Goal

The goal of the PhysTEC program at Cornell University is to increase the number and improve the quality of the physics and physical science teachers that we train. Cornell has very large programs and outstanding students in the physical sciences and engineering, but has on average produced only one physics teacher per year. To capitalize on the potential of our undergraduate and graduate student populations, we need to raise the awareness and change the attitudes of our students and faculty regarding careers in high school science teaching, provide opportunities for our students to experience firsthand the challenges and rewards of classroom teaching, and provide mentoring and support as they work through our education program and on into their first years as teachers.

Selected Outcomes

- Partnership between Physics and Education, with generous support from Cornell's Provost, has produced a significant increase in visibility for Cornell's Teacher Education Program among undergraduates enrolled in physics courses.
- Efforts in Physics are producing a culture change in which more and more of our faculty, graduate students and undergraduates view training and careers in high school physics teaching as important and worthy options for our students.
- After three semesters, our Undergraduate Teaching Assistant Program is generating large numbers of UTA applications, significant numbers of UTAs enrolling in Education Department classes, and enthusiastic response from both UTAs and the students in the introductory courses they serve.
- The benefits of the UTA program to the perceptions of physics within the broader student body, to our Physics Major program, and in developing spirit and identity among both physics majors and those with teaching interests are becoming clear.
- Extensive use of surveys and pre-post testing is providing insight into the relative preparation of students in our four introductory course sequences, and into student attitudes towards science and to high school science teaching careers.
- Our PhysTEC program website is now online, and focuses on recruiting students into physics and physics teaching. With ongoing development it should become a useful resource for other PhysTEC institutions.
- The TIR is critical to all of our efforts. The TIR brings a perspective, energy and approach that are very different from those of our lecturers and professorial faculty, and that are very beneficial to the teaching and the mentoring in our undergraduate physics program.

Recruiting

Successes

- The Cornell Teacher Education Program has had larger attendance at its Information sessions, with roughly 1/3 of attendees learning of the sessions through advertising within the Physics Department, especially in our introductory physics courses.
- Six UTAs enrolled in Education courses in Fall 2009.
- All students in introductory and core physics courses, as well as all Physics graduate students, are now aware of physics teaching as a career option, and where to go to obtain more information.
- Collaboration with two Cornell MBA students from the Johnson School of Management yielded the "This is Physics" marketing campaign concept.
- Excellent posters and brochures provided by PhysTEC advertising Noyce Fellowships and direct contact by the PI and TIR yielded two successful applicants.
- We continue to develop our PhysTEC site, focusing on recruiting students into physics and physics teaching. A web designer will be improving the site's look and feel in Summer/Fall 2009.

Challenges

- The largest pool of potential "new recruits" is students majoring in the life sciences, chemical sciences and in engineering. We need to find approaches to reach these students outside of our introductory physics courses, and as early in their academic careers as possible. Many life science students do not take physics until their junior year, when it is difficult to make program adjustments to include teaching courses.
- Extensive summer and academic year research opportunities for our undergraduates attract students – including those interested in teaching – toward research careers. We have proposed a PhysTEC Teaching Experience for Undergraduates (TEU) program to counteract this pull away from teaching and provide more opportunities for undergraduates to explore their teaching interests.

Sustainability

- Slides, presentations and posters created can be reused in subsequent years with minimal revisions.
- We have migrated our website to Drupal, an open source content management system, which provides an easy and free way for multiple people to be involved in the site design and upkeep.

Lessons Learned

- The key parts of recruiting are (1) building relationships with students and (2) changing the attitudes of faculty, graduate TAs and our undergraduates toward careers in secondary science teaching. Flashy websites and posters serve an

important function, but it is the personal relationships with students and faculty that have the greatest impact.

Activities

- The PI and TIR made presentations to graduate teaching assistants and faculty at course meetings for nearly all of the introductory physics courses. Topics discussed included the need for more physics majors and more physics teachers, instructional approaches that encourage students to become majors, and the PhysTEC program and its goals.
- Revised the Physics Department's course catalog entry and its website to encourage students with broader interests to consider the physics major.
- Surveyed students in introductory physics courses about their attitudes toward careers in high school teaching.
- Advertised high school physics teaching and Cornell's MAT program in introductory physics courses, in emails to physics majors, and at career information sessions for physics majors.
- Developing recruiting website and associated print marketing materials.
- "Tell Your Students … Consider Physics Teaching" presentations at the joint NYS APS & AAPT meeting at Cornell, and included in workshops given at the Science Teachers Association of NY State (STANYS), the Pennsylvania Science Teachers Association (PSTA), and other conferences.
- Met with Biological Sciences advising committee to request that they advertise the "outside concentrator" physics option to their students.
- Met with Cornell Career Services senior staff to discuss ways to promote careers in high school teaching.
- Met with undergraduate advising staff in Astronomy and Engineering to discuss opportunities in physics teaching for their undergraduate and graduate students.
- Made brief (~5 minute) presentations in all the introductory physics course lectures to raise awareness of the need for more physics teachers, how to ‘try out teaching,’ and where to get more information.

Early Teaching Experience

Successes

- An Undergraduate Teaching Assistant (UTA) (formerly Learning Assistant) program was established in Spring 2008, based upon the University of Colorado model. Eight UTAs were teamed with graduate Physics TAs in facilitating cooperative learning problem solving sessions in the recitation sections of Physics 1112, a calculus-based mechanics course for non-honors physics and engineering students. Assistant Professor Erich Mueller, lecturer in Physics 1112, was an extremely enthusiastic and supportive host for the UTA program. He set up and maintained a staff Wiki, where TAs and UTAs could log their experiences.
- Major revisions to the program after the first semester – including generating exercises for the seminar more directly relevant to the cooperative session content and improving the quality of the coop exercises – have led to an overall enthusiastic response from UTA participants, and very positive reviews from the students they serve. The UTA program now services four of our introductory courses – Physics 1112, 2213, 2207 and 2208.
- An online application process has streamlined our processing of candidates.
- Six UTAs are currently enrolled in CTE program courses.
- Our current recruiting efforts, in which all TAs and faculty in introductory and core physics courses are asked to nominate potential UTAs who enjoy physics and communicate well with their peers, combined with in-class announcements and careful interviewing has improved the yield of those who pursue courses in Education from 0 in Spring 2008 to 6 in Spring 2009.
- Applications for UTA positions have increased dramatically. We received 72 applications for 10 new positions for Fall 2009. All offers were accepted. We have redirected funds from our Cornell match to allow us to support 12 new and 7 continuing UTAs. **Appendix 1** shows the progress of our UTA program and recruiting efforts over the last two years.
- The UTA program provides excellent PR for the Physics Department, especially to students from outside the department who enroll in our introductory courses. It helps build team spirit among our Physics majors, and among those inside and outside physics who have interests in teaching, giving these groups another way to identify themselves within the university. We now see the UTA program as an important part of our undergraduate physics program, independent of its importance in helping to recruit future teachers.
- All UTAs benefit from being observed and receiving formative evaluation by the TIR. This helps them develop confidence that they can be effective teachers, and also helps them see that teaching effectively is a real challenge worthy of their abilities.

Challenges

- In Spring 2008, UTAs and TAs generated their own cooperative learning problems, drawing on an on-line library of materials. This increased the time burden and/or took away from other preparation time, and led to an uneven experience for the P1112 students. Course faculty generated the coops in subsequent semesters.
- Cornell undergraduate students have extremely busy schedules, and many strong UTA candidates must defer their participation because of scheduling conflicts. This is complicated by the fact that scheduling of cooperative learning recitation sections is not decided by course staff until the week before the start of class.
- Students who have a declared interest in the physics major comprise less than 5% of the students who take introductory physics classes. A large expansion of the UTA program to include as many of the other 95% as possible in physics teaching activities could have tremendous benefits to the strength and perception of undergraduate physics education. How do we secure the financial resources for that expansion?
- Cornell science and engineering undergraduates are extremely interested in gaining teaching experience for the growth and credentials they know it can provide them. We need to figure out how to convert that kind of interest into a desire to become teachers.

Sustainability

- The Physics Department provided financial support for additional UTAs in the Spring 2008 semester.
- The PI and Physics Department Chair met with the Assistant Dean for Alumni Affairs and Development in the College of Arts and Sciences to request alumni/private contributions to sustain and expand the UTA program to include physics and teaching capable UTAs from across the university. A fundraising document was generated, and the Department Chair has met with two potential donors. Unfortunately, private giving has all but collapsed since the country's financial crisis began in Fall 2008.
- Two Physics senior lecturers were due to retire, and the Physics Department Chair pledged to fill one of these positions with a PER trained lecturer to help run our UTA program after PhysTEC support ends. Unfortunately, because of the University's financial crisis, the first of these positions to open up (as well as two Physics faculty lines) were eliminated to meet this year's required budget cuts, and next year's cuts will almost certainly eliminate additional lecturer positions.
- Our Physics Lecture Demonstration Support Specialist retired in Summer 2008. The person hired to fill this position taught high school physics for 10 years. We hope to engage her in our program once she has mastered the core parts of the demonstration support position.
- Eric Mueller, the host for the first semester of our UTA program, is our new Director of Undergraduate Studies, and enthusiastically supports our program.

- Ritchie Patterson, a physics faculty member who has worked with two of our PhysTEC courses, is our new Physics Department Chairperson, and understands and enthusiastically supports our program.

Lessons Learned

- In Spring 2008, graduate TAs involved in Physics 1112 were *required* to take the "Teaching and Learning Physics" seminar course together with the UTAs. The resulting discussions were very rich and varied, but there were some problems. Although the TA workload was adjusted to open time for this requirement, two TAs were particularly resentful of what they perceived to be an increased time burden and were toxic to the seminar atmosphere. TAs are no longer required to take the seminar, class atmosphere is much better, and the few TAs who *elect* to take the seminar truly enjoy it, contribute to it, and benefit from it. Several of our UTAs have commented that many of their TA partners would benefit from the seminar. In Fall 2009, 8 graduate students from Physics, Applied Physics and Astronomy enrolled in the course.
- UTAs and TAs are extremely busy with other commitments, and so the UTA program should make as efficient use of their time as possible. The weekly teaching and learning seminar should be tightly integrated with the physics course in which the UTAs are placed, utilizing the upcoming course material as a basis for exercises and activities. The seminar should be scheduled in the evening to reduce schedule conflicts.
- Cooperative learning session materials should be pre-programmed by senior course staff. Accompanying scripts/worksheets should be generated to help guide the TAs and UTAs in both the physics and in the pedagogical approach (as we have done for our laboratories in Physics 2207 and 2208). Coop problems and reading assignments should be distributed to UTAs and TAs at the beginning of the semester. UTAs and TAs are extremely busy during the last third of the semester, so "frontloading" should help them stay on top of their teaching responsibilities.
- The TAs that participate in our program and work with the UTAs should be volunteers, and should be screened by senior staff.
- Careful attention to student curiosity/interest in teaching during UTA interviews yields a higher likelihood of later recruitment into teaching.
- The instructional team meetings in our introductory physics courses should address PCK issues, and help TAs and UTAs alike to pre-script questioning strategies so as to shepherd students through topics of particular difficulty.

Activities

- We have initiated and developed a successful UTA program.
- The course “Teaching and Learning Physics” was created and modified to meet the needs of our students.

Induction and Mentoring

Successes

- The TIR was the University Supervisor (US) of one physics/math student teacher this semester. He supervised the physics placement, and co-supervised the math placement.

Challenges

- Too few physics education students in the pipeline when our project began.
- We have 2 Noyce scholars and six UTAs enrolled in Education department courses. Converting these students into CTE program graduates remains a significant challenge. There are no other physics teachers currently fully in the CTE pipeline, and the overall visibility of the CTE program with undergraduates remains low. The fiscal crisis – and its impact on the state-funded Education Department – is further complicating our efforts. But it is also making high school teaching careers more attractive to our undergraduates.

Lessons Learned

- The TIR provides a helpful voice of experience to pre-service teachers that is complementary to that of Education faculty.

Activities

- The TIR attended all lectures and actively participated in Cornell Teacher Education's TED 404 and 405 - Learning and Teaching I and II.
- The TIR assisted 5 Masters of Arts in Teaching candidates with projects in Physics/Physical Science

Teacher-in-Residence

PhysTEC has advertised the Teacher in Residence (TIR) as a key component of their program. Our initial experience has made us believers: a good high school physics teacher can be a tremendous asset not only to the PhysTEC project, but also to many other aspects of undergraduate physics and education programs. Cornell's TIR, Marty Alderman, has been engaged in an extremely broad range of activities.

Successes

- The TIR brings a perspective, energy and approach that are very different from those of our lecturers and professorial faculty, and that are very beneficial to the teaching and the mentoring in our undergraduate physics program.
- The TIR has been instrumental in making all physics faculty, lecturers and graduate students aware of the need for more high school physics teachers, and for faculty and grad student assistance in recruiting them.
- The TIR has been a consistent and strong voice for course reform focusing on student-centered instruction, and has introduced several useful methods to our instructional staff.

Challenges

- PhysTEC expects its institutions to engage in an extremely broad range of activities, but only provides personnel support for the TIR. Like all Cornell physics faculty, the PI is engaged in a full range of research, teaching and administrative activities, leaving insufficient time for all of these activities and interaction with the TIR. Too many program activities were left to the TIR, diluting his efforts and limiting his impact. This problem was exacerbated by an administrative delay in hiring our PhysTEC Program Coordinator (paid for by Cornell's institutional match.)

Sustainability

- We are exploring the possibility of some combination of a part-time Physics lecturer position, a part time outreach position in one of Cornell's NSF-funded centers, and private funding to obtain sustainable support for the TIR, but these efforts have been greatly complicated by the university's financial difficulties.

Lessons Learned

- PhysTEC senior faculty should carefully plan and coordinate activities with the TIR and with other support staff to maximize overall impact of the TIR's activities.
- TIR participation in undergraduate Education courses (TED 404 and 405) can create some tensions with Education faculty. The instructors had well established and developed programs, and there was little or no pre-class collaboration to integrate the TIR into their programs. In order for the integration of a TIR into a course to occur smoothly and without tensions, the nature of the TIR’s involvement must be clearly defined (co-teaching, assisting, observing, or

mentoring individual students) in advance and communicated to the students. A 'Statement of Expectations' would allow the lead instructor and TIR to clearly agree on the TIR's role.

Activities

- Managed and implemented most aspects of Cornell's Learning Assistant Program, including UTA interviewing and scheduling, and taught the associated weekly seminar course "Teaching and Learning Physics".
- Wrote a proposal to Cornell's Big Red Incubator program, and worked with two Cornell MBA students in developing a physics marketing campaign directed at teenagers.
- Provided suggestions and a professional educator's perspective at the 2-day Physics Graduate TA training sessions, and at instructional team meetings in introductory physics courses throughout the year.
- Provided 'Teacher Tricks' emails to TAs, UTAs, and PhysTEC course faculty.
- Provided some new physics concept demonstrations with recommendations on their learner-centered use.
- Advertised high school teaching careers at the student facilitator training sessions for the Cornell Engineering School's Academic Excellence Workshops
- Helped to resurrect our Society of Physics Students. Although it remains weak, there is a new "SPS Room", there are regular monthly programs, and they had a year-end picnic. Our SPS has promise to grow into a significant source of support for physics majors.
- Participated in Cornell Teacher Education (CTE) planning meetings.
- Assisted the instructors and was an additional resource to students in Learning and Teaching I & II (EDUC 4040 & 4050)
- Reviewed lesson plans of CTE students, participated in all of the pre- student teaching meetings and the student teaching seminar, and supervised one of the student teachers during this fall semester.
- Served as Cornell University supervisor of one physics/math student teacher during the fall '08 semester.
- Assisted 5 Masters of Arts in Teaching candidates with projects in Physics/Physical Science
- Advertised the Cornell Teacher Education (CTE) information / recruiting sessions in most physics courses, through in-lecture announcements and pre-lecture PowerPoint presentations. Nearly all students enrolled in undergraduate physics courses and all physics graduate students received emails advertising the sessions.

Presentations

- Several presentations to Cornell undergraduate and graduate students and also the Physics Department Faculty about the PhysTEC program and careers in physics teaching.

- Presentation on teaching careers at the junior/senior meeting "Physics Degree … What Next?, which had previously focused on graduate study, research careers and seeking employment.
- At the instructional team meetings (attended by faculty, graduate student TAs, and undergraduate UTAs) for the introductory physics courses, the PI and/or TIR discussed
  - Marketing the “Teaching and Learning Physics” seminar.
  - Marketing the physics major and the physics major with outside concentration.
  - Student-centered instructional techniques for use in recitation sections.
  - The critical need for high school physics teachers.
  - Ways instructional team members can help recruit and retain a broad and diverse group of students in physics (those destined to go to physics graduate school, as well as the much broader group who enjoy physics and could wonderfully apply a physics major’s skill set to the many other fields where it is so highly valued.)
  - Specific classroom and course administration strategies to improve student perceptions of physics.

The TIR is actively involved with the Cornell Institute for Physics Teachers (CIPT), the Science Teachers Association of New York State (STANYS), and the Central NY Physics Alliance (one site for Teacher Advisory Group discussions). He gave 2 lab workshops at the annual STANYS conference, and (with Jim Overhiser, our TIR for 2009-2010) a series of workshops for physics teachers in Doha, Qatar, in association with the CIPT and Cornell's Medical School there. At each of these workshops, the TIR discusses how physics teachers can motivate their students to consider a physics major or minor and a career in physics teaching.

Course Reform

Cornell's calculus-based introductory sequences for life, chemical and earth science students (Physics 2207 and 2208) and for engineering and non-honors physics students (Physics 1112 and 2213) have been using polling/peer instruction, cooperative learning sessions and several other PER-validated methods for more than a decade, and thus provide very good models for effective teaching to our UTAs. However, the third semester of our non-honors (Physics 2214) and honors (Physics 2218) introductory physics courses - covering oscillations, waves and quantum mechanics - have lagged behind our other courses. Physics 2214 is especially important for recruiting students into physics who are considering careers outside of physics research, and thus to increasing the number of physics majors.

Aside from our introductory sequences, our upper division core physics courses - in electricity and magnetism, mechanics, and modern physics - are very traditional. They present an obstacle to the "non-traditional" physics majors we hope to attract.

Successes

- A major revision of Physics 2214 was undertaken by the PI beginning in Spring 2008 and continuing in Spring 2009. After significant teething pains in the first semester, there have been significant improvements in student attitudes and overall level of effort. The revised course includes 200 questions for in-lecture polling and self-study, roughly 40 new context, application and/or transferable skill rich homework problems, roughly 25 PowerPoint slide shows on physics applications, and three new lecture demonstrations.
- Based upon a suggestion from a colleague, we both implemented online anonymous feedback systems using Goggle Forms, which provided excellent "real time" feedback useful in tweaking lectures and assignments and in catching TA grading and teaching issues.
- Two students in Spring 2009 decided to switch their majors to Applied Physics and Physics.
- The Physics 2214 website is used as a resource by Physics 2218 students.
- The TIR instituted evening “Homework Parties” in the UTA-supported courses, that have been very popular with students. Some UTAs were assigned to work with TAs in providing help during these parties, and other helped during regular office hours.

Challenges

- The revision of Physics 2214 was undertaken with no additional senior staff support beyond the standard introductory course allocation, in part because of a shortage of senior teaching staff.
- An important remaining question is whether our honors sequence for majors, which caters only to students with very strong physics and math backgrounds, should be reformed. We need to have a sequence that can adequately

challenge these students, but we also need to ensure that Physics majors who follow our non-honors sequence 1112-2213-2214 do not feel like second-class citizens.

Sustainability

- With a new chair and new director of undergraduate studies, the Physics department is likely to soon have an undergraduate curriculum committee that can set priorities and suggest resource allocations in our undergraduate program.

Lessons Learned

- To make introductory course teaching more attractive to faculty, we need to move to a "no hero" model like that at the University of Illinois.
- Faculty in introductory courses should focus on providing help in learning/studying skills, and not tutorial assistance with course content.
- The first semester of any major reform will always be challenging for both the faculty and their students. Stay the course and focus on continuous improvement based upon a tight feedback loop with the students and TAs.

Content Assessment

Physics 1112: A calculus-based introduction to mechanics targeted at engineering majors and at physics majors with non-AP high school physics and calculus preparation.

FCI Results for Physics 1112					
Semester	**N**	**Pre-Test Average**	**Post-Test Average**	**Normalized Gain**	**Standard Error**
Fall 2007	42	0.673	0.809	0.361	0.096
Spring 2008	119	0.619	0.769	0.367	0.034
Fall 2008	120	0.646	0.809	0.473	0.032
Spring 2009	114	0.654	0.738	0.134	0.107

EBAPS Results for Physics 1112					
Semester	**N**	**Pre-Test Average**	**Post-Test Average**	**Normalized Gain**	**Standard Error**
Spring 2009	49	0.686	0.698	-0.032	0.052

- Physics 1112 enrollment in the fall semester is typically half that in the spring semester. Students who enroll in the fall (as first-semester freshman) on average have better preparation than those in the spring semester.
- Undergraduate teaching assistants (UTA) were used (in cooperative learning recitation sections) for the first time in the Spring 08 semester of Physics 1112. UTAs were used again in both the Fall 08 and Spring 09 semesters.
- This course has used polling/peer instruction and cooperative learning sessions/tutorials for the last 15 years.
- The EBAPS is an attitude survey that attempts to determine how students think about knowledge in the physical sciences. Do they think claims are simply true or false, right or wrong, or do they understand that claims are well or less well supported. Do they understand that individual pieces of content fit together into a coherent whole, so to solve problems we need to understand the deeper structure.

Physics 1116: A calculus-based introduction to mechanics and special relativity for honors physics majors.

FCI Results for Physics 1116					
Semester	**N**	**Pre-Test Average**	**Post-Test Average**	**Normalized Gain**	**Standard Error**
Fall 2007	40	0.855	0.863	-0.040	0.158
Fall 2008	41	0.859	0.905	0.237	0.090
Spring 2009	11	0.928	0.967	0.763	0.154

- The extremely high pre-test scores in this course suggest that the FMCE would be a more appropriate instrument to measure learning gains in future semesters.
- This course uses polling/peer instruction. There have been no reforms conducted in this course during the PhysTEC program to date.

Physics 2207: A calculus-based introduction to mechanics and heat for life, chemical, earth and atmospheric science majors and pre-medical/pre-veterinary students. This course may also be taken by biomedical engineering students.

FCI Results for Physics 2207					
Semester	**N**	**Pre-Test Average**	**Post-Test Average**	**Normalized Gain**	**Standard Error**
Fall 2007	142	0.442	0.682	0.436	0.025
Fall 2008	244	0.475	0.693	0.419	0.021

- Undergraduate learning assistants were used for the first time in the Fall 08 semester of Physics 2207. This is already a reformed course, having used polling, peer instruction and cooperative learning for over 15 years. The course also includes extensive real-world applications of physics.

Physics 102: An algebra-based introduction to electricity, magnetism, optics and modern physics targeted at the same clientele as Physics 2207-2208.

CSEM Results for Physics 102					
Semester	**N**	**Pre-Test Average**	**Post-Test Average**	**Normalized Gain**	**Standard Error**
Spring 2009	17	0.355	0.507	0.248	0.057

- There were no reforms conducted in this course during the spring semester. This course was the first autotutorial physics course in the US. Students work through interactive demonstrations on their own, watch video lectures, solve problems on paper and via online tutorials, and obtain one-on-one tutoring with course staff before taking unit tests.

Physics 2208: A calculus-based introduction to electricity, magnetism, optics and modern physics targeted at life, chemical, earth and atmospheric science majors and pre-medical/pre-veterinary students. This course may also be taken by biomedical engineering students.

CSEM Results for Physics 2208					
Semester	**N**	**Pre-Test Average**	**Post-Test Average**	**Normalized Gain**	**Standard Error**
Spring 2009	41	0.424	0.590	0.292	0.055

- Undergraduate learning assistants were used for the first time in the Spring 09 semester.
- This is already a reformed course, having used polling, peer instruction and cooperative learning for over 15 years. The course also includes extensive real-world applications of physics.

Physics 2213: A calculus-based introduction to electricity, magnetism and thermodynamics targeted at engineering majors and non-honors physics majors.

CSEM Results for Physics 2213					
Semester	**N**	**Pre-Test Average**	**Post-Test Average**	**Normalized Gain**	**Standard Error**
Spring 2008	159	0.414	0.590	0.310	0.018
Spring 2009	48	0.536	0.674	0.318	0.050

- This course uses polling/peer instruction and cooperative learning sessions. There were no reforms conducted in this course during the spring semester.

Physics 2217: A calculus-based introduction to electromagnetism targeted for honors physics majors.

CSEM Results for Physics 2217					
Semester	**N**	**Pre-Test Average**	**Post-Test Average**	**Normalized Gain**	**Standard Error**
Spring 2009	24	0.689	0.814	0.433	0.098

- There were no reforms conducted in this traditionally-taught course during the spring semester.

Content Assessment Methods

We switched from paper-based testing to online testing in the Spring 09 semester. Data from previous semesters was collected via paper tests given in recitation section.

- The logistics of distributing (to roughly 30 TAs), collecting, correcting (e.g., student mistakes in entering course numbers and id numbers), scanning and analyzing 1200 paper tests per term was prohibitive, an inefficient use of staff time, and not sustainable in the long term.
- Instructors were understandably reluctant to give up 2 recitations for the testing, especially the post-testing recitation at the end of the term.
- Online testing greatly simplified the logistics, and allowed us to expand our testing to more courses. However, an administrative error in Spring 2009 related to human testing guidelines, in which students were told the tests were optional, resulted in roughly half as many respondents as in previous semesters. Many of these suffered from fatigue and did not fully complete the tests.
- We plan to request that faculty give course credit for completing the tests to obtain a better return rate.

Demographics

PhysTEC Teachers									
	Grade Band	**Baseline**			**Project**				
		Year 1 2004-2005	**Year 2** 2005-2006	**Year 3** 2006-2007	**Year 1** 2007-2008	**Year 2** 2008-2009	**Year 3** 2009-2010	**Year 4** 2010-2011	**Year 5** 2011-2012
PhysTEC Secondary Graduate'	7-12	2 men	3 men 1 woman	1 man	1 woman	0			
PhysTEC Future Teachers					0	0			

Commentary on PhysTEC Teachers data: These numbers reflect individuals who were formally recommended for certification by the Cornell Teacher Education (CTE) program. They may then have applied to NY State or another state for their actual certificate. The State of New York does not recognize certification for physical science. All of our pre-service teachers complete a physics major and an education minor as undergraduates, and then complete a one-year Master of Arts in Teaching Consequently, the earliest that students recruited at the freshman and sophomore level into our PhysTEC UTA program could appear in our teacher data is 2011-2012.

PhysTEC Mentors & Mentees								
	Baseline			**Project**				
	Year 1 2004-2005	**Year 2** 2005-2006	**Year 3** 2006-2007	**Year 1** 2007-2008	**Year 2** 2008-2009	**Year 3** 2009-2010	**Year 4** 2010-2011	**Year 5** 2011-2012
PhysTEC Mentors (Current and Prior TIRs)	0	0	0	1	1	2		
PhysTEC Mentees	0	0	0	48	26			
Mentored PhysTEC Teachers	0	0	0	0	1			
Mentored Non-PhysTEC Teachers	0	0	0	7	8			

Under PhysTEC Mentees, the number includes Graduate TAs, Undergraduate TAs, and students in Education courses with which the TIR assisted. The mentoring standard applied was a minimum of one personal contact per month plus regular availability of email contact.

Course Type		PhysTEC Enrollment							
		Baseline			Project				
		Year 1 2004-2005	**Year 2** 2005-2006	**Year 3** 2006-2007	**Year 1** 2007-2008	**Year 2** 2008-2009	**Year 3** 2009-2010	**Year 4** 2010-2011	**Year 5** 2011-2012
Introductory calculus-based mechanics*	Phys1112	513	508	583	441	528			
Introductory calculus-based mechanics*	Phys2207	173	204	294	303	317			
Teaching and Learning Physics (TIR is the instructor)	Phys4484/7684	xxx	xxx	xxx	17	24			
Secondary science teaching methods*	EDUC 4050	24	14	18	13[1]	16			
Total		710	726	895	774	885			

*TIR assisted in course instruction

Physics and Education Faculty Involved In PhysTEC Project

- Robert Thorne, Professor, Department of Physics. PPI Lead
- Deborah Trumbull, Associate Professor, Department of Education. PPI co-Lead
- Erich Mueller, Assistant Professor, Department of Physics. Physics 1112 instructor and host for UTA (LA) program Spring 2008.
- Julia Thom, Assistant Professor, Department of Physics. UTA (LA) partner in Physics 1112 Spring 2008; Physics 1112 instructor and host for UTA (LA) program in Fall 2008.
- Matthias Liepe, Assistant Professor, Department of Physics. Physics 207 instructor and host for UTA (LA) program Fall 2008.
- Edith Cassel, Senior Lecturer and Alan Giambattista, Senior Lecturer, Department of Physics. UTA partner in Physics 1112 Spring 2009.
- Robert Fulbright, Senior Lecturer, Department of Physics. Physics 209 instructor and host for UTA (LA) program Spring 2009.
- Barbara Crawford, Associate Professor, Department of Education.

Collaboration among the College of Arts and Sciences, the College of Agriculture and Life Sciences, University Administrators, and Local Public School Systems

Successes

- Prior to our efforts, the last collaboration between the Physics and Education Departments was in the early 1990's, and involved co-advising a graduate student studying reform of Physics 2207.
- Although our program is based and administered in the Physics Department, there have been extensive interactions of the TIR and PI with Cornell Teacher Education faculty and staff, especially in recruiting activities directed at students enrolled in Physics courses.
- Our TIR has participated in Education Department classes, attended CTE planning meetings, and observed CTE students in their student placements in local schools.
- Like most Education programs, the CTE has an extensive network of local and regional teachers who serve as mentors and hosts for field experience.

Challenges

- The Physics Department is in the endowed College of Arts and Sciences, while the Education Department is in the NYS funded College of Agriculture and Life Sciences. The latter has suffered from shrinking budgets in recent years. The Education Department is unlikely to receive any new support from the College to enhance its physics and math teacher training programs. This support should return to being a responsibility of the university as a whole, since it is the College of Arts and Sciences (which houses Physics, Chemistry, Math and many of the biological sciences) and the College of Engineering that are most strongly impacted by the shortage of qualified high school teachers in STEM disciplines.
- Support for our efforts from the broader Education Department has been less than one might have hoped, given the department's issues with recruiting and total number of enrolled students. This is in part due to historically weak ties between Education and math and the hard science disciplines.
- Although the Provost's office has sponsored our efforts, there is still no high-level communication between the Physics and Education Department, or between the College of Arts and Sciences and the College of Agriculture and Life Sciences on the subject of teacher preparation.

Sustainability

- Cornell needs a University-wide committee responsible for STEM teacher preparation, that at a minimum should involve faculty from Education, Physics, Chemistry, Mathematics, and Biology and representatives from the Deans of Arts and Sciences, Agriculture and Life Sciences, and the Provost's office. STEM teacher preparation is critical to the university's mission, and should be supported by all of the stakeholders.

Lessons Learned

- At a research university like Cornell, collaboration between the Education Department and the Physics Department (and Math and Chemistry and the life sciences) is essential in effectively marketing teaching careers to undergraduates. The disciplines have much greater access to the pool of potential teachers. Participation of the disciplines helps to legitimize high school teaching careers in the eyes of undergraduates.

Activities

- Cross-college collaboration in advertising teaching careers and the CTE program.

Publications and Presentations

Publications

“Non-Physics Teachers Are Teaching Physics–We Cannot Replace Them, But We Can Help Them!” Marty Alderman (APS Forum on Education Fall 2008 Newsletter, Pg. 19)

Presentations

- "Tell Your Students … Consider Physics Teaching" at the joint NYS APS & AAPT meeting at Cornell, and again for science faculty at the Owego staff development day, April 2008. Marty Alderman, TIR.
- The TIR presented at the annual Science Teachers Association of New York State (STANYS) conferences and at the Edmonton AAPT meeting.

Appendix 1: Statistics for Cornell's Undergraduate Teaching Assistant (UTA) Program

	Spring '08	Fall '08	Spring '09	Fall '09
Course impacted	Phys 1112	Phys 1112 Phys 2207	Phys 1112 Phys 2208	Phys 1112 Phys 2207
Lead Instructor	Erich Mueller	Julia Thom-Levy Matthias Liepe	Edith Cassel Bert Fulbright	
Recruiting efforts	2	1	1	1
Info meeting attendance	8	10	15	32
New UTA openings	10	10	10	10
UTA Applications	12/7	21	32	72
# of UTAs continuing*	xxx	0	3	6
# of Noyce Scholarships	xxx	xxx	2 ($15,000 each)	

*Continuing UTAs must enroll in an Education Department course.