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Integrating Technology With Meaningful Content and Faculty Research: The UTeach Natural Sciences Program

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> But there are a few dozen universities like UT–Austin for which research is a mission of equal importance to teaching. I'm not just talking about scientific or engineering research–a research university is a place where you have people producing new ideas about the sonnets of Shakespeare or the Constitution of the United States or how businesses are organized. No one gets on the faculty at a research university just to teach. The research and teaching missions don't conflict; they reinforce each other.
>
> – Steven Weinberg, Nobel Laureate

The words of Dr. Weinberg resonate with particular clarity when thinking of the challenges facing teacher educators at research universities at the start of a new century. With calls for a "research based" approach to education (Lyon, 1997; No Child Left Behind Act of 2001) and a reexamination of the merits of scientific research in education and the social sciences (Flyvbjerg, 2001; Jacob & White, 2002; National Research Council [NRC], 2002; Strauss, 2001), this is certainly an exciting time to be involved in the education of this country's next generation of secondary mathematics and science teachers. The challenges facing a research university are especially unique in such a climate, since answers to the many questions and criticisms of how educators learn and teach most effectively come from just such an institution. Faculty members at universities like The University of Texas at Austin, therefore, have two charges: to teach the next generation of teachers with the latest understanding from the science of learning and instruction and to conduct and to provide to the academic community their own research on how people best learn.

This article presents a description of how one research university, The University of Texas at Austin, has approached secondary mathematics and science teacher education. Through a unique and joint effort between the College of Natural Sciences and the College of Education, as well as an integrated plan for the incorporation of content, pedagogy, equity, and technology, The University of Texas at Austin's UTeach Natural Sciences program is fast becoming a national model of cooperation between colleges at a university, as well as a model for effective technology integration and research in teacher preparation.

First, the unique circumstances which collaborated to create the UTeach Natural Sciences program will be described. New legislation by the State of Texas; new initiatives from the deans of the College of Natural Sciences and the College of Education; and interested, committed faculty and master teachers all converged. Next, some aspects of the UTeach Natural Science student population and characteristics will be described. This will be followed by a description of the UTeach curriculum and course sequence, with a special emphasis on multiple entry points for university undergraduates interested in the teaching profession. With the background set, we will then examine what each college has done to facilitate and to support technology integration in UTeach courses. Finally, three courses will be introduced, by which we intend to show how meaningful content in mathematics and science education is woven with technology integration and faculty research expertise to create a unique opportunity for UTeach students.

HISTORY

Shortages of qualified teachers have been a central concern in the United States for some time (Ingersoll, 1999). Reacting to warnings about the decaying state of secondary education in *A Nation at Risk* and other widely circulated reports, the Texas Senate tried to remove primary responsibility for secondary education from Colleges of Education. Senate Bill 994 in 1987 was an especially aggressive response. Since the passage of Senate Bill 994, secondary teachers must obtain their degrees in the specific subject they want to teach (e.g., mathematics, chemistry, biology, English). Prospective teachers, by law, are not required to take more than 18 hours of courses from the College of Education, including 6 hours of student teaching.

Beginning in 1997, in partial response to Senate Bill 994, The University of Texas at Austin began an effort to initiate continual and systematic change in the manner in which mathematics and science majors were being prepared for careers as secondary school teachers. To help facilitate this process, The University of Texas at Austin's College of Natural Sciences brought together a group of experienced secondary school teachers and administrators to design an innovative teacher preparation program. Entitled UTeach Natural Sciences, the program was based on national standards, educational research, and the program designers' years of experience in the K-12 setting. As a hallmark of this approach, the College of Natural Sciences continues to employ several of the most exceptional high school mathematics and science teachers in the state of Texas to lead the introductory courses (STEP 1 and STEP 2) and to coordinate a range of ongoing field-based experiences. In order to reinforce the value of such a career choice for students, the College of Natural Sciences made a commitment that it has kept to this day to pay the tuition for these introductory STEP courses.

Concurrently, The University of Texas at Austin's College of Education was independently in the process of a major commitment to rebuild and to strengthen the college's program in secondary mathematics and science education. The faculty, with the full support and encouragement of the College of Education's administration, decided to completely revise the professional development courses. New faculty lines were created specifically for recruitment and design of these courses, as well as to commit faculty energies to this evolving program. Because the program is restricted by state law to 18 professional development hours, careful consideration was given to the content, field experiences, and technology competencies of each course in the certification sequence. A three-course sequence (Knowing and Learning, Classroom Interactions, and Project-Based Instruction) was developed that builds on research on student learning, the examination of standards-based curricula, the study of effective classroom interactions, and the development of models of teaching. A unique aspect of this sequence is that issues of technology use and effective approaches to equitable participation are embedded in all aspects of the sequence (as well as the entire UTeach program of study), rather than being addressed in stand-alone courses. Most importantly, the mathematics and science education faculty prioritized placing students in urban schools, where students would learn firsthand of the needs, challenges and opportunities involved in urban education.

COORDINATION OF EFFORTS BETWEEN COLLEGES OF EDUCATION AND NATURAL SCIENCES

In a short time it was decided that the College of Natural Sciences and the College of Education should coordinate their activities, and the initial seeds of the unique collaboration known as the UTeach Natural Sciences program were sown. Faculty members of both colleges continue to work closely. One fruit of this collaboration is the generation of a new set of domain courses for the UTeach Natural Science program. Domain courses (see http://www.uteach.utexas.edu/technology/domaincourses.html) integrate mastery of subject matter with inquiry-based methods and the use of modern technology for scientific discovery. These courses (Functions and Modeling, Geometry and Visualization, and Molecular Biology) are specifically designed for mathematics and science teachers and are required for those students in the UTeach Natural Sciences program. They provide an opportunity for students to explore the mathematical content behind the secondary curriculum in considerable depth. The courses model exemplary classroom practices and focus on not only what is being taught but also why and how it is being taught (as recommended in Schulman, 1987).

Another example of collaboration between the colleges has been the development and implementation of International Society for Technology in Education (ISTE) National Educational Technology Standards for Teachers (NETS*T) technology benchmarks (ISTE, 2000) that have been integrated throughout the UTeach Natural Sciences program. A potential disadvantage of integrating technology into courses is that it is easy for competencies to fall by the wayside. To alleviate this possibility, UTeach has undergone an iterative curriculum-mapping process and has collected data from faculty and students on technology usage in their classes and in the field.

As early as the fall 1999 semester, faculty members examined UTeach curricula and developed an initial set of UTeach technology benchmarks. We soon found the ISTE NETS*T benchmarks to be a superior model to the proposed in-house benchmarks. The two colleges then surveyed UTeach professors about their course technology goals and ultimately generated a preliminary curriculum map that correlated the NETS*T with the stated course goals. This initial map was revised in spring 2000 and again after the release of the third version of NETS*T during fall 2000. Both the UTeach program evaluation team and the UTeach faculty have continued to revise UTeach curricula to better reflect the NETS*T. This is, and will continue to be, an ongoing iterative process of program evaluation and revision (see http://www.uteach.utexas.edu/technology/techmap.html).

STUDENTS

UTeach Natural Sciences students are chosen from a large pool of talented and academically successful applicants from the College of Natural Sciences. These students are selected based upon their academic performance and an expressed desire to pursue a career path in mathematics or science education. UTeach Natural Sciences students have high SAT scores and consistently earn higher than average grades (3.05) in comparison to their College of Natural Science undergraduate peer group (2.90) or the average student at the university (3.00). Furthermore, UTeach students represent each of the major teaching areas, including chemistry, biology, physics, geological sciences and computer science. Nearly one half of the program participants are mathematics majors. Approximately one third of the UTeach students are traditionally underrepresented minorities—twice as many as in the overall University of Texas at Austin undergraduate population. For much more information on UTeach Natural Sciences student characteristics, see www.uteach.utexas.edu/uteach/pdf/studcharacrpt.pdf.

CURRICULUM

In accord with national guidelines for teacher preparation (e.g., Conference Board of the Mathematical Sciences, 2001), UTeach Natural Sciences students begin supervised classroom teaching in Austin public school classrooms during their first semester in the program. Working with mentor teachers, UTeach students are encouraged and supported to discover as early as their freshman year whether they are truly interested in teaching as a career and vocation. With little exception, these classroom experiences are uniformly exciting and positive and raise the level of a students' commitment to the teaching profession. Field-based experiences take place primarily in urban schools with high-minority, low-socioeconomic high school student populations. These experiences introduce the UTeach students to the rewards and challenges of teaching in an underserved setting and to witness firsthand the real differences that well-educated, properly trained and motivated teachers can make in the lives of high school students on a daily basis.

As students transition into their professional education sequence of courses (see Appendix A), they learn the pedagogical significance of understanding the cognitive, affective, and social dimensions of teaching and learning mathematical and scientific ideas. In the course Knowing and Learning, they conduct interviews and reflect on and analyze video-based excerpts from real classes. In Classroom Interaction, they engage in model teaching both as direct instruction (see Schwartz & Bransford, 1998) and in small groups. Their experience culminates in preparation and design of an innovative technology-enhanced, project-based unit (see Krajcik, Czerniak, & Berger, 2002) and an intensive student-teaching experience.

MULTIPLE ENTRY POINTS

A distinctive feature of the UTeach Natural Sciences program is its ability to attract students at different stages in their academic careers and to provide them with an accessible means of deciding whether or not they wish to pursue a career in education. The UTeach Natural Sciences program of study is designed to be flexible to accommodate diverse student schedules. Normally, students need at least three semesters to complete the entire program. A cohort model is utilized. For instance, students who enter STEP 1 (the introductory, one-credit, field-based course) together tend to form a cohort group that is sustained throughout their time at The University of Texas at Austin, leading to the conscious formation and development of meaningful collegial and professional relationships (see Figure 1).

Freshman Year Entry (8 semesters):

Semester	1	2	3	4
Class	STEP 1	STEP 2	Knowing & Learning	Classroom Interactions

Semester	5	6	7	8
Class	Perspectives	Research Methods	Proj. Based Instruction	Student Teaching

Sophomore Year Entry (6 semesters):

Semester	1	2	3	4
Class			STEP 1	STEP 2

Semester	5	6	7	8
Class	Knowing & Learning Perspectives	Classroom Interactions Research Methods	Proj. Based Instruction	Student Teaching

Junior Year Entry (4 semesters):

Semester	1	2	3	4
Class				

Semester	5	6	7	8
Class	STEP 1 Knowing & Learning	STEP 2 Classroom Interactions Research Methods	Perspectives Proj. Based Instruction	Student Teaching

Figure 1. UTeach Natural Sciences' numerous flexible entry points.

The first cohort of 28 UTeach Natural Science students were selected in the fall of 1997. By the spring of 2003, UTeach enrollment had grown to more than 360 students. Retention rates for UTeach students have surpassed the retention rates of their undergraduate College of Natural Sciences peer group (see Appendix B). This success is attributable to a number of factors, including a cohort approach that fosters close, interdependent relationships among participating students; pervasive field experiences; and guidance from nationally recognized faculty and master teachers. UTeach Natural Sciences is expected to grow to approximately 400 students and to graduate 60 to 80 new secondary mathematics and science teachers each year. According to available numbers, the UTeach Natural Sciences program at The University of Texas at Austin is already the largest program for secondary science and mathematics certification at any major research university in the United States. In fact, only around 1,000 math and science majors from all the U.S. research universities put together have been obtaining secondary certification each year. UTeach will be adding 10% to the national total (Marder & Confrey, 2000).

FACILITATION OF TECHNOLOGY

College Supported: College of Natural Sciences

To facilitate technology integration into UTeach courses, the College of Natural Sciences has purchased hardware and software for UTeach classrooms, in addition to laptops and peripherals for student use in the field. Additionally, space has been renovated for a UTeach student workroom funded by the Southwestern Bell corporation. This workroom has multimedia editing capabilities, a training area with Internet ports for laptop access, PDA Ethernet synching and recharging cradles, and printing and projection systems. To ensure that field experiences match our expectations for technology integration, e-mail accounts for cooperating teachers are provided free of charge. We regularly utilize a portable networked cart with 30 laptops and probes for use at one of our field sites. Grants also provided 10 laptops for the science and math teachers and four laptops for preservice teacher use, as well as training for our master and cooperating teachers.

The College of Natural Sciences’ commitment to preparing excellent mathematics and science teachers also extends into their content courses. Future mathematics and science teachers must experience effective teaching that emphasizes the NETS*T in their undergraduate mathematics and science classes if they are to implement these strategies effectively at the secondary level. The college has renovated lecture halls with multimedia capabilities and class talk systems. The college has showcased effective use of instructional technology through teacher assistant training sessions, faculty luncheon demonstrations, and an annual teaching strategy conference. Currently, UTeach students are serving as a pilot group for a new series of courses that emphasizes effective use of technology. The first of these courses, an inquiry molecular biology lab, is planned for spring 2003.

The College of Natural Sciences' commitment to UTeach is best indicated by the considerable resources being expended to make it a success. The college has provided office and classroom space for personnel involved with UTeach and full-time administrative support. The UTeach co-director and assistant director have been provided with teaching relief to permit them to oversee the growth of UTeach. The college has employed five full-time master teachers, a full-time student advisor, and a program evaluator. Tuition refunds are made to students for their first two UTeach courses, STEP I and STEP II. Beginning with a multimillion dollar donation, we have established an endowment for UTeach to ensure its future funding. Currently, our college is working with donors to provide induction support for our alumni.

College Supported: College of Education

In order to facilitate technology integration into the UTeach experience, the College of Education has received outside funding for professional training and hardware and software purchases for the UTeach program. For instance, through Project INSITE (Inventing New Strategies for Integrating Technology into Education), a Preparing Tomorrow's Teachers for Technology (PT^3) grant from the Department of Education, the College of Education has received over $800,000 for the training of mentor teachers from the Austin Independent School District to help facilitate effective utilization of technology into secondary mathematics and science classrooms throughout Austin. In this way, Project INSITE is building capacity for classrooms using technology effectively and consistent with the college's pedagogical courses, for a meaningful teaching experience for our UTeach students. Since 2001, 45 Austin-area teachers have been provided with laptop computers, a Palm personal digital assistant (PDA), and a projection system, along with 6 days of professional training. The College of Education is expecting an additional cohort this coming academic year with the same resources.

To help students gain competency in employing technology in their content instruction and to support faculty research on effective technology usage, a fully equipped technology classroom and learning laboratory has been dedicated specifically to the UTeach program. This classroom was made possible primarily by a grant from the Intel Foundation, as well as through Project INSITE support.

In addition, since they contribute to student activity fees for the College of Education via tuition, UTeach students have full use of the College of Education's Learning Technology Center (LTC). The LTC provides timely and effective computing and media services to the faculty and students of the College of Education, assists the faculty and students of the College of Education in the production and use of instructional materials using a wide variety of media and technologies, and provides support and development for research programs in the use of technology in educational settings. The LTC has been especially helpful in the Project-Based Instruction and Knowing and Learning classes in the UTeach program.

The College of Education has recently received a grant from the National Science Foundation to establish a close collaboration between participants in the Austin Independent School District, UTeach, and the National Science Foundation (NSF) VaNTH Engineering Research Center (ERC) of Bioengineering Educational Technologies (VaNTH is an ERC involving Vanderbilt University, Northwestern University, The University of Texas at Austin, and the Harvard-MIT Health Sciences and Technology Program). The goals of this grant are to enlist mathematics and science teachers to help design and evaluate instructional materials that use science content as anchors and challenges (Cognition and Technology Group at Vanderbilt [CTGV], 1992) for the teaching of science and mathematics fundamentals at various levels in K-12 education. The UTeach students involved in Knowing and Learning will be especially involved in this new initiative.

To further emphasize the commitment to effective integration of technology in teacher education, the College of Education has recently completed the final details for implementation of a new laptop initiative. Beginning in the fall 2002 semester, UT Austin students engaged in the final phase of teacher preparation professional certification programs are required to have a laptop computer conforming to prescribed hardware and software specifications. Laptop computers will be required for use in most professional development courses and field experiences, will facilitate innovative instructional technology integration in public school teaching, and will equip graduates for teaching in Texas classrooms for the future.

PUTTING IT ALL TOGETHER: THE RECIPROCAL NATURE OF FACULTY RESEARCH AND TEACHING MEANINGFUL CONTENT WITH TECHNOLOGY

In this section three cases will be described in which faculty research is coupled with teaching in the content areas with technology. In each example, the course was designed by full-time faculty members whose research interests lie in the intersection of meaningful learning within the content area of mathematics and science education utilizing technology.

Classroom Interactions

An excellent example of the reciprocal nature of research and teaching can be found in the Classroom Interactions section of Dr. Jill Marshall. Dr. Marshall is a recent hire to the College of Education, and her academic line was funded by a provost's initiative specifically designed to bring national-caliber faculty who have a commitment to both research and teaching to the UTeach Natural Sciences program. The curriculum of the Classroom Interactions section that she teaches is not only informed by research in the learning and teaching of science; the class itself serves as an active research site, particularly for investigations in preservice teachers' conceptions in physical science (Marshall, 2001). The evolution of student understanding is characterized not only by the instructor as a researcher, but also by the students themselves in self-reflection, as they re-engage in science activities at a deeper conceptual level (Marshall, 2002a). In one study, for example, *Interactive Physics*™ was employed to investigate student understanding of conservation of momentum and the effect of technology (simulations) on the learning process (Marshall, 2002b).

Knowing and Learning

In Knowing and Learning, students are introduced to the foundations of how people learn and how this impacts instruction. Recent National Academy of Sciences publications are used as primary source books (NRC, 1999, 2001) and a novice-to-expert paradigm is emphasized (Goldman, Petrosino, & CTGV, 1999). As in other classes, technology is fully integrated in the forms of simulations, modeling, concept mapping, and the use of PDAs (Petrosino, Slaughter, Vath, & Tothero, 2003; see Figure 2). In addition, UTeach students are shown effective ways to incorporate hands-on instruction and data gathering into their teaching (Petrosino, 1998), as well as meaningful ways for secondary students to analyze data once it is collected (Petrosino, Lehrer, & Schauble, 2003).

Figure 2. Students beaming data to each other in their Knowing and Learning course.

Students are also exposed to new research on how the learning sciences are being utilized in the area of postsecondary education (see Figure 3). While this may not seem like a perfect fit upon initial reading, one must realize that most of the work conducted in the area of project-based, case-based, and problem-based instruction incorporating technology was initiated in middle and secondary schools. The importance of such research emerges quickly. UTeach students see firsthand how the very instructional pedagogies they are learning in their sequence of courses is being used across prestigious universities like Vanderbilt, Northwestern University, Harvard/MIT School of Health Sciences and The University of Texas at Austin, as part of the NSF-funded VaNTH ERC project (see http://www.vanth.org/; also Petrosino & Pandy, 2001).

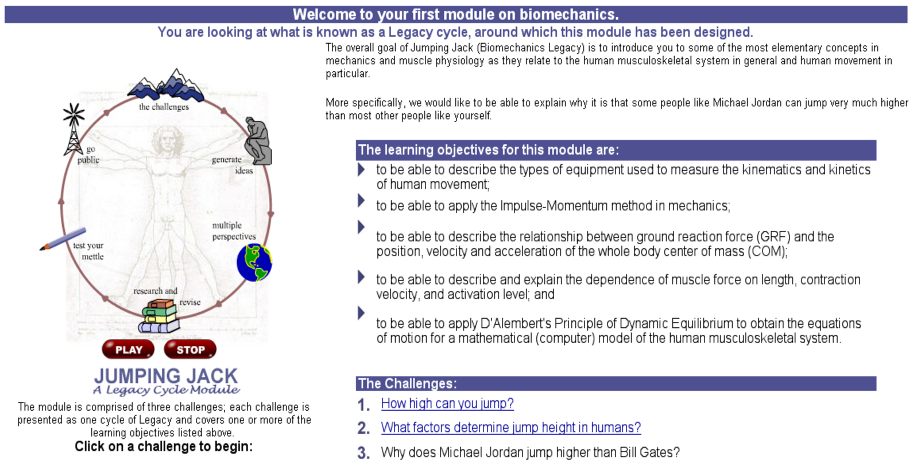

Figure 3. Integration of technology with meaningful learning principles using the VaNTH Legacy Cycle. Available at http://www.telecampus.utsystem.edu/vanth/

Project-Based Instruction

In project-based instruction (PBI), students use a wide variety of software to develop project-based curricular units that are infused with technology. Software includes Web-authoring, video-editing, concept-map, and modeling applications. Units produced by students are posted to the Web and pressed onto a class CD so that students have access to a library of projects (see http://www.uteach.utexas.edu/technology/corecourses.html). Project-based instruction students are also required to spend 24 hours in the field working with secondary students in a project-based environment. Most PBI students satisfy this requirement through a 4-day field trip to the Gulf coast of Texas. Our students plan and implement the 4-day trip with local high school students. Where appropriate, PBI students incorporate technology in their lessons.

A major hurdle in creating project-based curricula is that the process requires simultaneous changes in curriculum, instruction, and assessment practices—changes that are often foreign to the students as well as to the teachers. In Uteach, PBI students develop an approach to designing, implementing, and evaluating project-based curricula that has emerged from collaboration with teachers and researchers. Previous work has identified four design principles that appear to be especially important: (a) defining learning appropriate goals that lead to deep understanding; (b) providing scaffolds such as beginning with problem-based learning activities before completing projects; using “embedded teaching,” “teaching tools,” and sets of “contrasting cases”; (c) including multiple opportunities for formative self assessment; and (d) developing social structures that promote participation and revision (Barron et al., 1998). While all four goals are important, the development of a quality anchor video best satisfies the first design principle and also paves the way for the other three design principles. Although this course has many innovative aspects, the most salient for the immediate issue at hand is the design, development, and incorporation of student-created video anchors for the project-based units the students create.

Over the past 3 years, technology-rich, project-based units have been developed in such diverse areas as energy expenditure of muscles during exercise, oil spills, habitats of Austin-area bats, chemical bonding, virus transmission, and mathematical modeling (see http://www.edb.utexas.edu/insite/iste-test/pbiprojects/Fall2001/index.html). In all cases, a set of design principles for creating a motivating question has been incorporated. These design principles have been informed by the work of Krajcik as well as the CTGV. Criteria for a quality “driving” question (Krajcik et al., 2002) include issues of whether the question is worthwhile (i.e., promotes higher order thinking), feasible (i.e., students can design and perform investigations to answer the question), contextualized (i.e., related to real world problems), meaningingful (i.e., relevant to learners' lives), and open ended (i.e., complex problem with multiple solution paths). Design principles for the creation of the anchor video include a narrative or first-person structure to the story, a generative design of the story, some embedded data, a complex problem involving multiple steps to mimic real-world problem solving, and the use of digital video to make the complexity manageable (Goldman et al., 1999).

SUMMARY AND CONCLUSION

The UTeach Natural Sciences preservice teacher education program represents a unique joint effort between the College of Education, the College of Natural Sciences, and the Austin Independent School District to recruit, prepare, and provide professional support for the next generation of secondary mathematics and science teachers for the State of Texas, as well as providing a model for other such partnerships across the nation.

This innovative and collaborative approach to teacher preparation has shown great promise in attracting students to careers in mathematics and science education. UTeach successfully unites practical experience in the classroom and scholarly investigation with early and continuous field experiences that capture the excitement and passion of preservice teachers, while providing a foundation for their more advanced pedagogical courses

Some unique aspects of the UTeach Natural Sciences program include the following:

1. Proactive recruitment and support of College of Natural Sciences undergraduates who are interested in careers in secondary mathematics and science education. Support includes but is not limited to tuition reimbursement, paid internships, small cohorts of students, and guidance by master teachers.

2. Emphasis on preparing teachers who will have irrefutable content expertise within their discipline, extensive instruction on employing their content expertise with sound pedagogical practices (Schulman, 1987), and practice in employing new and emerging technologies to enhance student learning.

3. A concise and research-based professional education sequence drawing from foundations on student learning (NRC, 1999), standards-based curricula, multiple forms of assessment (NRC, 2000), and proven strategies for achieving equity and integrating technology into mathematics and science education (Bruer, 1995; Polman, 2000).

4. Program flexibility with multiple points of entry (from freshman to postbaccalaureate) to facilitate the possibility of obtaining certification and fulfilling all degree requirements within 4 academic years, integrated degree plans, and proficiency-based assessments, including the development and utilization of individual teaching portfolios.

In 1997 the President's Committee of Advisors on Science and Technology concluded the following:

> The probability that elementary and secondary education will prove to be the one information-based industry in which computer technology does not have a natural role would at this point be appear to be so low as to render unconscionably wasteful any research that might be designed to answer this question alone. (pp. 93-94)

Teachers want and need concrete skills in using and producing technology resources and cognitive tools. At the same time these very teachers must be truly skilled in integrating rapidly changing technologies only if they are also adept at instructional systems design and applying learning theories, instructional strategies, and pedagogical and curricular knowledge to technology integration and the use of these cognitive tools. Teachers must be prepared to use cognitive tools and must gain strategies for staying abreast of evolving technologies. Concurrently, the faculty who are instructing this next generation of teachers at research universities need to be actively involved in taking seriously the call of the President's Committee of Advisors on Science and Technology, and to adhere to the words of Dr. Weinberg in the opening quotation of this article as they pursue their own research goals in the learning sciences. When these factors merge, as they do at The University of Texas at Austin in the UTeach Natural Sciences program, the beneficiaries include not only the next generation of teachers here at the university but, we hope, the next generation of secondary mathematics and science teachers from around the county.

References

Barron, B.J.S., Schwartz, D.L., Vye, N.J., Moore, A., Petrosino, A., Zech, L., Bransford, J.D., & Cognition and Technology Group at Vanderbilt. (1998). Doing with understanding: Lessons from research on problem- and project-based learning. *Journal of the Learning Sciences, 7*(3&4), 271-311.

Bruer, J.T. (1993*) Schools for thought: A science of learning in the classroom*. Cambridge, MA: MIT Press.

Cognition and Technology Group at Vanderbilt. (1992). Anchored instruction in science and mathematics: Theoretical basis, developmental projects, and initial research findings. In R. A. Duschl & R. J. Hamilton (Eds.), *Philosophy of science, cognitive psychology, and educational theory and practice* (pp. 244-273). Albany: State University of New York Press.

Conference Board of the Mathematical Sciences. (2001). *The mathematical education of teachers*. Providence, RI: American Mathematical Society.

Flyvbjerg, B. (2001). *Making social science matter: Why social inquiry fails and how it can succeed again*. Cambridge, MA: Cambridge University Press.

Goldman, S.R., Petrosino, A.J., & Cognition and Technology Group at Vanderbilt. (1999). Design principles for instruction in content domains: Lessons from research on expertise and learning. In F.T. Durso, (Ed.), *Handbook of applied cognition*. Chichester, England: Wiley.

Ingersoll, R.M. (1999). The problem of underqualified teachers in American secondary schools. *Educational Researcher, 28*(2), 26-37.

International Society for Technology in Education. (2000). *National educational standards for teachers*. Eugene, OR: Author.

Jacob, E., & White, C.S. (2002). Theme issue on scientific research in education. *Educational Researcher, 31*(8).

Krajcik, J.S., Czerniak, C., & Berger, C. (2002). *Teaching science in elementary and middle school classrooms: A project-based approach* (2nd ed.). Boston, MA: McGraw-Hill.

Lyon, G.R. (1997, July 10). *Statement of G. R. Lyon, Ph.D., before the Subcommittee of Education Reform*. Committee on Education and the Workforce, U.S. House of Representatives, Washington, D.C. Available: http://edworkforce.house.gov/

Marder, M., & Confrey, J. (2000). Uteach. *Discovery: Research and scholarship at the University of Texas at Austin*, *15*(4). Retrieved March 5, 2003, from http://www.utexas.edu/admin/opa/discovery/disc2000v15n4/disc_uteach.html

Marshall, J.A. (2001, November 4-6). Pre-service teachers' conceptions of radioactive decay. Paper presented at the meeting of the Texas section of the American Physical Society/American Association of Physics Teachers, Texas Christian University.

Marshall, J.A., (2002a). Preservice teachers' use of technology to explore momentum conservation. *AAPT Announcer, 32*(4), 112.

Marshall, J.A, (2002b). *Pre-service teachers' conceptions of conservation of linear momentum*. Manuscript submitted for publication.

No Child Left Behind Act of 2001. (2001). Retrieved March 5, 2003, from http://www.ed.gov/legislation/ESEA02/

National Research Council. (1999). *How people learn: Brain, mind, experience, and school*. Washington, DC: National Academy Press.

National Research Council. (2001). *Knowing what students know: The science and design of educational assessment*. Washington, DC: National Academy Press.

National Research Council. (2002). Scientific research in education. In R. J. Shavelson & L. Towne (Eds.), *Committee on Scientific Principles for Educational Research*. Washington, DC: National Academy Press.

Petrosino, A.J. (1998). *At-risk children's use of reflection and revision in hands-on experimental activities*. Dissertation Abstracts International A, 59(03). (UMI AAT 9827617)

Petrosino, A.J., Lehrer, R., & Schauble, L. (2003). Structuring error and experimental variation as distribution in the fourth grade. *Mathematical Thinking and Learning*, *4*(2&3).

Petrosino A.J., & Pandy, M.G. (2001, April). *Incorporating learning science research in college biomechanics*. Paper presented at the American Educational Research Association Annual Meeting, Seattle, WA.

Petrosino, A.J., Slaughter, R., Vath, R., & Tothero, M. (2003, April). *The utilization of PDAs in preservice teacher education in mathematics and science education*. Paper presented at the Annual Meeting of the American Educational Research Association, Chicago, IL.

Polman, J.L. (2000). *Designing project-based science: Connecting learners through guided inquiry*. New York: Teachers College Press.

President's Committee of Advisors on Science and Technology, Panel on Educational Technology. (1997, March). *Report to the president on the use of technology to strengthen K-12 education in the United States*. Washington, DC: Author.

Schulman, L.S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review*, *57*(1), 1-22.

Schwartz, D.L., & Bransford, J.D. (1998). A time for telling. *Cognition & Instruction*, *16,* 475-522.

Strauss, S.L. (2001). An open letter to Reid Lyon. *Educational Researcher, 30*(5), 26-33.

Weinberg, S. (2001). *2001 commencement address*. Retrieved March 5, 2003, from http://www.utexas.edu/admin/opa/news/01newsreleases/nr_200105/nr_weinberg010517.html

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APPENDIX A
UTEACH NATURAL SCIENCE COURSE SEQUENCE

1. UTS 101/110: STEP 1 & STEP 2. The aim of these STEP courses is to attract students to careers in math & science teaching. With the assistance of Master teachers, STEP 1 students prepare and teach 4 lessons in elementary classrooms, and in STEP 2 students prepare and teach 3 lessons in middle school classrooms.	**2. EDC 371: Knowing & Learning.** This course expands the prospective teacher's understanding of current theories of learning and conceptual development. Students examine their own assumptions about learning. They critically examine the needs of a diverse student population in the classroom.
3. EDC 371: Classroom Interactions. This course moves from a focus on thinking and learning to a focus on teaching and learning. Prospective teachers are introduced to the way in which curriculum and technology are used in classroom settings to build interrelationships among teachers and students.	**4. BIO 337/CH 368/PHY 341: Research Methods.** The student's goal in this interdisciplinary, advanced research course is to solve a complex problem by designing and performing independent research in his or her particular field of interest.
5. HIS/PHL 329U: Perspectives. Faculty in History and Philosophy introduce students to the historical, social, and philosophical implications of mathematics and science through investigations of five significant episodes in science history.	**6. EDC 371: Project-Based Instruction.** In this course, students aim to master new technologies for project-based investigations in math and science classrooms. Students also teach self created project-based units to high school students.
7. EDC 667S: Student Teaching. Students are immersed in the schools to prepare them to confidently assume a teaching position in the public schools.	**8. UTS 170: Special Topics Seminar.** Students reflect on their student teaching experiences and examine contemporary critical issues in education.

APPENDIX B
UTEACH NATURAL SCIENCES ENROLLMENT AND GRADUATION HISTORY

	New Recruits	Enrollments[1]	Graduates[2]	Teaching[3]
Fall 1997	28	28		
Spring 1998	19	47		
Fall 1998	37	66		
Spring 1999	39	89		
Fall 1999	65	133		
Spring 2000	53	142	2	1
Fall 2000	82	186	7	5
Spring 2001	67	203	26	24
Fall 2001	68	201	20	18
Spring 2002	61	204	26	21
Fall 2002	80	284	17	14
Spring 2003	97	362		
TOTAL	696	362	98	83 (85%)

[1]The term enrollment refers to the 12th class day enrollment figures for the courses each semester. Students who leave the program are identified in the database by their last semester enrolled in UTeach Natural Sciences. However, these students are not removed from the enrollment figures until the following semester.
[2] The term graduate refers to all students who have completed the UTeach Natural Sciences sequence including student teaching.
[3] Teaching refers to traditional K-12 mathematics, science, and computer science placements as well as other types of teaching jobs (i.e., teaching English in Japan).