

The Impact of Teacher Quality Grants on Long-Term Professional Development of Physical Science Teachers

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Abstract. The Texas Higher Education Coordinating Board Teacher Quality Grants, supported through No Child Left Behind, are intended to ensure that secondary teachers of specific subjects are “highly qualified”. Now in their third year, these grants have done much to shape long-term professional development for teachers in the physical sciences at the University of Texas at Dallas (UTD). The grants have also created a suite of challenges and benefits for the UTD Science Education M.A.T. program. Teacher Quality Grants are based on the No Child Left Behind framework that requires teachers to be “highly qualified” as defined by the state. Recruitment is required to be targeted at teachers who are uncertified or teach one or more classes out of their content area and who work in high needs local school districts. Many of the students brought into our program through these grants have incoming content knowledge in physics similar to that typical of undergraduate non-majors, and a large percentage are uncomfortable with basic mathematics as well. How and what we teach has been dramatically impacted by the Teacher Quality Grants, as have our assessments and evaluations. An ongoing challenge has been to implement a Physics Education Research (PER)-based course design while meeting the specific requirements of the Teacher Quality Grant program. The Teacher Quality Grants have also provided a great deal of opportunity to new and existing teachers in our program. A barrier to our teachers, rising tuition costs, has been removed and as a result a mandate has become a doorway of opportunity for physical science teachers.

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TEACHER TRAINING AND NO CHILD LEFT BEHIND

No Child Left Behind [1] makes specific provisions for the training of in-service teachers, and to which teachers funds will be targeted. The focus is on ensuring that all secondary teachers be “highly qualified” in the subject(s) they teach. The need for qualified teachers in Texas is apparent in the *Texas Strategy to Address the Teacher Shortage* [2] which noted more than 50,000 teachers in the 2001-2002 school year were assigned to teach out of their content areas for >50% of the school day. This number **does not include** science teachers who are teaching a science subject for which they are not trained.

In science, the goal to have every teacher be “highly qualified” for every subject taught is especially daunting. School districts in Texas prefer composite science certified teachers. A teacher with a degree in biology and a composite certification can be assigned to any science class. This provides flexibility for a district or principal, but also results in many life science teachers teaching one or more sections of

physics, chemistry, and/or physical science. According to *No Child Left Behind* (NCLB), a highly qualified teacher:

- is certified or licensed to teach,
- has a bachelor’s degree, and
- knows the subject(s) he or she teaches.

For in-service secondary science teachers who hold bachelor degrees in subjects other than those taught (science degrees or otherwise), a great deal of variation exists in the application of the term “highly qualified”.

NCLB has refocused professional development resources for middle and high school in-service teachers (currently in a classroom) on teachers who serve high needs student populations and who are not highly qualified to teach the subjects to which they are assigned. Teacher Quality Grants are available in all states and are from the same source of funds as the former Eisenhower Grants funded through states by the Department of Education.

The primary difference between the Eisenhower Grants and the Teacher Quality Grants is the focus. Eisenhower-supported programs tended to attract the

best teachers who were teaching the most advanced students. Teacher Quality Grants require program design and recruitment of participants based on the characteristics of individual teachers and school districts. High needs districts (high poverty, English as a second language, etc.) must be partnered with the program institution. Recruitment must be targeted at teachers who are not “highly qualified” (as defined by the granting institution rather than the school district.) Because recruitment must focus on teachers who are not highly qualified, how the term is defined is increasingly important. The Texas Higher Education Coordinating Board (THECB) is the body that oversees the Texas Teacher Quality Grant Program [2]. The THECB recognizes that although a teacher may hold a composite science certificate and be considered highly qualified for a physical science course by a district or principal, he or she may not have an academic background in the subject taught.

In our recruitment for the UT Dallas Teacher Quality Programs, and with the encouragement of the THECB, we seek teachers who are teaching topics outside of their academic major. For our physical science program, most participants have degrees in biology, interdisciplinary studies, geology, or elementary education.

SHAPING TEACHER TRAINING

Physics and space sciences programs for in-service teachers, and indeed the entire Science Education Program at UT Dallas, have been significantly affected by Teacher Quality Grants. Professional development for physics content is now exclusively focused on assisting physical science teachers working out of content area in becoming “highly qualified”.

Becoming “Highly Qualified”

The Texas Teacher Quality Grant Programs must meet several criteria with the goal of assisting teachers in becoming highly qualified with regard to content knowledge. The most successful programs, according to the THECB, are year-long and give participants nine graduate credit hours.

Each university-run program is required to have a three-week summer institute, generally at the beginning of the program, followed by regular meetings during the academic year. Depth rather than breadth is emphasized in the program request for proposals, but programs must cover all state standards for the targeted grade level(s) or course. Middle school programs are also required to be highly interdisciplinary. Teacher training curricula were

created by the state in 2004, but are no longer mandatory for Texas Teacher Quality Grant programs.

The expectation of all Teacher Quality programs is that participant content knowledge will be greatly enhanced. Evidence for success required by the state of Texas comes primarily from pre-post testing and observations of participant classrooms.

The UT Dallas Integrated Physics and Chemistry Teacher Quality Program

Teacher Quality Grants have primarily impacted teacher training at UT Dallas through our Masters of Arts in Teaching (M.A.T) in Science Education Program, which serves in-service and post-baccalaureate pre-service teachers. No physical science courses for secondary teachers were offered through the M.A.T. program prior to 2003. The first offering of the three course *Physics in the Classroom* series began in Spring 2003, just before the beginning of our first grant for Integrated Physics and Chemistry (IPC) teachers. IPC is the 8th, 9th, or 10th grade physical science course in Texas. In high school IPC is usually the course option for students who are not expected to take physics, and is not a preferred assignment for teachers.

Teacher Quality Grant requirements and participants have played a fundamental role in the design of the course sequence. In the summer of 2003 we restarted our course sequence, retooling the program to meet Teacher Quality requirements. Our first group of participants had very limited physical science or mathematics backgrounds. Many participants were master teachers within their own disciplines, but were uncomfortable with physical sciences. In essence, we were offering an introductory physics course for in-service teachers in a laboratory/discussion format. Our approach was to mix physics content with modeling of, and reflection on, sound pedagogical strategies. Laboratory equipment was the same used in the teaching of IPC by our partner school district for the grant.

Goals of the UT Dallas IPC Teacher Quality Program

Our program goals are a direct reflection of the Teacher Quality requirements through No Child Left Behind. We seek to (1) deepen the physics and physical chemistry content knowledge of teachers of physical science content who do not have a strong academic foundation in the subject; (2) provide teachers with a *usable* conceptually-based teaching tool kit to bring back to their own classrooms; (3) increase participant comfort level with, and interest in, physical science content and the teaching of

physical sciences, and most importantly; (4) impact the quality of physical science instruction for pre-college students, especially at high needs schools.

Mixing PER-Based Teaching and Teacher Quality Grants

We have employed a number of PER-based teaching tools and techniques in the UT Dallas IPC Teacher Quality Grant Program. Our program is a full year, similar to other programs for physics teachers [3], and is conceptually-focused and laboratory-based.



FIGURE 1. The UT Dallas IPC Teacher Quality program integrates small group laboratory experiences with class discussions of content and teaching strategies. Teachers are asked to complete laboratory exercises for their own learning and to evaluate them for use with their own students. Here participants conduct an investigation using CPO equipment adopted by partner schools.

The formal laboratory equipment used is from CPO [4] and is available to teachers in our partner school districts. Most other small group and individual explorations require inexpensive and readily available equipment. Many classroom activities used, including those from CPO, are education research based but not specifically PER-based. However, the program as a whole has been designed to reflect PER findings and methods. For example, small group and class discussions of concept tests, some drawn from *Peer Instruction* [5] as well as other sources are utilized, as is the *Force Concept Inventory* (FCI) [6]. Common pre-college students misconceptions are also addressed, as are classroom strategies for shaping conceptual understanding.

Creating a Teaching Tool Kit

We recognize that understanding content and scientific inquiry does not necessarily make one ready to teach it. Thus, a major goal of our program is to provide participants with a portfolio of classroom-

ready resources, activities, laboratory exercises, and demonstrations for use in their own teaching.

In each Summer Institute class and weekly 3-hour session during the academic year, we discuss teaching strategies for helping different learners understand physical science content. Addressing common student misconceptions and effective ways to present concepts in the pre-college classroom are integrated with teacher learning. More experienced physical science teachers are actively encouraged to share their knowledge, ideas, and resources with participants new to the teaching field or the subject.



FIGURE 2. A variety of other activities and demonstrations applicable to IPC instruction are used in addition to the CPO Supplemental Curriculum, including design contests for rockets and balloon racers, experiments with freefall, demonstrations in which students play an active role, and trips to local amusement parks and science museums.

Assessments

Multiple forms of assessments are an important part of our program. The Teacher Quality Grants require us to use pre-post tests, but do not provide us with specific tests to use. We have adopted the FCI for our summer program and have created a composite test drawn from the Texas high-stakes test given in grades 5, 10, and 11. (The newly developed test for grade 8 has not been released.)

In addition to testing, we use a variety of qualitative assessment methods including pre and post instructional journals given for each class meeting, take home quizzes, thought questions, and projects, classroom observations (in our own classroom and those of participants), and either a final instructional unit presentation or peer teaching of a pre-approved content-rich physical science lesson during a class session.

Many of the incoming teachers in our IPC Teacher Quality Program express concerns over their effectiveness in teaching physical sciences. We are utilizing a modified version of the *Science Teaching Efficacy Beliefs Instrument* (STEBI) [7] to establish a connection between learning and feelings of efficacy. Participants also use a reflective journal to explore

their own thoughts about what attributes, skills and knowledge define effective physical science teachers.

Class assignments, including journaling activities, and discussions serve as embedded assessments and are intended in part to provide data on which instruction in the program is subsequently modified. Extensive qualitative data as well as pre-post test results are reported to the THECB.

Evaluation - Are We Helping Teachers Become Highly Qualified?

Qualitative data based on journals, interviews, surveys, projects, and quizzes, as well as our classroom observations are overwhelmingly positive. Journals show clear gains in pre and post instructional content knowledge for most students, as well as increased awareness of classroom applications for specific topics. Participants frequently report that the course is impacting how and what they teach, and that for some the instruction is “just in time”. We know of at least one case in which the course enabled a participant to pass the state licensing exam for physical sciences, and several cases in which participation in the program has been a major contributor to achieving “highly qualified” status.

Our different assessments, however, combine to give us a mixed picture and suggest further modifications of the program may be necessary. Significant normalized gains (0.38 over the 2005 Summer Institute) have been measured for the pre-post test based on the state high-stakes testing, but similar gains have not been measured on the FCI. Possibilities for low gains on the FCI include our participant needs and teaching mandate (to prepare teachers of IPC rather than high school physics) and the compression of force and motion concepts into a 60+ contact hour 3-week institute rather than a full semester.

Our assessments reflect the challenges we face in tailoring our program for students of such varied science backgrounds and needs. Clearly a “one size fits all” approach would not serve the needs of participants. The wide range of participant interest and background is evident in reactions to pacing of the courses, the use of mathematics, specific activities, and the depth of content covered.

We have concerns that our pre-post tests, including the FCI, are not the proper choice for our program. One possibility for future pre-post tests is an instrument derived from the state physical science licensing exam. Other assessments we are utilizing are also non-standard and sometimes experimental, as in the case of pre-post instructional and reflective journals. We are in the process of standardizing

journal questions for the current program and changing how our assessments impact student grades.

INTEGRATING TEACHER QUALITY PROGRAMS WITH AN M.A.T

Since receiving our first Teacher Quality Grant, the Science Education Program has grown by more than 200%. Our rapid growth is a reversal of a trend that began when local school districts became unable to pay for teachers to earn graduate degrees. Even as the UT Dallas Science Education Program continues to grow, however, elective courses (such as astronomy) not providing tuition assistance are struggling to maintain minimum enrollment numbers. Neither astronomy nor Earth sciences are tested by the state in high school, and Teacher Quality grants for middle school teachers focus extensively on life and physical sciences. In 2004 we had three simultaneous Teacher Quality Grant programs, for IPC, 6th, 7th, and 8th grade teachers, each mandated to serve at least 20 participants. In general, students brought into the program by the grants preferentially enroll in other grant courses. Due to the requirements for Teacher Quality Grants, the makeup of the student population in the program has also changed. We are indeed contributing to the THECB goal of attracting students who might not otherwise consider pursuing a masters degree [8]. Our challenge is to shape master teachers while we simultaneously assist them in becoming “highly qualified” with regard to content knowledge.

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