Colorado PhysTEC

Physics Teacher Education Coalition
Summary of Year 1 Activities

N. Finkelstein, S. Pollock, M.Dubson, V. Otero, C. Keller and C. Turpen
phystec.colorado.edu

The Colorado PhysTEC Initiative is comprised of two fundamental components: i) a coordinated program for developing, preparing and supporting undergraduate (and graduate) physics majors for their roles as future educators, and ii) to research and document these efforts. The University of Colorado at Boulder builds on increasing attention to education in the physics department, strengthening ties between the school of education and the department, a new program in physics education research, and several initiatives on campus that bring significant resources and interest to this endeavor.

Building on local resources, networks, and projects, the Colorado PhysTEC initiative creates an integrated program through efforts which:

- support the (re-)vitalization of an undergraduate major track in physics and teaching with reforms in undergraduate introductory courses, increased access into teaching for physics majors, and a new advanced physics course in *Teaching and Learning Physics*,
- support efforts to more thoroughly mix reformed pedagogy into departmental practice,
- partner with the School of Education, the STEM-TP collaborative, and local schools to create and maintain a continuum of K-12 teacher preparation that begins in the college of Arts and Sciences,
- partner with other CU initiatives and local schools to create opportunities for school teachers to collaborate in educational programs at the university and in the schools, and
- conduct research studies within and evaluations of these coordinated activity systems.

Each of these efforts is designed to complement and in fact shape the others. Our emphasis at Colorado is on increasing physics student engagement in education (Goal #1 below), the implementation of PER-inspired reforms (goal #2), and researching these efforts (goal #4). Notably, strong partnerships with the School of Education and the broader educational system (goal #3) and the development of a robust TIR/TAG program (goal #5) support these other objectives.

GOAL #1: Increase opportunities for physics students to engage in education
MEASURABLES:

- Tracking of students' teaching activities subsequent to PhysTEC participation, particularly, after taking Physics 4810/7810 (a course titled "Teaching and Learning Physics")
- Documentation of coupling with Colorado STEM-TP program
- Development and coupling with Preparing Future Physics Faculty (PFPF) program
- Documenting STEM-TP and Physics 4810/7810 student work
- Tracking faculty involvement / awareness in these reforms and related PER-based reforms/approaches
- Creating ties with and opportunities in regional high schools

GOAL #2: Improve undergraduate physics course sequence with inquiry-based practices
(Introduction of Tutorials, and other PER-inspired reforms)
MEASURABLES:

- Documenting what forms of change are being implemented and how
- Measuring student conceptual gains, expectations/beliefs & their development, and affective response
- Tracking number of faculty & graduate students involved in changes, and number of courses that are affected

GOAL #3: Build long-term partnerships between the Physics Department, School of Education, and local school faculty & programs
MEASURABLES:

- Track faculty involvement in collaborating programs
- Document success of joint programs
- Develop and sustain the Teacher Advisory Group (TAG)
- Track student cross enrollment with School of Education and participation in community

GOAL #4: Research the mechanisms by which goals #1 #2 #3 are achieved
MEASURABLES:

- Study correlations of measures of student success (conceptual mastery, attitudes, beliefs, etc.), ethnographic observations of what occurs, and micro-genetic (local) documentation of what happens
- Comparisons with other sites (such as the University of Washington) to determine what replication of educational transformations means
- Measure forms of interaction among these activities (such as course reforms and teaching opportunities)
- Identify characteristics of sustainable reforms of these activities

GOAL #5: Development of models for the role of the Teacher in Residence (TIR), the Teaching Fellows program, and Teacher Advisory Group (TAG) to support goals 1 - 4
MEASURABLES:

- Identify productive activities and modes of interaction for TIR, Fellows, and TAG
- Establishment of the Teacher Advisory Group as a sustained activity which supports/benefits TIR
- From collaborating with local schools, create a pool of teachers in which potential TIR and TAG members can be identified

Over the past 10 months of Colorado PhysTEC program (Aug 2004 – June 2005), we have made significant progress towards achieving each of these goals. The efforts to date have both been designed to establish the infrastructure for completing these long-term goals, to leverage resources from a number of existing programs, and to assess their impact via measurements described above. These data documenting progress toward each of the goals are organized into five main threads and are reported in the annual report: (i) course transformation, (ii) impact on future teachers (pre-service or pre-pre-service teachers), (iii) core PhysTEC initiatives, (iv) complementary PhysTEC programs, and (v) coupled research studies.

Theme 1: Course Transformations: Course Development, Implementation, and Research Results

Physics 1120 - General Physics 2: main findings include successful implementation of *Tutorials in Introductory Physics*, its successful hand-off to a second instructor, measurement of increased learning grins by students, support of productive attitudes and beliefs, and assessment of student affect.

Physics 4810/7810 - Teaching and Learning Physics: the successful development and implementation of an upper division undergraduate and graduate level course which increases student mastery of physics, interest and ability in teaching, and practical experience teaching and researching in education.

ARSC 4040 - Educational Theory, Philosophy & Practice: the successful implementation of a methods/ theory course in the school of Education, which support the STEM-TP Learning Assistant program, and guides students into future educational opportunities (such as Phys4810 and the Teacher Education Program).

Theme 2: Related Data on Learning Assistants

Through evaluation of students who participate as Learning Assistant program in STEM-TP or in the practicum portion of Teaching and Learning Physics course we observed increased mastery of physics content (as measured by conceptual assessments), high degree of student interest in education (compared with the national average or with the departmental average), and a variety of productive teaching and research experiences in which student engage.

Theme 3: Core PhysTEC Programs

Teacher in Residence (TiR): In our first year of activity a part-time TiR supported the establishment of our program, developed strong ties between PhysTEC and STEM-Colorado, assisted in the development of courses and course transformations, organized and supported the establishment of the teacher advisory group, developed the summer teacher in-service workshop, and recruited Fellows and the next year's TiR. For the coming year, 3 teachers applied and one has been selected – The cost of next year's TiR is being supported by PhysTEC, the Department of Physics and the Boulder Valley School District. A second Teacher in Residence will be hired as part of the Physics Education Technology project.

PhysTEC Fellows: Three Fellows (current K12 teachers who will spend 1 month working in the physics department in PhysTEC) have been selected (out of 8 applicants) to conduct their Fellowships over the Summer 2005. Two will be supported by PhysTEC and one from the Physics Education Technology Project.

Teacher Advisory Group (TAG): a group of 10 local high school teachers meets quarterly to advise on the Colorado PhysTEC program, network with each other, ground our efforts, and serve as local mentors to students engaged in practicum activities (though STEM-Colorado and Phys 4810).

Theme 4: Complementary PhysTEC Programs

A variety of programs have been developed or supported over the past year, including:

- ***Coupling with Colorado STEM-TP***: a strong synergy has formed between these two programs. The STEM-Colorado program seeks to increase the number of qualified teachers in all STEM disciplines and works across five departments. To date a number of programmatic efforts have moved from PhysTEC into STEM, including: a model for TAGs, the use of disciplined based education research to support these efforts, and methods of assessment and evaluation. Similarly the STEM has strongly influenced and supported PhysTEC with the LA model, the summer workshops (from which the TAG began), a variety of assessment tools, administrative support and other resources.
- ***Preparing Future Physics Faculty (PFPF):*** a graduate / postdoctoral program to support interest in all areas of professional practice, but emphasizing teaching and education.
- ***Lunchtime Brown Bag Discussions in Education:*** bi-weekly faculty seminars in physics discussing / revising the efforts in the undergraduate curriculum. Results include: the participation of approximately half the faculty in discussions of education, the significant restructuring of sophomore mechanics / math methods courses, and the elimination of the honors sequence.
- ***Faculty Use of Educational Technology and Assessment Tools***: particular emphasis has been placed on the use of the personal response system or "clicker." Spear-headed by the physics department and the PhysTEC PI's, clickers are currently used in 12 departments, 3 dozen courses (per semester), and over 2000 physics students per semester on campus.
- ***Additional partnerships*** are evolving with: the Center for Engineering Education and Outreach (CEEO) at Tufts University and their efforts to use Lego Robolab to promote pre-college age kids interest in science (and opportunities for undergraduates to engage in innovative teaching experiences); and the CU's Alliance for Technology, Learning and Society Institute (ATLAS), which strives to leverage the affordances of new technologies to support ubiquitous education for university students (PI's Finkelstein and Pollock are among the first Faculty Fellows of this Institute).

Theme 5: Additional Research Investigations Coupled with PhysTEC Course Development Efforts

A series of research efforts go beyond the documenting of the Colorado PhysTEC program, to understand why these efforts work and to further the field of physics education research (PER). In the past year approximately two-dozen papers, talks and workshops related to the Colorado PhysTEC program have been given around the country. Among the topics of research are studies of: student use of textbooks, the use of analogy in student learning, how students use representations to learn physics, what role computer simulations can serve, the development, validation, and application of the Colorado Learning Attitudes about Science Survey (CLASS), and one of the first studies of what it means to replicate innovations in physics education.

In the past year the Colorado PhysTEC program has impacted:

- more than 700 undergraduates in the Phys 1120 sequence
- Roughly 20 future physics teachers
- Approximately 10-15 current / practicing pre-college teachers
- Half the physics department faculty (20 physics faculty)
- One quarter to one- third of the current physics graduate students (approximately 60)