High School Physics Survey, AIP Statistical Research Center

What needs to be done?

Better preparation of future teachers

What is PhysTEC?



Program to improve the science preparation of future K-12 teachers

Goal:

To produce more and better-prepared science teachers

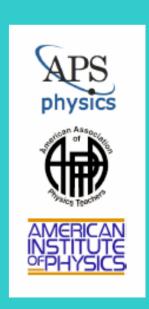
www.phystec.org and www.ptec.org

PhysTEC was initiated by APS, in partnership with AAPT and AIP, in response to national reports calling for the improvement of K-12 science teaching

A few resources:

Before It's Too Late, The Glenn Commission (2000) http://www.ed.gov/americacounts/glenn/

Educating Teachers of Science, Mathematics, and Technology: New Practices for the New Millenium, National Academy of Sciences (2000)



PhysTEC Program Components

- Collaboration between departments of physics and education, and local schools
- Teacher-In-Residence (TIR) program
- Induction/mentoring of science teachers
- Revision of physics and science methods courses based on research and active learning
- Involvement of physics faculty with preservice science teachers

BSU Physics and Astronomy Department Efforts

Emphasizes a student-centered, hands-on, inquiry-based approach to learning science

Revised Physics 110/112 class

- All secondary science education majors must take these courses
 - Interactive Lecture Demonstrations (ILD)
 (Sokoloff and Thornton)
 - Revision of labs into inquiry-based methodology
 - Teaching Assistant training for lab instruction
 - Personal Response System (PRS) to improve conceptual understanding
 - Computerized homework

New Certification Requirements

DEPARTMENT OF PHYSICS AND ASTRONOMY Ball State University

PHYSICS CERTIFICATION PROGRAM – 4½ YEAR PROGRAM Teaching Major in Middle School/Junior High Science and High School Physics – 68 hrs

This is a four and one-half year program that will meet the middle school/junior high science and high school physics certification standards of Indiana.

COMMON CORE - 52 hrs

ASTRO 120 STARS STEL SYS ASTRO 121 HONRS ASTR LAB

BIO 111	PRINC BIO 1	4
BIO 112	PRINC BIO 2	4
GEOL 102	EARTH TIME (3 hr)	3
GEOG 230	ELM METEOR (3 hr)	_3
		18 hrs
CHEM 111	Gen Chem 1	4
CHEM 112	Gen Chem 2	4
MATHS 165	Calculus 1	4
MATHS 166	Calculus 2	4
PHYCS 120	Gen Phycs 1	5
PHYCS 122	Gen Phycs 2	5
PHYCS 260	Intro Modern (& QM)	4
PHYCS 262	Modern Lab	1
RESEARCH	(HONRS THESIS,	
	INTERNSHIP, OR	
	DEPT. RES)	3
		34 hrs

STUDENTS WILL SATISFY ONE OF THE OPTIONS LISTED

Common Core Total

Ontion I. Physics Teaching Main

ption 1: Physics	reaching ivrajor	
PHYCS 330	Mechanics	3
PHYCS 354	Electronic 1	4
PHYCS 450	Elect Magnet	3
PHYCS 340	Physcl Optics	3
PHYCS 434	Thermo	_3
		16 hrs

Total 68 hrs

52 hrs

Option II: Have a Degree in One of the Four Areas

- A. SECONDARY LIFE SCIENCE
- B. SECONDARY EARTH/SPACE SCIENCE
- C. SECONDARY MATHEMATICS
- D. SECONDARY CHEMISTRY

PHYSICS CERTIFICATION PROGRAM – 4 YEAR PROGRAM Teaching Major in Physics –50 hrs

This is a four-year program that will meet the high school physics certification standards of Indiana.

COMMON CORE - 34 hrs

CHEM 111	Gen Chem 1	4
CHEM 112	Gen Chem 2	4
MATHS 165	Calculus 1	4
MATHS 166	Calculus 2	4
PHYCS 120	Gen Phycs 1	5
PHYCS 122	Gen Phycs 2	5
PHYCS 260	Intro Modern (& QM)	4
PHYCS 262	Modern Lab	1
RESEARCH	(HONRS THESIS,	
	INTERNSHIP, OR	
	DEPT. RES)	_3

STUDENTS WILL SATISFY ONE OF THE OPTIONS LISTED

Common Core Total

Ontion I. Physics Teaching Maio

RIOH I. I HYSIC	s reaching major	
PHYCS 330	Mechanics	3
PHYCS 354	Electronic 1	4
PHYCS 450	Elect Magnet	3
PHYCS 340	Physcl Optics	3
PHYCS 434	Thermo	_3
		16 h

Total 50 hrs

Option II: Have a Degree in One of the Four Areas

- A. SECONDARY LIFE SCIENCE
- B. SECONDARY EARTH/SPACE SCIENCE
- C. SECONDARY MATHEMATICS
- D SECONDARY CHEMISTRY

Teacher-In-Residence (TIR)

Who are they?

- Local K-12 master teacher
- Leaves school position for 1 year, then returns to classroom
- Full-time participant in Physics Department

What do they do?

- Assist faculty with physics and science education courses
- Mentor pre-service and in-service science teachers
- Recruit future science teachers

Teacher In Residence

- Prepare materials to aid physics faculty to improve conceptual learning in the classroom
- Train Teaching Assistants for PRS system in labs
- Present at state and national science conventions
- Recruiting
- Work with pre-service teachers in methods courses
 - Teach Methods classes
 - Individual mentorship of students
 - Provided registration costs for HASTI
- Mentor new in-service teachers
 - Currently mentoring 6 teachers (30+ over the six years)
 - Content mentoring



Collaboration between Teachers College, Biology Department and Physics & Astronomy Department

- PhysTEC Team
- Teacher Advisory Group (TAG)
- TIR

Recruitment Efforts

- Visits to college classes
- Education and Job Fairs
- Contact all Mathematics teaching majors
- Community Outreach Programs
 (Society of Physics Students)







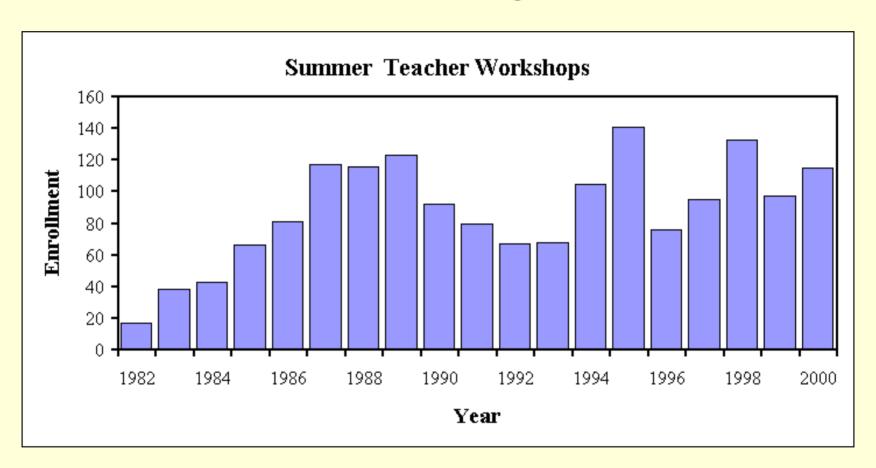
Summer Workshops

- Certifying In-service Science Teachers as Physics Teachers
- Summer Updating/Retraining
 - In-service teachers engage in more research and self-directed inquiry
 - Includes strategies dealing with Physics Education Research and reformed teaching methods





Ball State University Updating/Retraining Summer Program



Many in-service teachers have participated, and have included a physics teaching certification

Ball State University Department of Physics and Astronomy 2006 Summer Updating/Retraining Workshops

Course Title	Upper Elem.	Middle School	High School
Observational Astronomy Workshop for Teachers	X	X	X
Modern Developments in Physics Teaching	X	X	X
Nanotechnology Fundaments and Applications			X
Computational Physics Workshop for H.S. Teachers			X
Theories of Physics for Secondary Physics Teachers		X	X
Instruments and Techniques in Planetarium Operations			X
Seminar in Modern Astronomy: Planetarium Program Production			X
AP Mechanics – B and C			X
Physical Foundations of Astronomy Workshop for Teachers	X	X	X
AP Electricity & Magnetism – B & C			X
Stellar Evolution and Black Holes Workshop for Teachers	X	X	X

Physics for Elementary Teachers (PET)



- One semester physics curriculum
- Directed-inquiry method
- Students work in groups; self-paced
- Use technology in experiments

Physics Problem-Solving Class

Introduced Fall 2003

- 2 one-hr sections 16 students + walk-ins
- Favorable student comments "needs to be longer"

Fall 2005

2 one-hr sections – 26 students + walk-ins

Class Format

- Review quiz
- Brief topic discussion
- Conceptual questions
- Problems worked in pairs
- Quiz



New Teacher Licensure

- New licensure rules were set up in 2002 (Rules 2002)
- Changes in assessment, both prior to graduation and for the first two years of teaching
- Caused systemic change throughout the Indiana higher education systems

Changes in Certification Requirements

And/Or Classes that have been impacted by the PhysTEC Project

- Addition of Courses
 - Basic Concepts in Science Education (SCI 150) for all secondary education majors
 - Science as Inquiry (SCI 498) for all elementary education majors
- Increased Participation in Science Education courses for junior high and high school science teaching majors (required courses)
 - Introduction to the Teaching of Science (SCI 395)
 - Using Science Methods and Materials (SCI 396)

Difficulties Impeding Improvement

- Student prior knowledge
- Student Majors
- Student Attitudes

Ball State Physics Student Population

<u>Physics Class</u> <u>No. Students / Year</u>

Conceptual 220

Elementary Ed. 360

Algebra-Based 330

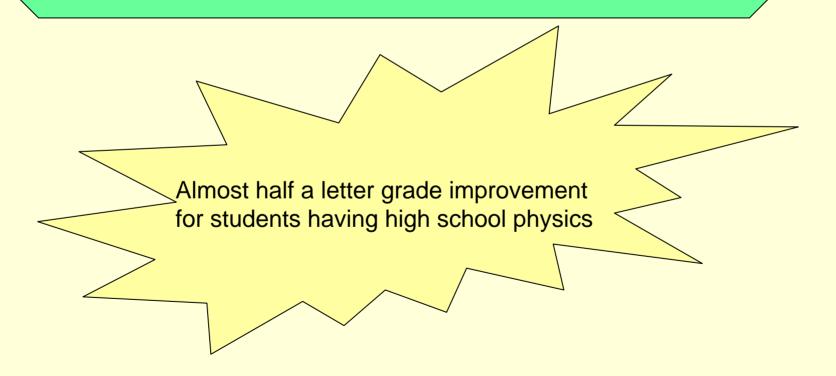
Calculus-Based 100





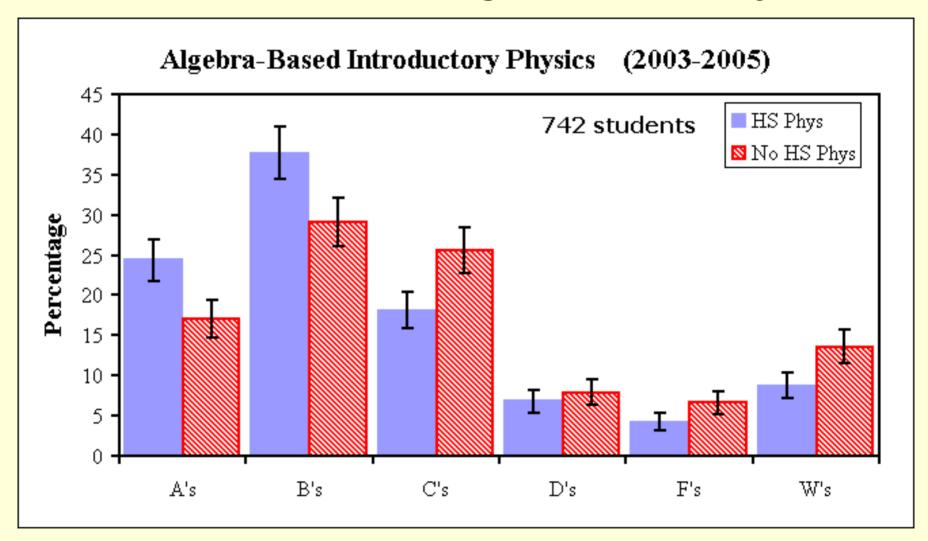
Correlation with High School Physics

Strong correlation exists between success in college physics courses with students having taken high school physics



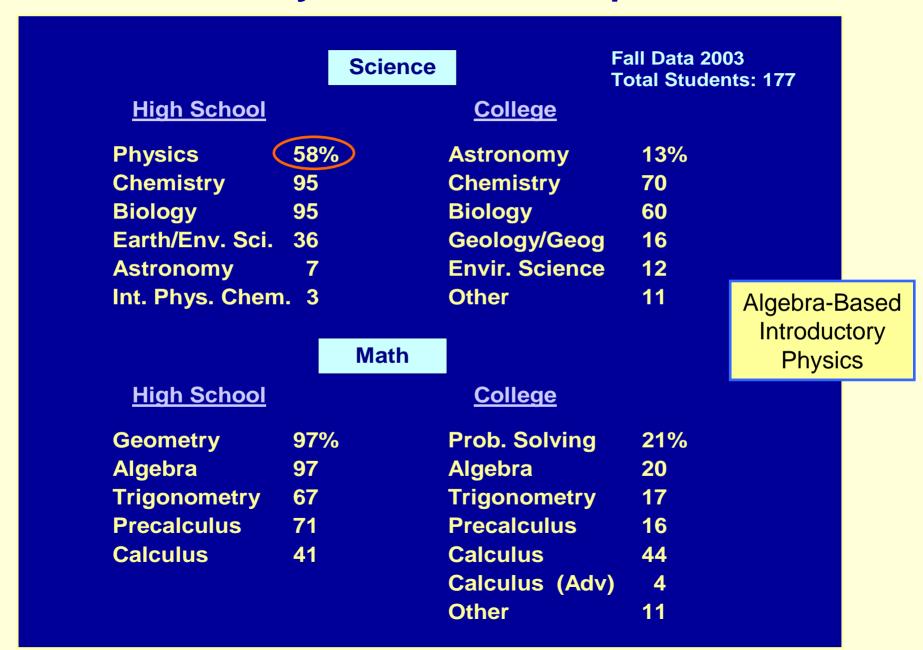
Similar observation was made at IU

Correlation with High School Physics



Final student grades – observe shift

Ball State Physics Student Preparation



Ball State Physics Student Preparation

	Science		Fall 2003 Dat Total Studen		
High School		<u>College</u>			
Physics	75%	Astronomy	9%		
Chemistry	98	Chemistry	25		
Biology	100	Biology	5		
Earth/Env. Sci.	45	Geology/Geog	5		
Astronomy	18	Envir. Science	11		
Int. Phys. Chem.	9	Other	14		
<u>High School</u>	Math	College		Calculus-l Introduc Physi	ctory
<u> </u>					
Geometry	95%	Prob. Solving	7%		
Algebra	95	Algebra	9		
Trigonometry	77	Trigonometry	18		
Precalculus	77	Precalculus	7		
Calculus	52	Calculus	45		
		Calculus (Adv	y) 18		
		Other	27		

Attitudes Survey on Teaching of Science and Math

Assesses attitudes and beliefs toward math and science

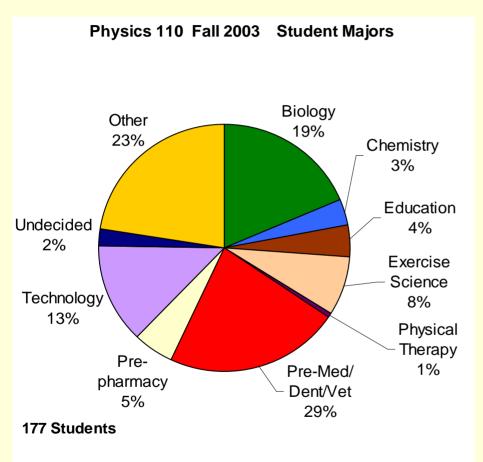
(and teaching for education students)

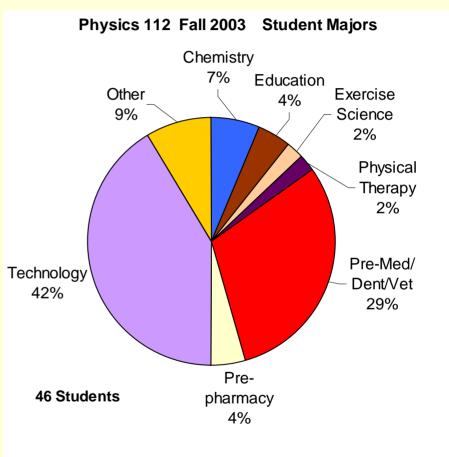
- 14 questions on attitudes toward math
- 16 questions on attitudes toward science
 - 8 questions on attitudes toward teaching (ed. students only)

Given to introductory physics students:

- Physics 101: elementary education
- Physics 110,112: algebra-based
- Physics 120: calculus-based

Student Majors





Algebra-Based Introductory Physics

1st Semester

Algebra-Based Introductory Physics

2nd Semester

Attitudes Survey on Teaching of Science and Math

Mathematics Fall 2003 Data		101	110	112	120
(1 = strongly agree,, 5 = strongly disagree)	И	Phys	Phys	Phys	Phys
I am looking forward to taking more math courses.	3.1	3.1	3.4	3.6	2.3
I like mathematics.	2.5	2.7	2.5	2.4	1.8
The use of technologies in math is an aid for slow learners.	4.3	4.2	4.3	4.3	4.3
Mathematics consists of unrelated topics (e.g. algebra)	4.0	3.6	4.1	4.0	4.5
To understand math, students must solve many problems	2.1	2.1	2.0	1.9	2.1
Getting correct answer is more important than investigating prob	3.9	3.9	3.9	3.9	4.0
The primary reason for math is to learn skills for doing science.	3.0	3.0	2.9	3.2	3.2
Small groups should be a regular part of the math classroom.	2.0	1.8	2.2	2.1	2.0

^{*} Selected questions from survey

Attitudes Survey on Teaching of Science and Math

Science Fall 2003 Data		101	110	112	120
(1 = strongly agree,, 5 = strongly disagree)	ΑII	Phys	Phys	Phys	Phys
I am looking forward to taking more science courses.	2.3	3.0	2.0	2.1	1.8
Getting correct answer is more important than investigating prob	4.1	4.0	4.1	4.0	4.3
Opportunities given to think about what students have learned	1.7	1.7	1.8	1.8	1.7
Theories in science are rarely replaced by other theories.	3.6	3.5	3.7	3.4	3.7
To understand science, students must solve many problems	2.3	2.2	2.3	2.5	2.1
I like science.	2.0	2.5	1.7	1.7	1.5
I enjoy learning how to use technologies in science.	1.9	2.0	1.8	1.9	1.5
Science consists of unrelated topics like bio, chem, and physics.	3.7	3.2	3.8	3.9	4.0

Evidences of Improvement

- INTASC Scores
- Retention of Teachers
- Pre- and Post- Assessments

These evidences are in no way meant to imply that these efforts are the ONLY reasons for the results seen, but do show that efforts made on behalf of Teachers College, the Biology Department, and the Physics & Astronomy Department are having an impact.

Addressing a Need for Assessment

- Ball State University uses the Interstate New Teacher Assessment and Support Consortium (INTASC) as part of their Unit Assessment System
 - Other certification qualifications:
 - Take PRAXIS exams (content-based)
 - rGrade electronic portfolio evaluation
 - At BSU, four-step decision point process
- This assessment has been utilized since the fall of the 2003-2004 school year
- BSU supervisor and the cooperating teacher work as a team for final assessment

Comparison of Inquiry-based INTASC Scores

(2003 - 2005)

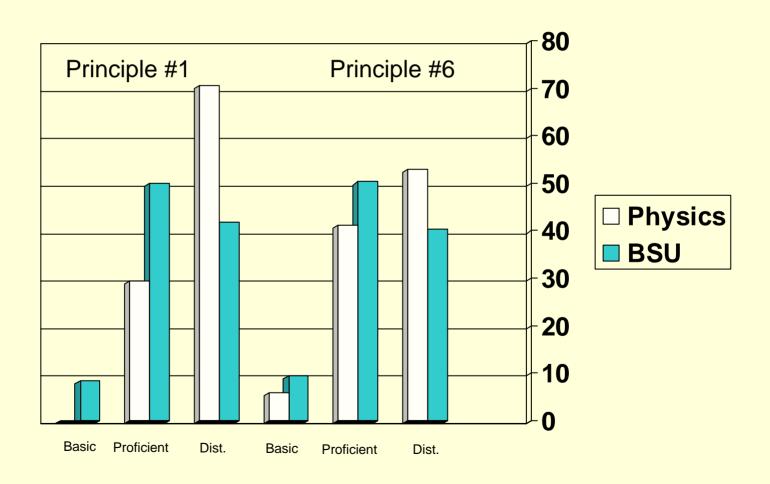
All BSU Student Teachers

- Principle #1
 - Basic 8.4%
 - Proficient 49.9%
 - Distinguished 41.7%
- Principle #6
 - Basic 9.5%
 - Proficient 50.3%
 - Distinguished 40.2%

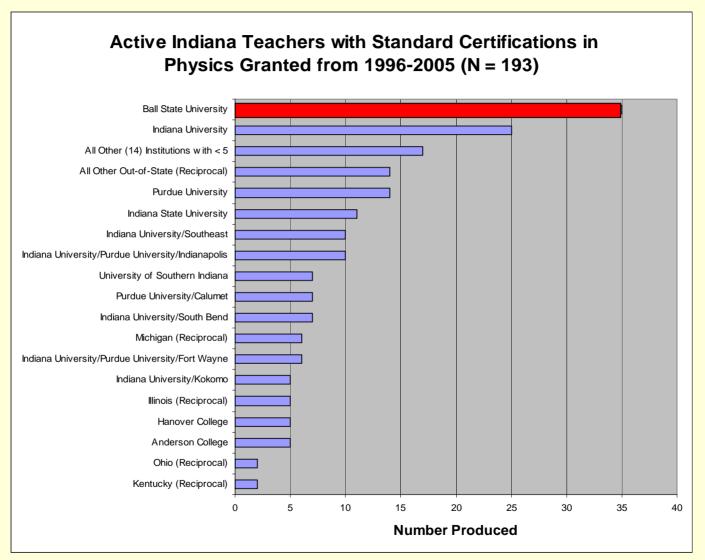
Physics Classes

- Principle #1
 - Basic0%
 - Proficient 29.4%
 - Distinguished 70.6%
- Principle #6
 - Basic 5.9%
 - Proficient 41.2%
 - Distinguished 52.9%

Graphical Comparison



Production and Retention of Indiana Graduates



Source: Raw data from Indiana DOE; DOE raw data numbers for BSU are at least 14% under-reported based on verified BSU local data for 1999-2005, so assume similar error rate for other institutions.

Ball State University Production of Teachers by First Year of Teaching with a Standard Certification in Physics from 1999-2005

	99-00	00-01	01-02	02-03	03-04	04-05	05-06	Avg/Yr
Teaching Bachelors	4	4	3	2	2	2	1	2.6
Post-Grads	2	0	3	4	2	1	1	1.9
Totals	6	4	6	6	4	3	2	4.4

Comments: This data varies from the Indiana DOE by time period covered, by first year of teaching versus year of certification, and by inclusion of two out-of-state teachers. In addition, five teachers, who were not in the DOE raw data, were discovered through the sources listed below and then verified by the DOE Teacher Inquiry website and/or by Internet searches and email contact.

Sources: Ball State University Advising Office, BSU student database, BSU Office of Educational Services, departmental advising reports, Indiana Department of Education Teacher Inquiry website, hard-copy class rosters, Internet searches, and email contacts.

Student Learning Assessment

Force Concept Inventory (FCI)

30 conceptual questions on Newton's laws

"Standard" for learning measurement

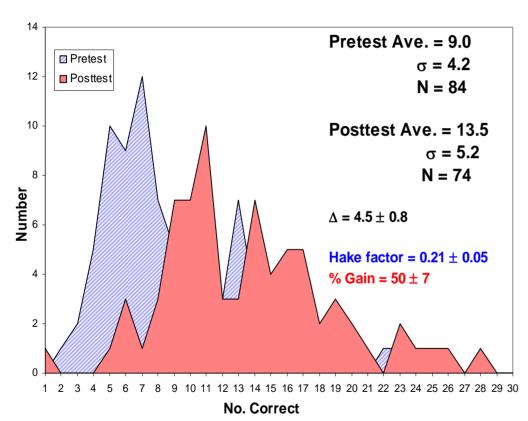
Conceptual Survey on Electricity and Magnetism (CSEM)

32 conceptual questions on basic E&M

Standardized Assessment Instruments from PER

Results of Force Concept Inventory (FCI)

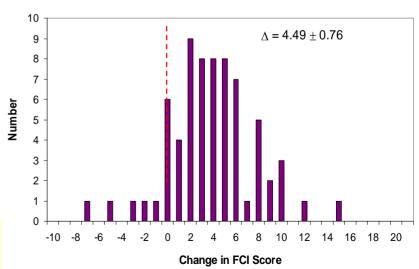
Physics 110 All Sections Spring 2005



Algebra-Based Introductory Class

Spring 2005

Physics 110 All Sections Spring 2005



Calculus-based introductory class has higher pre- and post-test scores

Summary

- Efforts continue to increase both the number of science teachers produced and the retention of science teachers once they enter the teaching field
- BSU addresses the need for "highly qualified" teachers at all levels
- BSU is committed to the PhysTEC project and its goals

Physics Teacher Education Coalition

