A Review and Analysis of the NSF Portfolio in Regard to Research on Science Teacher Education

Robert D. Sherwood
Indiana University

Deborah L. Hanson
Hanover College

Some of this analysis was undertaken while the first author was a Program Director at the National Science Foundation. However, any opinions, findings, conclusions or recommendations expressed in this publication are those of the author and do not necessarily reflect the views of the National Science Foundation

Abstract

Several recent policy papers have called for science education to be based on substantive research activities that provide guidance for the field both in teacher preparation and student learning. For example, *America's Pressing Challenge – Building a Strong Foundation* (2006) calls for the country to "Invest in research on teaching and learning that will better inform development of science and mathematics curricula and pedagogical approaches." (p.5). In an attempt to understand what the National Science Foundation has supported in terms of research within science education teacher education a review was undertaken based upon the publicly available NSF Awards Database in regard to projects funded. The database for selected programs at NSF contained over 3000 awards for the time period January 1, 1996 to January 1, 2006 however the percentage of awards that were deemed to represent research studies in regard to science teacher education were a very small fraction of these awards (approximately 2.5%). The awards that were identified were categorized by research method, grade level and project focus. Selected awards were also reviewed to see if the results of the studies could be found in the science education literature. Implications for policy and the research community are discussed.

Correspondence should be addressed to Robert D. Sherwood (Email: rdsherwo@indiana.edu), School of Education, Indiana University Bloomington, IN 47405, or Deborah L. Hanson (Email: hanson@hanover.edu), Hanover College Hanover, IN 47243

Introduction

In the recently completed *Studying Teacher Education: The Report of the AERA Panel on Research and Teacher Education* (Cochran-Smith & Zeichner, 2005), the authors note that, "Again it is worth repeating that this dearth of larger and longer studies is the case, at least in part, because teacher education has rarely been a research priority for funding agencies or a focus of well-supported programmatic research." (p. 5). This

report and discussions within NSF undertaken by the senior author raised the question of whether research in science teacher education had been a significant part of the programs that NSF had supported in the late 1990's and early 2000's. Such programs as Teacher Preparation (NSF 99-96), Teacher Enhancement (NSF 99-92), Teacher Professional Continuum (NSF 05-580) and the Research on Learning in Education (NSF 02-023) program had been active during this time period. As will be shown in this paper, these programs had been funded with multiple millions of dollars. Had NSF funding gone to projects that had a research on science teacher education emphasis?

In considering the funding history of teacher education from NSF, a distinction needs to be made between funding for research on teacher education and funding for teacher education activities. As noted by Vanderputten (2004) NSF has had a long history of funding projects that have supported the teacher education in the science, technology, engineering, and mathematics (STEM) disciplines. As early as 1956, NSF was providing support for secondary school teachers to develop new knowledge and skills related to their teaching. These activities include presently funded projects with such programs as the current Mathematics Science Partnership program (MSP). Generally, these types of projects have been implementation projects that have funded individuals or groups of teachers in upgrading their skills within STEM content areas or developing their pedagogical knowledge. While recent projects (within the last ten years) have had requirements for evaluation studies attached to the projects, the evaluations have been limited to particular aspects of the project and have not, in general, produced a significant amount of new knowledge for the general STEM teacher education literature. It was determined that a review of the types of projects funded within the last ten years might be especially useful in developing an overall picture of the funding levels and general direction of funding.

Data Sources and Selection of Awards

Using the publicly available NSF Awards Database (http://www.nsf.gov/awardsearch) a search was made for all awards that had award start dates of January 1, 1996 until January 1, 2006 from the division of Research, Evaluation, and Communication (REC). A second search for all awards from the division of Elementary, Secondary, and Information Education (ESIE) was made for the same period. The third division that funds some STEM teacher education research is the Division of Undergraduate Education (DUE) and it was also searched. All of these divisions are part of the Education and Human Resources Directorate (EHR) of NSF. NSF divisions outside of the Education and Human Resources directorate do at times fund or co-fund projects that have some relationship to teacher education. If the project was co-funded by one of the divisions in EHR it appeared in the database. However, some limited independent funding does occur. For example, the Engineering Directorate has made a substantive commitment to Research Experiences for Teachers (RET) supplements to engineering research projects that have been previously been funded. In general, however, these projects have been of the "summer workshop" type activity which will conduct only a limited evaluation study of the particular funded activity.

These searches produced 774 awards for REC, 2283 awards for ESIE and 307 for DUE. The DUE search was restricted to programs where a possible relationship to teacher education would have been found including the Teacher Preparation program, Teacher Professional Continuum program, and Teacher Enhancement program. All of these divisions fund projects of a variety of natures and therefore a first review was made to determine which of the programs within the divisions would be appropriate to examine more closely for projects that had a direct bearing on STEM teacher education research.

For the REC dataset (774 awards, $599 million total funding), a search on the word "teacher" was conducted of both the title of the project and the abstract. This resulted in a reduced dataset of 273 awards. The abstract of each of these awards was reviewed, if present, to determine if the award could be considered a research study that involved teachers as the main subject of the study. This resulted in a subset of 107 awards meeting this initial criterion (13.8 % of the original data set). These 107 awards were reviewed to determine which of the awards were related to science teacher education versus other STEM areas or were focused on science and another STEM area. Awards, for the REC awards and the other divisions outlined below, were also checked to see if the PI transferred an award to a new institution, which generates a new award number but not a new project. This reduced the dataset further to 42 awards with total funding of $35.5 million (5.4 % of the original data set by number of awards and 5.9% by funds).

For ESIE the categorization of awards was somewhat more complicated due to the large number of awards. To facilitate review, the larger database was split into two five year periods, 1996 to 2001 and 2001 to 2006. The raw database for the 96-01 awards contained 1531 awards and represented $1.078 billion dollars and the 01-06 database represented 752 awards and $919 million dollars of awards. For the 96-01 database only those awards that were made in the Teacher Enhancement and Instructional Materials Development programs were considered for categorization. Searching first on the word "teacher", then "science" and then reviewing the resulting abstracts produced only three awards representing $1.94 million dollars that could be considered science teacher education research awards.

For the 01-06 awards period, more programs had been started therefore, and a wider search was conducted. Removed from consideration were the following programs; Instructional Technology Experiences for Students and Teachers (ITEST), and Informal Science Education (ISE). These programs do not fund projects with a research focus. This resulted in a reduced dataset of 399 awards representing $598 million in funding. The key words of teacher and science were then searched for in the abstract and title in this reduced dataset and resulted in 179 awards being found that met these criteria. The abstracts of these awards were then individually read to see if the award had a teacher education research focus. As previously noted, a large number of the awards in the ESIE reduced subset were for projects that were designed to enhance the professional development of teachers and, even with evaluation components; they were not considered to be studies of STEM teacher education. This resulted in 36 awards representing $33.28 million dollars

The DUE dataset of 307 awards, with a dollar amount of $154 million, was searched for projects related to science, which reduced the dataset to 154 awards. These abstracts were then read to determine if the project was a teacher education research related project. Only five awards met this criterion with awards totaling $4.44 million.

Given the relatively small number of awards found from the ESIE and DUE datasets, they were combined into a single set of 41 awards (1.6% of the total awards) and $37.72 million dollars (1.7% of the total dollars).

Proposal submitted to NSF are, by regulation, not public documents and are considered the property of the submitting organization and cannot be released. General information (Title, Organization, Dates, Principle Investigators, Funding Level and Abstract) on proposals funded must be made public but the actual proposals are not released by NSF. Abstracts are of a modest length (approximately one page) and generally provide the major objectives of the project and expected outcomes. Therefore, this study was restricted to only information that was publicly available from the NSF database.

Characterization of Reduced Datasets

ESIE and DUE Reduced Datasets

The awards found in the combination of ESIE and DUE reduced datasets (41 awards) could be characterized in a number of ways but a limited set of these was used for this analysis. First, the NSF program that funded the study was determined. All but ten of the studies were funded by the relatively new (2003) Teacher Professional Continuum (TPC) program, with five being funded by the Instructional Materials Development (IMD) program, four by the Teacher Enhancement (TE) program, and one by the Science, Engineering, Technology, and Mathematics Teacher program.

Project abstracts where reviewed for the research method and the grade level of the teachers involved in the study. Tables one and two show a summary of these characteristics.

Table 1
Categories of Method

Method	Number of Awards
Descriptive	19
Experimental	2
Quasi-experimental	12
Case Studies	4
Multiple Methods	4

Table 2
Grade Level of Teachers in Study

Grade Level	Number of Awards
Elementary	7
Middle	5
Secondary	12
Elementary & Middle	3
Middle & Secondary	5
Multiple Grades	8
Undetermined Grades	1

Two types of designs are the most prevalent in the studies. About half of the studies are descriptive in nature, examining an intervention of some type and reporting on the results of the intervention usually using a change in teacher ability as an outcome measure although some also used measures of student outcomes. Fourteen studies have quasi- or experimental designs where some type of comparison group is used. Smaller numbers of studies use case studies or were using multiple methods. The most common grade level of the teachers was secondary with other grades and combinations thereof somewhat evenly distributed below that level.

Perhaps of more interest is what the project was actually studying. Given that the TPC solicitation had as a category of study "Research on Models of Professional Development" it was not surprising that several studies had this as the focus. Table three shows the number of studies in various categories.

Table 3
Focus of Project in ESIE/DUE Reduced Dataset

Focus of Project	Number of Awards
Testing of a Professional Development Model (PDM)	16
Induction Programs	3
Professional Content Knowledge (PCK)	5
Teacher Portfolios	2
Use or Modification of Curriculum Materials by Teachers	4
Impacts of Technology on Professional Development or Teaching	3
Assessment Practices of Professional Programs	2
Development of Adaptive Expertise in Teachers	1
Amount of Teacher Turnover	2
How Teachers Sustain Reform in a Local System Change Project	1
The Nature of Science and Inquiry Orientation of New Teachers	1

The assignment of studies to these categories was difficult and the variation in what was being studied in the projects that were lumped under the "Testing of a Professional Development Model" includes projects that are working in a variety of settings. They include pre-service programs, in-service programs and studies at both levels. The professional development models vary greatly in their depth of the model, activities and outcome measures.

REC Reduced Dataset

The awards from the REC reduced dataset were classified in the ways that were described above for the ESIE/DUE dataset. In terms of NSF program, the great majority of studies were funded by the Research on Learning in Education (ROLE) program, 19. Eight awards were funded by the Program Evaluation program, three by the Educational Research program, one each for the Advance program and the Professional Opportunities for Women in Research program. Nine awards did not have data in that cell in the database.

Tables four and five provide summary of the method of the study and the grade level of the teachers.

Table 4
Categories of Method

Method	Number of Awards
Descriptive	20
Experimental	1
Quasi-Experimental	4
Case Studies	5
Survey	4
Instrument Development	3
Existing Databases	3
Multiple Methods	4

[1] Total does not add to total number of awards (42) due to some studies being in more than one category

Table 5
Grade Level of Teachers in Study

Grade Level	Number of Awards

Elementary	5
Middle	3
Secondary	4
Elementary & Middle	3
Middle & Secondary	2
Multiple Grade	23
Undetermined Grades	2

From the abstracts provided, most of the studies were of a descriptive nature that involved multiple grade levels although classification was somewhat more difficult than with the ESIE/DUE studies due to the more general nature of abstracts.

As with the ESIE/DUE reduced dataset the abstracts of the REC dataset were reviewed to determine the focus of the study. More categories were needed for this dataset and the results of this analysis are shown in Table 6.

Table 6
Focus of Project in REC Reduced Dataset

Focus of Project	Number of Awards
Study of a professional development model	6
Long term impact of systemic initiative	5
Studies of middle and secondary school teachers practice of teaching science	4
The design or study of teacher induction programs	3
Teachers' use of web-based instructional/knowledge environments	3
The use of video cases to assist in teacher professional development	3
The use of modeling by teachers as an approach to instruction	2
Analysis of teachers who are successful in both science and reading	2
Teachers understanding and use of inquiry-based science	2
Long term studies of how elementary teachers learn to teach science	2
The study of new models of teacher preparation	2
Evaluation of alternative routes to teacher certification	2
Studies of policies that effect hiring of teachers or their participation in professional development	2
National surveys of STEM teachers	2

Collection and analysis of the stories of Native American teachers-in-training	1
How to adapt and then study the process of Japanese lesson study	1

While the two datasets yielded somewhat different results in terms of the focus of the studies, there were some similarities. Both had a significant number of the studies related to the study of professional development models, which is consistent with the major thrust in that area in terms of NSF funding on professional development of STEM teachers. Prior to the start of the Teacher Professional Continuum program these awards, usually from the Math Science Partnership and or Teacher Enhancement programs, provided for the actual professional development activities and some evaluation. In depth study of the activities, however, were usually not part of the awards and principle investigators, evaluators, or faculty who were interested in their study had to apply through REC for research awards. In the REC dataset, as opposed to the ESIE/DUE dataset, there were a significant number of studies related to the systemic initiatives awards that had been funded during the late 1990's and early 2000's. As with the teacher professional development activities, these studies appear to be attempts to study in more depth the activities of particular projects with the objective of finding principles that could generalize to other school systems. In addition, the study of teacher induction programs appears in both lists as well indicating the interest in the field in these programs that have generally been introduced within the last ten years.

Impact of Awards on the Field

While fully connecting awards to papers that appear in the literature is a task that will take additional study for a full review, some examples do appear from the analysis. More examples are available from the REC dataset than the ESIE/DUE dataset owing to the fact that almost all of the research studies that have been awarded under ESIE/DUE are still underway. However, an on-going study from the first cohort of the TPC program has prepared a manuscript based upon first year results. Okhee Lee (NSF Award ESI - 0353331) and colleagues at the University of Miami (Lee, et al., in review a & b) have reported on the teachers' perspectives on teaching science to ELL students in the current testing environment in the State of Florida, as well as, student achievement results. While tentative, the first year results do show positive teacher response to the science activities of the project, as well as, increased student achievement.

In terms of the REC dataset seven examples from projects that have been completed can be connected to work funded, in part, by NSF.

Sasha Barab and colleague's work on web-based professional development communities (Barab, Makinster, & Scheckler, 2003) is one example of such a connection between a funded award (NSF Award ESI-9980081) and a published paper in the literature (Barab, MaKinster, & Scheckler, 2003). In their work with 5-12 grade mathematics and science teachers, they have provided some design principles for such environments as well has outlining some of the opportunities and challenges that such

environments afford for teachers. Of particular note is one finding from the paper, "Our research suggests that designing for virtual communities involves balancing and leveraging complex dualities from the "inside" rather than applying some set of design principles from the "outside." (p. 237). This provides an interesting commentary on the design process and the need to understand the community of users well if the system is going to be used effectively.

Tom Smith and collaborators (NSF Award ESI - 0231884) have studied multiple policy issues related to the professional development of science and mathematics teachers. Their work (Desimone, Smith & Rowley, in press), using a national sample from the Schools and Staffing Survey (SASS), provides insights into the relationship of policy factors such as; authority (teacher leadership and control over school and classroom policy), power (frequency of evaluation of teachers and professional development, and ease of dismissal of teachers), consistency (extent to which a policy is aligned with other policies in the same school, district, and state), stability (the extent to which policies and people remain a stable part of the policy landscape) and the types of professional development teachers choose to participate in. They conclude, "This analysis suggests that authority and stability may play more of a role than power or consistency in fostering teacher's participation in professional development that is focused on content, and has opportunities for interaction." (p. 11).

Gaining insight into teaching science within urban settings was researched by both Barry Fishman and colleagues (Marx, Blumenfeld, Krajcik, Fishman, Soloway, Geier and Tal, 2004) and Kenneth Tobin and Rowhea Elmesky (Elmesky & Tobin, 2005) under the auspices of NSF funding. Both research groups investigated effective strategies to promote science learning to these typically low achieving students in rather poor and unpredictable conditions. Fishman reported gains in student science understanding from their work with the Detroit Public Schools (REC-9876150) in urban systemic reform. In this three-year study, the research team concluded that low achieving students in an urban setting could succeed by implementing a carefully designed curriculum supported with teacher professional development. Middle-school (6-7-8th grades) students demonstrated yearly statistically significant gains using inquiry and technology-based units that related to the students' daily lives and embedded activities to build skills and background content knowledge (How Can I Build Big Things?, What Is the Quality of Air in My Community?, What Is the Water Like in My River?, and Why Do I Need to Wear a Helmet When I Ride My Bike?). All units were collaboratively designed initially by university facility then later incorporated suggestions and feedback by the teachers. This research demonstrates that through collaboration and through a specified multi-faceted program, even low achieving students can experience success in science.

Using a critical ethnographic lens, Elmesky and Tobin (2005) described insight gained while teaching science in an urban setting. The research team used students as researchers to provide insight into Tobin's teaching and to their culture. This methodology was successful as the students provided a deeper level understanding than was previously possible. The researchers discovered the value of respect (symbolic

capital) in the student-teacher relationship and recognized how valuable incorporating elements of their culture, giving the students a voice, were to that relationship. They also saw how the students' identities outside the classroom may influence their science learning. Many students felt alienated by the cultural differences and the idea that their cultural capital, knowledge and perspectives are not valued. Successful science teaching in this setting "recognizes, understands, and draws upon the resources of low-income and minority students" (p. 825) Based on their five-year research, Elmesky and Tobin recommend conscious efforts be made to connect practices from their culture into their science lessons.

In her work in the learning sciences, Sharon Derry and colleagues (Derry, 2006; Derry, Hmelo-Silver, Feltovich, Nagarajan, Chernobilsky, & Halfpap, 2005; Derry, Hmelo-Silver, Feltovich, Chernobilsky & Beitzel, in press) (REC #0107032) developed a unique online resource to assist teacher candidates in transferring conceptual content presented in teacher preparation courses to actual classroom practices. Their program, STELLAR, combined text-based instruction with video case studies, instructional activities, and online tools to allow the preservice teachers opportunities to engage in interactive problem based learning. This program was integrated into two teacher education courses at the University of Wisconsin and Rutgers with promising results. By analyzing authentic video cases, it appears that preservice teachers using the STELLAR program developed a deeper level of student understanding over comparable sections using traditional methods. Although the model is still being refined, this grant-based program represents a "pioneering step" in developing effective collaborative problem-based learning that may be capable of influencing future classroom practices.

Senta Raizen and Edward Britton used National Science Foundation funding to research various induction systems over a three-year period. Raizen and Britton, along with colleagues (Raizen, Paine, Pimm & Britton, 2003), shared their findings on comprehensive and successful teacher induction programs. Using many international models, they provided insight that into programs that support beginning science and math teachers in numerous modes of support. In this book, the authors provide a guide for beginning teacher induction programs with information ranging from whom it should serve, what should be included in such programs and the policies needed for it to become a reality.

The work of Betsy Davis (NSF Award ESI - 0092610) in collaboration with Joe Krajcik is a final example. Their article titled "Designing Educative Curriculum Materials to Promote Teacher Learning" (2005) notes that with careful design, and a full consideration of some of the principles of teacher development, curriculum materials that are designed for K-12 students can also provide teachers ways to improve their knowledge base. This combination of perspectives that involves a faculty member whose primary work involves teachers (Davis) and one whose work is primarily with K-12 students (Krajcik) has implications for educational research. The education of K-12 students has multiple aspects, curriculum, teachers, assessments, schools, policy, etc. If work can be undertaken that allows groups of researchers to cover multiple aspects of this arena, the impact of the work may be greatly enhanced. NSF has made some

commitment to this direction through the "Learning Progressions" (Smith, et al., 2006) solicitation that is part of the IMD 2005 solicitation (NSF 05-612) and DR-K12 (NSF 06-593).

Limitations and Conclusions

The analysis undertaken does have some significant limitations. The use of key word searches may have left out some studies that would have been appropriate to consider but did not happen to use the key words. One person did the categorization and the work was undertaken using only project abstracts, which are sometimes limited in their content. Also, the review did not take into consideration some types of awards such as the Centers for Teaching and Learning (CLT) projects, many of which have multiple research projects some of which may be teacher education research related, and the Math Science Partnership's Research, Evaluation and Technical Assistance (RETA) projects. Finally, documents funded by NSF such as NRC reports, e.g., *Educating Teachers of Science, Mathematics, and Technology: New Practices for the New Millennium* (NRC, 2001) do not appear in an awards analysis such as this.

The question of whether publication is the only indication of impact is also a concern within this study. Projects that have demonstrated a strong local or regional impact on teacher knowledge, skills, attitudes, etc. via an evaluation study must be considered to have been important for those teachers. While publication in referred journals is not the only measure of success of a project it generally results in wider knowledge disbursement than local evaluations. As Burkhardt and Schoenfield (2003) point out in their article on improving educational research;

> "Although good insight-focused research identifies problems and suggestions possibilities for progress, it does not itself generate reliable solutions that can be directly implemented on a large scale. To achieve that, research-based development and robust well-tested models of large-scale change are both essential." (p. 5)

Neither one of these two outcomes can be readily measured unless the information about the project reaches the field through publication.

Even considering these limitations, this analysis would indicate that the amount of support that NSF has put toward research in STEM teacher education has been relatively small compared to the amount of funding for STEM professional development projects and research on student learning. In the ten-year period of this analysis, only 83 awards out of a total of 3364 (2.5%) and $73.24 **million** out of $2.751 **billion** dollars (2.7%) met the criterion of having a project focus on science teacher education research. Based on some of the intermediate datasets, all of STEM teacher education research would probably only double the number of awards and dollars. This is not especially surprising given, as noted in the introduction, the relatively low support at the policy level for studying teacher education. Similar to the issues surrounding the general funding of educational research, policy makers have found it difficult to see major impacts from

research activities as compared to services directly to teachers or the support of the new curricula/materials for students. Part of the responsibility of research supporters such as NSF, as well as the educational research community, is to be able to answer policy makers concerns in this area and show the impact of funding decisions.

However, even with these very limited funds, several projects have been able to show results that have made their way into the peer reviewed literature. While a fuller analysis of the datasets is needed to confirm these examples, it does show some promise that impact can be shown and progress made in understanding the K-12 educational system.

In addition, recent STEM policy documents; *Rising Above the Gathering Storm: Energizing and Employing American for a Brighter Economic Future* (NRC, 2006), *American Competitiveness Initiative* (OSTP, 2006) and *America's Pressing Challenge - Building A Strong Foundation* (NSB, 2006) all call for increased and improved STEM teacher education, including some indication of the importance of research on learning as a priority. For example in the *American Competitiveness Initiative,* a "bullet" notes that the initiative is designed to; "Strengthen K-12 math and science education by enhancing our understanding of how students learn and applying that knowledge to train highly qualified teachers, develop effective curricular materials, and improve student learning." (p. 3). *America's Pressing Challenge* calls for the country to "Invest in research on teaching and learning that will better inform development of science and mathematics curricula and pedagogical approaches." (p. 5) Making these initiatives reality will take more than rhetoric. Significant long-term funding for research in STEM learning, including teacher education, is needed.

Acknowledgements: The authors gratefully acknowledge the work of Linda S. Sherwood for her assistance in database analysis and editorial efforts.

References

Barab, S., MaKinster, J. & Scheckler, R. (2003). Designing system dualities: Characterizing a web-supported professional development community. *The Information Society*, 19, pp. 237-256.

Burkhardt, H. & Schoenfield, A. (2003). Improving educational research: Toward a more useful, more influential, and better-funded enterprise. *Educational Researcher*, 32 (9), pp 3-14.

Cochran-Smith, M. & Zeichner, K. (Eds.)(2005). *Studying Teacher Education: The Report of the AERA Panel on Research and Teacher Education.* Mahwah, NJ: Lawrence Erlbaum Associates.

Davis, E. and Krajcik, J. (2005). Designing educative curriculum materials to promote teacher learning. *Educational Researcher*, 34 (3), pp. 3-14.

Derry, S. J., Hmelo-Silver, C. E., Feltovich, J., Nagarajan, A., Chernobilsky, E., & Halfpap, B. (2005). Making a mesh of it: A STELLAR approach to teacher professional development. Paper presented at the Proceedings of Computer Support for Collaborative Learning (CSCL) 2005, Taipei, Taiwan.

Derry, S. J., Hmelo-Silver, C. E., Nagarajan, A., Chernobilsky, E., & Beitzel, B. (in press). Cognitive transfer revisited: Can we exploit new media to solve old problems on a large scale? *Journal of Educational Computing Research*.

Derry, S. (2006). ESTEP as a case of theory-based web course design. In A. M. O'Donnell, C. E. Hmelo-Silver & G. Erkens (Eds.), Collaborative learning, reasoning and technology (pp. 171-196). Mahwah, NJ: Lawrence Erlbaum Associates.

Desimone, L. M., Smith, T. M. & Rowley, K. J. (in press). Does Policy Influence Mathematics and Science Teachers' Participation in Professional Development? *Teachers College Record.*

Elmesky, E. & Tobin, K. (2005). Expanding our understandings of urban science education by expanding the roles of students as researchers. *Journal of Research in Science Teaching, 42(7), 807-828.*

Fernandez, C. (2002). Learning from Japanese approaches to professional development: The case of lesson study. *Journal of Teacher Education, 53(5), 393-405.*

Lee, O., Carr-LeRoy, K., Thornton, C., Adamson, K., Maerten-Rivera, J., & Lewis, S. (in review a). Teachers' perspectives on a professional development intervention to improve science instruction among English language learners. *Journal of Science Teacher Education.*

Lee, O., Maerten-Rivera, J., Carr-LeRoy, K., Penfield, R. D., & Secada, W. (in review b) Science achievement of English language learners: Results of a first-year intervention in urban elementary schools. *Journal of Research in Science Teaching*.

Marx, R. W., Blumenfeld, P. C., Krajcik, J. S., Fishman, B., Soloway, E., Geier, R., & Tal, R. T. (2004). Inquiry-based science in the middle grades: Assessment of learning in urban systemic reform. *Journal of Research in Science Teaching*, 41(10), 1063-1080.

National Research Council (2006). *Rising Above the Gathering Storm: Energizing and Employing American for a Brighter Economic Future.* Committee on Science, Engineering and Public Policy. Washington, D.C.: National Academy Press. http://fermat.nap.edu/books/0309100399/html

National Research Council (2001). *Educating Teachers of Science, Mathematics, and Technology: New Practices for the new Millennium*. Committee on Science and Mathematics Teacher Preparation. Washington, D.C.: National Academy Press.

National Science Board (2006). *America's Pressing Challenge - Building a Strong Foundation*. (NSB 06-02). http://www.nsf.gov/statistics/nsb0602/

Officer of Science and Technology Policy, (2006). *American Competitiveness Initiative*. Domestic Policy Council. http://www.ostp.gov/html/ACIBooklet.pdf

Raizen, S. A., Paine, L., Pimm, D. & Britton, E. D. (2003). *Comprehensive Teacher Induction: Systems for Early Career Learning*. Springer.

Smith, C., Wiser, M., Anderson, C., & Krajcik, J. (2006). Implications of research on children's learning for standards and assessment: A proposed learning progression for matter and atomic molecular theory. *Measurement: Interdisciplinary Research and Perspective*, 4 (1&2), 1-98.

Vanderputten, E. (2004, April). Knowledge *about what works for teachers: Why is it rarely used?* Paper presented at the Annual Meeting of the American Educational Research Association, Montreal, Canada.

Appendix A

ESIE and DUE Awards

Award Number	Award Title	Principal Investigator
ESIE Dataset		
0455819	Investigating the Meaningfulness of Preservice Programs Across the Continuum of Teaching (IMPPACT) in Science Education	Tillotson, John
0455637	Entering the Guild: The Effects of Teacher Professional Community and Professional Development on New Teachers and Their Students	Shore, Linda

0098406	Exploring Potential Research Uses of Connecticut's Beginning Teacher Portfolios in Mathematics and Science -- A Small Grant for Exploratory Research	Britton, Edward
9553548	Investigating the Implementation of a Classroom-based Assessment System: The Case of SEPUP	Wilson, Mark
0455811	Professional Development Threading Content, Pedagogy and Curriculum: A Study of Classroom Impact	Singer, Jonathan
0083276	SGER: Exploring the Portfolios of National Board of Professional Teaching Standards (NBPTS) Candidates in Middle School Mathematics and Science	Baxter, Gail
0353451	Project MAESTRo: Measuring Adaptive Expertise in Science Teachers' Reasoning	Crawford, Valerie
0353440	Mentoring and Induction Support for Urban Secondary Science and Mathematics Teachers	Radford, David
0455711	What Influences Teachers' Modifications of Curriculum?	Hammer, David
0455679	Policy Research Initiatives in Science Education (PRISE) to Improve Teaching and Learning in High School Science	Stuessy, Carol
0455744	The Organizational Sources of Mathematics and Science Teacher Turnover	Ingersoll, Richard
0003857	Research-based Science Curricula: Developing Methods to Determine How They are Used in High School Classrooms -- A Small Grant for Exploratory Research	Miller, Jacqueline
0545445	Effects of Content-focused and Practice-based Professional Development Models on Teacher Knowledge, Classroom Practice and Student Learning in Science	Shinohara, Mayumi
0455685	Change Associated with Readiness, Education and Efficacy in Reform Science (CAREERS)	Young, Betty
0455582	The Impact of Online Professional Development: An Experimental Study of Professional Development Modalities Linked to Curriculum	Fishman, Barry
0455735	Research on the Effectiveness of the Observing for Evidence of Learning Professional Development Model for Improving Grades 6-8 Science Instruction	Hood, Leroy
0353377	The Professional Learning Community Model for Alternative Pathways in Teaching Science and Mathematics (PLC-MAP)	Herbert, Bruce
0455846	Project BEST: Better Education for Science Teachers	Powell, Janet Carlson

0353406	Problem-based Learning Designed for Science and Mathematics Professional Development	Eberhardt, Jan
0003895	Sustainable Reform In Science Education -- A Small Grant for Exploratory Research	Kozaitis, Kathryn
0455359	Project TEACH - CWU: Targeted Science Instruction for Future Teachers	Filson, Robert
0455573	Developing Inquiry-based Instruction Skills	Adams, April
0455786	Temple University Science Math Assessment Research for Teachers: TU-SMART	Jansen Varnum, Susan
0550847	Exploring the Development of Beginning Secondary Science Teachers in Various Induction Programs	Luft, Julie
0455877	Mentored and Online Development of Educational Leaders for Science (MODELS)	Linn, Marcia
0538974	Effects of a Coach-focused Professional Learning Model on Lesson Development, Lesson Delivery and Student Learning, Achievement and Performance	Stowell, Scott
0455752	Project NEXUS: The Maryland Upper Elementary/Middle School Science Teacher Professional Continuum Model	McGinnis, James
0455781	Development of K-8 Teachers' Knowledge and the Transition from University Student to Professional	Allen, Deborah
0456124	Teacher Learning of Technology-enhanced Formative Assessment	Leonard, William
9731282	Primary Science Documentation: Strategies and Materials	Jones, Jacqueline
0455866	Strategic Integration of Mathematics and Science	Baxter, Juliet
0455795	Researching the Wireless High School: Effects on Science Teaching and Implications for Professional Development	Drayton, Brian
0455749	Low Science and Math Teacher Retention: Causes, Consequences, and How Some Urban Middle and High Schools Are Making Progress	Levy, Abigail Jurist
0455710	Lesson Study for Successful Science Teaching: Creating Science-specific Accommodations for Students with Learning Disabilities?	Mutch-Jones, Karen
0353331	Promoting Science Among English Language Learners (P-SELL) within a High-stakes Testing Policy Context	Lee, Okhee
0435727	Applied Research on Implementing Diagnostic Instructional Tools	Minstrell, James
Total Funding for ESIE Awards		$33,275,982

DUE Dataset		
9727648	A Model for Physics Education in Physics Departments: Improving the Teaching of Physics from Elementary through Graduate School	McDermott, Lillian
0088840	Development of Research-Based Curriculum to Improve Student Learning in Physics	McDermott, Lillian
0302119	Induction and Mentoring in a Middle Grades Science and Mathematics Accelerated Teacher Preparation Program	Mitchener, Carole
0119078	A Follow-up Summative Evaluation of the New York City Collaborative for Excellence in Teacher Preparation	Flugman, Bert
0427570	Use of Research to Improve the Quality of Science Education in Urban High Schools	Tobin, Kenneth
Total Funding for DUE Awards		$4,442,713
Total Funding for ESIE and DUE Awards		$37,718,695

Appendix B

REC Awards

Award Number	Award Title	Principal Investigator
9973004	Modeling Nature: A Route to Understanding Central Themes in Elementary and Middle School Science	Abbeduto, Leonard
0128062	Supporting Teachers and Encouraging Lifelong Learning: A Web-Based Integrated Science Environment (WISE)	Linn, Marcia
0237922	CAREER: Teaching Elementary School Science as Argument (TESSA)	Zembal-Saul, Carla
0089222	Looking Inside the Black Box: Classroom Practice that Supports High Achievement in Both Science and Reading: A Planning Grant	Century, Jeanne Rose
0238129	CAREER: Comprehension Strategy Support in Inquiry-based Science	Bannan-Ritland, Brenda
0092610	PECASE: Making a Case for New Elementary Science Teachers	Davis, Elizabeth
9903328	Pathways to Teaching Science for Understanding in Diverse Schools: Merging Inquiry-Based Science and Sociocultural Constructivism with Multicultural Education	Brown, Susan
9876150	CAREER: Teacher Knowledge, Beliefs, & Technology: Constructing Models of Change in Systemic Reform	Fishman, Barry

0087560	Beginning Science Teachers in Action: Investigating Mis/Connections Between Preservice Content and Classroom Instruction	Bianchini, Julie
0107022	ROEL: Teaching and Learning of Science in Urban High Schools	Tobin, Kenneth
9733700	Science Teaching and Learning in Economically Disadvantaged Urban Areas.	Barton, Angela
9970830	Teacher Leadership for Systemic Reform	Miller, Barbara
9815931	A Longitudinal Study of a Teacher Enhancement Project	Hynes, Michael
9804929	The Inquiry-based Classroom in Context: Bridging the Gap Between Teachers' Practice and Policy Mandates	Drayton, Brian
0000976	SGER--Identifying and Understanding the Effects of SMET Education Undergraduate Reform on K-16 Teachers	Feldman, Allan
9909475	Learning from Lesson Study, A Japanese Approach to Developing Teaching Skills and Innovations	Fernandez, Clea
9980081	KDI: The Internet Learning Forum: Fostering and Sustaining Knowledge Networking to Support A Community of Science and Mathematics Teachers	Barab, Sasha
0089247	Professional Development Support Systems for Mathematics and Science Teaching	Gitomer, Drew
0133900	CAREER: Understanding the Role of Video in Teacher Learning	Sherin, Miriam
0231808	Understanding and Fostering Model Based Learning In Science	Clement, John
0087562	Experimental Design to Measure Effects of Assisting Teachers in Using Data on Enacted Curriculum to Improve Effectiveness of Instruction in Mathematics and Science Education	Blank, Rolf
0438359	Improving Evaluation of Professional Development with Mathematics and Science Teachers through Developing Research-based Measures of Quality with States and School Districts	Blank, Rolf
0115716	IERI/REC: Planning an Infrastructure to Support Ambitious Science for Urban School Children	Gomez, Louis
0228158	Phase-I Study of the Effects of Professional Development and Long-term Support on Curriculum Implementation and Scaling Up	Brandon, Paul
0335523	Alternate Routes to Teacher Certification in Missouri:	Scribner, Jay
9714189	Evaluating the Long Term Effects of Teacher Enhancement	Lawrenz, Frances

9804925	Systemic Reform, Mathematics and Science Education, and Equity In New Jersey	Firestone, William
9602137	Bridging the Gap: Equity in Systemic Reform	Meece, Judith
0310721	Making Visible the Science in Science Teaching: Using TIMSS-R Conceptual and Video Tools to Support Teachers' Inquiries of Science Teaching, Content, and Student Learning	Roth, Kathleen
0238385	PECASE: Bridging the Gap Between Theory and Practice in Teacher Education: Guided Interactive Virtual Environments (GIVEs) for Case-Based Learning	Moreno, Roxana
0107032	ROLE: Video Cases Online: Cognitive Studies of Preservice Teacher Learning	Derry, Sharon
0089271	Promoting Active Reading Strategies to Improve Students' Understanding of Science	McNamara, Danielle
0118355	Evaluating Quality of Teachers and Teaching in Science and Mathematics Education: Use of Surveys and Data Systems to Evaluate Quality of Preparation, Development & Practices	Blank, Rolf
9980458	Going to Scale with High Quality Instructional Practice: Exploring Strategies in New Jersey's SSI	Firestone, William
9814246	1999 National Survey of Science and Mathematics Education	Weiss, Iris
0337061	Examining Teacher Preparation: Does the Pathway Make a Difference?	Wyckoff, James
0137730	ADVANCE Fellows Award: Implementing Inquiry Pedagogy in Elementary and Middle School Science Classrooms	Cartier, Jennifer
0207623	Research-Based Design Framework for Mathematics and Science Teacher Induction	Britton, Edward
0075011	POWRE: A Narrative: Science Stories by Native American Teachers-In-Training	Ollerenshaw, Jo Anne
9814803	Middle Grades Mathematics and Science Teacher Induction in Selected Countries	Raizen, Senta
0107014	ROLE: Empirical Research on Critical Issues in Recruiting and Retaining the Mathematics and Science Teaching Workforce	Burke, Daniel
0231884	Teacher Professional Development in Mathematics and Science: Do the Policies Add Up?	Smith, Thomas
Total Funding for REC Awards		$35,517,772