Chapter 12
Research in Education

Background

Because SRI was founded by Stanford University, its charter quite naturally contains reference to the field of education. In this case, the reference was to support the educational goals of the University, and that orientation led to some of SRI's early research contracts being in the education field. As early as 1953, SRI had a dozen education-related contracts in what was then called the Behavioral Sciences Program.

Following those early efforts, SRI has essentially maintained a continuous role in educational research work. The main thrusts of this work lay in two areas: one area has been a decades-long interest in the assessment and evaluation of educational methods and programs and the other area has been a number of significant explorations in the use of technology in learning. That SRI has had impact in these fields is underscored by its role of effectively guiding the U.S. government, including Congress, in its oversight of educational and child development programs. These have included programs such as Follow Through, the role of technology in aiding the disabled, and, more recently, aid to the government in ongoing support of special education; that is, the education of children with disabilities.

Project Follow Through—Assessing the Impacts of "Head Start"

When it commenced in the summer of 1965, the U.S. government's Head Start program was intended as a "temporary" source of supplemental funds to better prepare poor, inner-city, preschool children during the summer so that they would enter school in the fall with a better chance of succeeding educationally. The purpose was to supply nutritional and health experiences, along with some social and mental health services, that were intended to break the so-called "cycle of poverty" that afflicted the inner city. The program flowed from the Economic Opportunity Act of 1964, an element of the widely heralded War on Poverty. It was housed in the Office of Economic Opportunity and later transferred to the Office of Child Development in the Department of Health, Education, and Welfare. Though intended to affect the scholastic readiness of disadvantaged children, it was not, by content, an educational program. Regardless, it quickly gained support among both the public and Congress, so much so that it still continues today. In fiscal 2001, the Head Start program was budgeted at $6.2 billion covering an estimated 916,000 children.[A] In its first 33 years it served more than 15 million children at a total cost of more than $30 billion. Remarkably, according to the U.S. General Accounting Office, this early childhood development program continued for more than three decades without any substantive validation of how well it was working.[B] That observation applies more to the noncognitive consequences of the program, for some early and extended attempts were made to understand the educational progress of Head Start children.

Head Start, of course, was intended to have an educational impact. In early measurements, it was noted that the IQ of Head Start children went up by as much as 10 percent compared with those who did not participate. But other studies showed that this and other preschool gains seemed to dissipate as the children entered school.[C] The Johnson Administration, perhaps seeking evidence of the desired benefits of Head Start, decided to explore their efficacy and staying power. In 1967, just 2 years after the initial Head Start implementation, Congress approved Public Law 90-92, creating another very large program that would "Follow Through" on Head Start. In other words, it would track Head Start-eligible students into their normal schooling and, even more, seek effective methods for teaching them. In pursuit of the latter objective, it was decided to examine a wide variety of teaching theories or methods for such children and to find out which were the most effective. The process was called "planned variation" and sponsors of different educational models were invited to implement them on a cooperative basis with selected schools. Designing and implementing a complete full-day curriculum governed by each educational model had never before been done in educational reform.[D] The scope of the research project was also unprecedented, with close to 10,000 children from 120 communities involved each year from 1969 to 1975.

SRI had several early roles in Follow Through.[E] One was to design, administer, and score the testing of Follow-Through children for both cognitive and noncognitive development across a range of 10 to 20 teaching methods.[F] Others were to determine whether a set of distinguishable teaching methods were, in fact, being used and, finally, to evaluate each teaching method in that set. Because of the sheer size of Follow Through and the nature of longitudinal studies, aspects of these roles continued for some 5 to 6 years.

Much of this methodology for evaluation was groundbreaking. First, SRI created a set of observational methods that were original, innovative, and more comprehensive than anything prior. They allowed for a spectrum of student groupings, how materials were used or not, the instruction methods used, and, of course, a wide range of childhood development outcomes: behavioral, cognitive, problem solving, attendance, and others. The SRI observational method and its analytical adjunct have been widely replicated in this country and adapted to settings in France, Spain, and China.

SRI's second important contribution was to determine whether some subset of the various teaching methods, which eventually came down to seven,[1] were actually in place and "pure" enough to have educational results unambiguously associated with them. Considering that this involved four first-grade and four third-grade Follow-Through classrooms and one each non-Follow-Through classroom in each of 36 cities, this was a huge task. Though each educational method had been in place and practiced for 2 to 3 years, assessing the adequate presence of each teaching method was still difficult. But SRI showed that each of the seven was unambiguously present. It then became necessary to measure student outcomes over a wide range of developmental and educational characteristics. The measuring instrument included more than 600 categories that described both students and teachers. Collectively, there were more than 1,000 observation days.

Though it tried to win a wider scope in the analysis of the data, SRI participated only in that part related to classroom observation. Here are a few important results from that work as reported by SRI's project leader, Dr. Jane Stallings:[G]

- The teaching methods and classroom environment are important to student achievement, certainly by the third grade and to a large extent by the first. The finding removed the uncertainty about the relative importance of a child's aptitude upon entering school. Even in the early 1970s, some researchers thought aptitude at school entrance was dominant, but Follow Through showed, for example, that even in the first grade a child's entering ability accounts for about one-third of the child's achievements in math, while instructional procedures account for about 40%. For reading, entry ability accounts for about half the achievement.
- Each of the seven instructional methods brought selected improvement to childhood development, but no individual method was universally better or consistently worse than all others. Each had a spectrum of successes and failures. For example, and perhaps not surprisingly, superior scores in math and reading for both first and third grades could be positively correlated with the average length of time spent on them during the school day. In open classroom settings, children attributed their success to themselves and failure to others, whereas in the more structured classrooms a successful child attributed success to the teacher and

[1] The seven consisted of two based on positive reinforcement theory (Univs. of Kansas and Oregon), one on Piaget's cognitive development theory (High/Scope Foundation), one on open classroom (Education Development Center), and three on combinations of Dewey's science-based cognitive development and the second and third just listed (Far West Laboratory, Univ. of Arizona, and Bank Street College). That each was adequately distinctive, however, was SRI's first burden of proof.

Figure 12-1. Education researcher, Dr. Jane Stallings.

failure to him/herself. Very little of the absence rate was explained by a child's outlook at entry, whereas instructional procedures accounted for almost two-thirds of the cases of inordinate absenteeism. What happens in school, therefore, is important to whether the child comes to school or not.

- Success in nonverbal problem-solving skills was favored by an environment where questions were more open-ended and the use of materials was extensive.
- An ability to respond well to testing is best served by so-called direct instruction. Direct instruction uses closed-ended verbal questions followed by assessment and explanation. That approach benefits from memorization.

In the opinion of SRI researchers, the best instructional method involves a blend of several of the methods isolated in Follow Through. That blend may include some direct instruction, some that favors nonverbal problem solving, and some of the more planning-intensive methods.

For better or worse, the U.S. educational system, with its highly distributed and diverse nature, is also highly resistant to change. Even though Follow Through evidenced some clear directions, little of what was learned in these evaluations has found its way into our elementary education system.[H]

Evaluating Programs in Special Education

One of the most significant and beneficent programs that SRI's education researchers have worked on is a nearly 20-year run in evaluating U.S. educational efforts for children in special education.[2] The motivation for doing this kind of work started with a small statistical study for the Department of Education (ED) in the mid-1970s that tried to count the number of handicapped children who could attend school. Many such children were invisible to the existing census and other counting methods. Beyond the outcome itself, the project was important to SRI's future work in special education since Phil Sorensen, then head of education research, used it in 1972 to bring to SRI Dr. Marian "Mimi" Stearns from ED's Bureau of the Educationally Handicapped, the agency that had funded the study (see Figure 12-2). She would come to have considerable impact on SRI's contributions in the field of education.

SRI's initial major opportunity in this field arose with the passage in the late 1970s of a new special education law, Public Law 94-142, intended to provide an improved education to such children.[3] Stearns received a contract in 1978 to perform the first longitudinal study to measure the effect of the Law. This was a 5-year study to watch how well 32 different school sites were meeting the mandate of P.L. 94-142; that is, to get children with disabilities out of their cloistered, institutional environments and into the schools. This included children with all kinds of disabilities and with ages from preschool to as old as 21. Each year SRI would submit to the client, ED's Office of Special Education Programs, an evaluation of how the target schools were doing. Regulations

[2] "Special education" is an umbrella term for a variety of programs intended to assist children with physical and/or educational disabilities that cannot be accommodated in a regular classroom.

[3] The Education for All Handicapped Children Act.

Figure 12-2. SRI vice president, Dr. Marian “Mimi” Stearns.

Figure 12-3. Dr. Mary Wagner.

stemming from the Law were redone every 2 years and the Law itself was modified every 5 years. Both regulation and legislation have been strongly influenced by the SRI observations. As perhaps one of the most regulated parts of education, the new provisions governing special education and even the law itself came to reflect what SRI had observed. With this influx of disabled children into the regular schools, an important but nebulous boundary came to exist between those in regular education and those in special education. Federal research money was made available to study that boundary and, importantly, SRI would participate in those studies.

The first evaluation study ended in 1983 and, after a 2-year hiatus, a second longitudinal study was conducted, this time to study the *children themselves*, not just the schools. It was a huge study involving 8,000 children and went on for 9 years! The study led to SRI testifying before Congress, and important changes that reflected SRI's findings were made in the reauthorization of the Individuals with Disabilities Education Act (IDEA). For example, SRI's data showed dramatically that a large fraction of emotionally disturbed children effectively fell into nonproductive and even criminal lives after they left school.[4] As a result of this insight, a whole new research program was started to learn more about that regrettable transition. Other disability categories are still being looked at; for example, what is the etiology of mental retardation and what is the role of public education over the formative years relevant to that condition?

With the exception of an unfortunate hiatus in the 1990s, longitudinal studies have continued at SRI in a variety of child development areas, all dealing with disadvantaged children. One ongoing study looks at a nationally representative sample of infants and toddlers with disabilities, along with their families, as they transition into elementary school. The purpose is to consider the circumstances of individual children and learn what factors produce good outcomes in the early years of school. Another study relates to an older age group as its members transition into middle and high school.

The consequences of these studies and their influence on legislation have helped define the framework of special education policy, something that was new to the field of education. SRI has earned a unique position in measuring and understanding this aspect of education. When the time arrives for a

[4] A specific example: some of the first statistics on what was happening to emotionally disturbed kids when they reached high school showed that 75% had been arrested by the time they were 3 years out of high school. New interventions had to be developed for such children. A new longitudinal study starting in January 2000 will look at younger emotionally disturbed kids (6-12) to see if school and other agency improvements are working. A separate study will look at babies with disabilities. With that SRI will have covered all age ranges. (Also, see *SRI Journal*, April 82.)

THE RESEARCHER'S TASK OF REMAINING OBJECTIVE

Being a research organization, SRI tries its best to be objective—to place before a client the information gathered in a clear and concise way that will permit unambiguous interpretation. Unfortunately, the dimensionality and complexity of the social sciences are such that information collected often seems to serve both sides of an issue. This fact is frustrating to the SRI staff, particularly when pre-positioned advocates "spin" the data and the analysis to reflect their views on a topic. One example was SRI's Mary Wagner's testimony before a U.S. House Committee on Education as it was considering reauthorization funding in 1992. Since SRI had the most relevant data, Mary was asked to provide information on the effectiveness of special education. One Congressman, seeking to pronounce the special education programs a failure, was looking for ammunition. But what he failed to realize was that, by law, most students involved in special education settings also spend most of their time in general education classrooms. So, a proper evaluation of the success or failure of such students must consider the role of both general and special education. Failure to do that would invalidate whatever conclusion is sought, biased or not.

Another, perhaps more incendiary example is the observation that there is a disproportionate number of African-American students in special education classes. Some would like to attribute this imbalance to racial discrimination in the schools. But SRI's comprehensive data show that disabilities are disproportionately evident even among African-American infants, long before school age. Therefore, the imbalance cannot be due to the schools. Moreover, examining the problem by income strata shows that racial/ethnic groups at a given income level are about equally represented among special education students and students in the general population.

Although Wagner and the SRI researchers try desperately to be objective, their preferred stance on issues is to become what she calls "myth busters," to have and present data that can dispel false notions, often invented to defend a position. That, it would seem, is another reflection of SRI's desire to innovate, here surfacing in a social science setting.

reauthorization of the enabling congressional legislation, the Department of Education and SRI are queried extensively about the current successes and failures of special education. Stearns, Mary Wagner (see Figure 12-3), and other SRI research leaders have made huge contributions to the guidance of the necessary legislation.

As mentioned, the original source of this work was the Bureau of the Educationally Handicapped, now known as the Office of Special Education Programs. SRI's relationship with this client has been extraordinary. For more than 25 years the principals of these two organizations have had a relationship of mutual respect and contribution. In fact, recently, they asked SRI to help them develop their long-range program for the next twenty years. As Mary Wagner points out, that's twenty years of relevant experience at SRI on which to base a twenty-year forecast. That requires a clear 20/20 vision, and SRI will be up to the task.

Technology in Learning— The Role and Promise of Computing in the Classroom

As with most places we frequent, computers, in all their manifold embodiments, have found their way into the classroom. Unlike many situations in industry, however, that migration has been intermittent and uncertain. You can easily imagine several reasons for this: teachers who are untrained or averse to computers yet are required to use them, the unevenness in building a clear and valid context for their introduction into the classroom, and their almost scheduled obsolescence, which spells recurring capital costs that invoke the chronic shortage of money. Also, perhaps more than in other environments, the presence of computers in the classroom has not come to imply their effective use.

While computers fairly easily entered the school districts' and even teachers' offices for administrative use, placing them in the hands of students has been less straightforward. Adding to the uncertainty or confusion, over the approximately 30 years that such classroom exploration has gone on, computers have also evolved and their potential has increased dramatically. They now range from scaled-

Figure 12-4. Dr. Barbara Means (who led SRI into the realm of technology in learning).

down, but more affordable and powerful "mainframes" in the district office to those that now approach wearability in the classroom. So, what are their educational roles? What is their educational efficacy? What do they enable by way of communications and collaboration? Perhaps most importantly, how do both the teacher and the students naturally and powerfully assimilate them into the curriculum? How do you prepare children for an increasingly technological world? These probing questions have been part of SRI's research for more than two decades.

The first time that educational technology became part of the organizational taxonomy at SRI was at the beginning of 1982, when Dr. "Mimi" Stearns initiated a program under Teresa Middleton called just that, Educational Technology. The scope later broadened a bit to include the technology of training. But the genesis of studying the role of technology in classroom instruction was created in the spring of 1989 with the formation of a group in Advanced Instructional Technology under Dr. Barbara Means (see Figure 12-4). Probably more than anyone else, she has been responsible for the growth of this work at SRI.[5]

[5] Though accepting a leadership position within 3 years after arriving at SRI, Dr. Means continued to contribute to her field. One very important contribution she has made is to the pioneering use of case studies as a method to evaluate the role of technology in education reform. She has written several books on the subject of technology in education, including the ways in which the Internet and its advantages can be successfully integrated. Two volumes with colleague Dr. Geneva Haertel containing papers on educational technology are also in press.

A very common thread through all of the SRI work, in one form or another, is the Internet and the technology that is increasingly a natural extension of it.

Research in computer-aided instruction at SRI has had three major thrusts: the building of tools or programs that help teach specific subjects, creating a computer-based environment to help teachers retain and hone their skills, and the very critical question of evaluating the efficacy and value of computers in the classroom. They will be addressed in that order.

Subject-Specific Educational Software

Elementary Probability and Statistics—Major Munchy

One of SRI's important achievements in educational software has the unlikely name of "Major Munchy" (see Figure 12-5). Funded by the National Science Foundation (NSF), this is a video-based, instructional software system that teaches middle-grade students elementary probability and statistics. It takes real-world problems and brings them into the classroom setting in the context of a game. Teachers show a few minutes of the video each day, and students become involved in classroom simulations using dice, random numbers, and (optionally) a computer to promote the learning of important concepts in probability and statistics. *Making Money with Major Munchy: Explorations in Probability* is a week-long instructional set that was designed and built by Andy Zucker and Ed Esty. It has been endorsed by the National Council of Teachers of Mathematics (NCTM), and in 1994 it won the top award among some 800 entries at an International Film and Video Festival in Columbus, Ohio, and third place in a similar competition in New York. Today it, along with three similar video kits, is in use by tens of thousands of students in grades 5 to 9 and has become a commercial educational product distributed by HRM Video of New York.

Another math-oriented program began at SRI in 1998 under NSF sponsorship. It is called *Math Insight*, and it also subscribes to the NCTM standards. With the collaborative participation of Virginia public schools and the careful observation of students' experience using computer-based mathematical tools, *Math Insight* was built around a structured math

Figure 12-5. The lead-in and student use of the SRI-developed probability and statistics program called Major Munchy.

problem-solving process. It can stand alone or be used as an adjunct to normal math textbooks.

Visualizing Chemistry—ChemSense

ChemSense is another NSF project, begun at SRI in 1999, which is intended to use the visual and representational aid of a computer to help students understand and learn chemical systems and to help teachers become more aware of the progress or difficulties students encounter. SRI partners were the University of Michigan, PASCO Scientific, NCSA ChemViz, and the students and teachers of local Northern California schools.

The brainchild of Drs. Robert Kozma and Elaine Coleman, the project builds on several theoretical approaches to learning, including collaborative investigations, ability to represent chemicals and their interactions, curriculum, and a place where knowledge building can occur. Students work together, ask questions of each other, and ultimately try to conduct a chemistry experiment or investigation, complete with data representation and analysis and the presentation of a conclusion or findings. The flexibility of a computer environment provides a source of standard chemical symbols, a workspace for experimental design, the use of animation to depict chemical change, and, importantly, an opportunity for collaborative input and peer review. An image of such a workspace is given in Figure 12-6.

Five areas are addressed that help portray observable states or changes in molecular structure:

- Connectivity or the structural representation and reactivity of molecules
- Molecular geometry or shape importance, particularly in biochemical reactions
- Proximity conditions, sometimes multiple, that enable some biochemical reactions
- State of a molecule in its environment under influences such as heat and light
- Concentration of molecules in a volume and the consequences of their collisions.

These five areas form a framework for developing a chemistry curriculum, for knowledge building, and, ultimately, for gaining a new or better understanding. The participating high schools in Northern California can prepare animated representations of experiments they have conducted, and place them in the ChemSense database, from where they can be viewed anywhere across the Internet. ChemSense is also being explored for use in instructional chemistry at the undergraduate level at the University of Michigan. A number of papers on this new teaching tool have been presented or published by SRI and its partners.

Educational Software Development and Testing

As mentioned earlier, educational software for the classroom has a checkered history. Often because of expensive development, limited acceptance, or interprogram incompatibility, such software doesn't find a profitable market or enjoy much longevity. So SRI approached NSF with another idea. The result was a 1998 project that addressed the building of instructional software through the use of small,

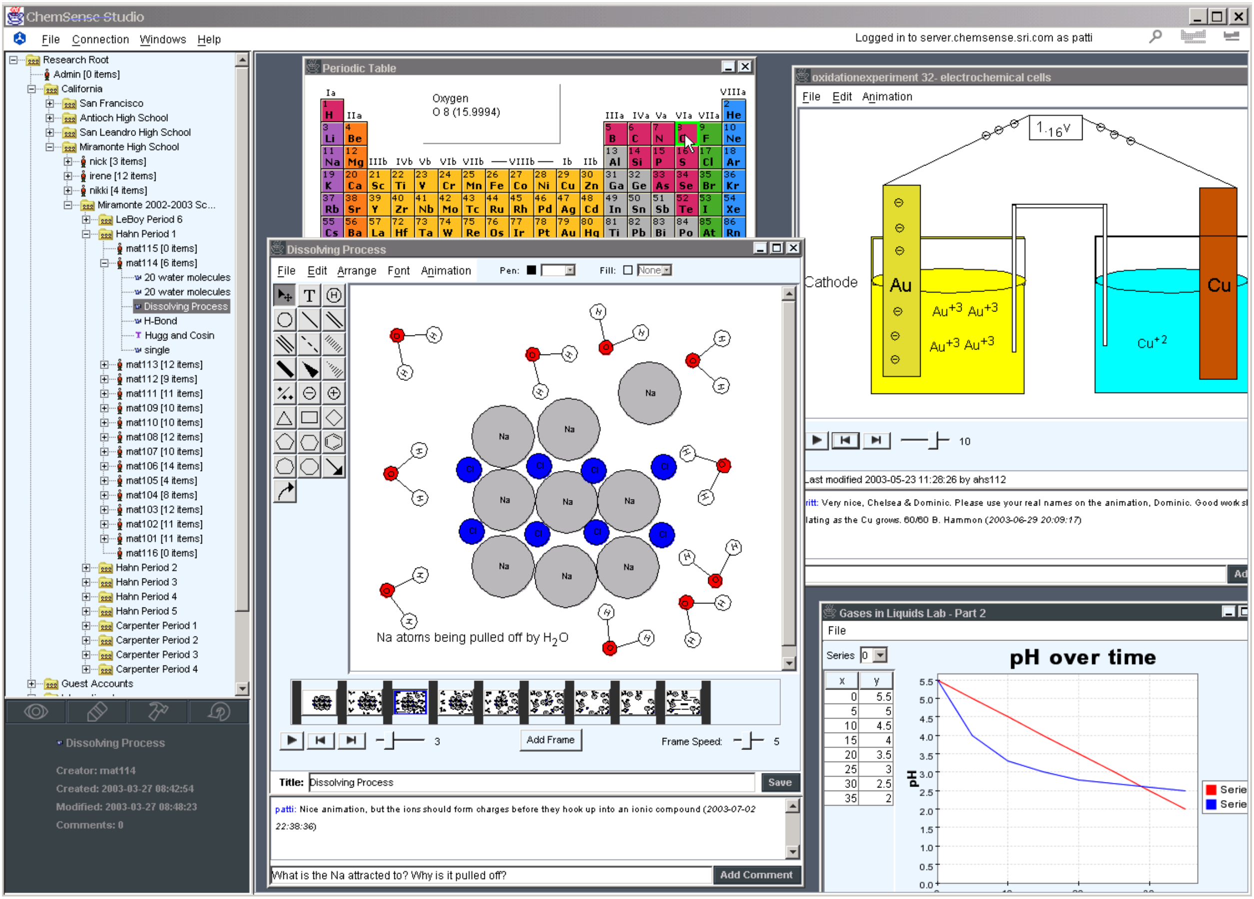

Figure 12-6. Browser window showing ChemSense.

portable software modules with enough compatibility and longevity to find use as components in larger programs. The initial specific target was reform in middle school mathematics, with a general goal of having an impact on the quality of math and science education from kindergarten to 12th grade. The project, called Educational Software Components of Tomorrow (ESCOT), uses the broad access to the Internet by both teachers and developers to build, collect, evolve, test, and use a wide variety of software components that can be applied to identified educational needs in mathematics. Teachers may draw on the ESCOT web site for components as needed. The hope is that, through this medium, valuable software components will aggregate over time, enable cheaper instructional software, and ultimately form the core of better math instruction.

Support of Teacher Development

Tapped In—An online meeting place for teacher interaction and development

An important, perhaps critical aspect of how well a given profession works is the interaction of its members. In spite of an almost total social immersion, in the context of professional interaction teaching can ironically be a lonely profession. The workday is enormously crowded with demanding schedules and continuous interaction. Afternoons and evenings are often filled with offering individual help, grading papers, and planning for the next class or subject. The opportunity to compare ideas or learn of new approaches from peers or others is limited, leaving most teaching improvements to be self-discovered. Greater teacher interaction and mutual support are simply unmet needs.

It was the occasion of the annual request for SRI internal investment funds in 1995, and Mark Schlager and Wayne Grant of SRI's Center

Figure 12-7. A starting page of SRI's first *Tapped In* (a virtual collaboration space for teachers).

for Technology in Learning (CTL) were applying for money to provide classroom teachers with the means to better interact with one another as they try to improve their classroom performance. Their idea was to use the emerging worldwide Internet as the basis for a very broad forum in which topics such as curriculum, teaching methods, and discipline could be explored. Since there was no time in a teacher's normal day for such potentially useful discussion, the Internet could offer after-hours interaction among interested teachers, no matter where they lived. The SRI funding was approved, and so began an important innovation in teacher development support, a virtual meeting place called *Tapped In*.[1]

Beginning with modest support from SRI and the Walter S. Johnson Foundation, CTL created the early mechanisms for *Tapped In*. Teachers were involved from the beginning and helped design the functionality needed. NSF then became involved and wisely encouraged SRI to concentrate on building an easily used, richly communicative medium and to use partnerships with the professional development community to provide the content materials and methods. Taking this approach, *Tapped In* has created an environment where teachers can improve their skills in individual disciplines such as math or biology. The materials and methods promulgated here are derived from partnerships with established organizations in teacher development.

A web interface to this virtual environment is shown in Figure 12-7. Modeled after physical space, it has meeting rooms, private rooms, a library, whiteboards, an auditorium, etc. modifiable according to the preference of the teachers. Since their access is very likely to take place after hours, teachers can sit in their pajamas, move into the math forum suite, look for resources available, or even interact with forum staff. Although initially many of the web-centered interactions across the education community were totally asynchronous, *Tapped In* developers at SRI believed that much of the learning experience required synchronous or real-time interaction. One of *Tapped In*'s notable contributions so far has been to cause others to see that need for immediacy and, as a result, both synchronous and asynchronous interactions are possible.

Tapped In includes forums that deal with both a traditional subject and the role of new technology in teaching it. While the SRI facilitators, mainly Drs. Mark Schlager and Judi Fusco, help new visitors get together, [6] the virtual venues that exist are the product and responsibility of the participating teacher community (see box). This gathering offers ordinary teachers the chance for dialogue with each other, and sometimes with the leaders in their field. Perhaps most importantly, it goes a long way toward breaking down the isolation that almost all teachers, but particularly new teachers, feel in their classroom.

[6] Others involved in the development and use of *Tapped In* are Alexandra Harris, Patti Shank, Melissa Koch, Larry Hamel, B.J. Berquist, Kari Holsinger, Richard Godard, Donna Hendry, Michael Hutchison, and Aaron Becker.

One very popular program that helps teachers bring the Internet and its information into the classroom is called *WebQuest*. It offers the student a means to search for and locate material relevant to a broad set of classroom subjects or assigned projects. Its popularity led Dr. Judi Fusco of SRI and a few interested teachers to open a *Tapped In* forum on how to use *WebQuest* more effectively. At their first online meeting, who should show up unannounced but Bernie Dodge, the creator of *WebQuest*! Dr. Dodge, from San Diego State University and often called "the teacher's best friend," is one of the country's most respected figures in bringing the new online technology to the classroom. The session went so well and the environment offered by *Tapped In* was so conducive to the interaction that Dr. Dodge became the forum leader and now holds monthly online meetings on the uses of *WebQuest* with teachers from all over the country.

Tapped In is also being used to offer formal educational opportunities for teachers. For example, Pepperdine University pays an annual institutional fee to use *Tapped In* for its masters and doctoral programs in education. The intent is to formally train teachers in new ways of interacting with each other. In addition, teachers who are not physically close to such a school can take advantage of such interactions.

The *Tapped In* program has been so successful that applicants to NSF for online teacher improvement regularly incorporate *Tapped In* as part of their process. In late 1999 this aspect of *Tapped In* involved about 8,000 teachers and was picked as one of the 20 most important innovations in educational technology to be presented at an educational summit for state governors. In spite of the fact that the SRI leaders have purposely let *Tapped In* become known only through word of mouth so as to not outstrip available resources, each month some 700 members and twice that many guests log in for sessions that are, on the average, 40 minutes long.

In spite of its meeting a clear need, *Tapped In* had to face a moment of truth as its extended funding from NSF was winding down. Lacking that support and with access privileges that hopefully would remain free to individual teachers, a continuation strategy was needed. How could it continue on its own and yet reach an even larger fraction of the country's 3 million teachers? The participating teachers didn't want it to become an in-your-face commercial environment, now so common to the web, and yet finding some operating model was critical. An answer came, at least for a while.

First, NSF provided SRI a supplemental grant to carry the operation through 2002. This money also served as a bridge to a new, expanded role for *Tapped In*. In early 2003 NSF, through a new 5-year grant, asked SRI to create a new version of *Tapped In* to help foster collaboration among a family of new research centers it was creating across the country. This change presented an opportunity to revamp *Tapped In* software and its functionality, but it also meant that existing users were left without a service as the old program was retired. By the fall of 2003, the new program was capable of serving not just the NSF centers, but an improved meeting place and service for individual teachers, private virtual teaching environments for groups of K-12 students, and other private meeting areas that were income-producing. The last and important revenue part derives from the ability of separate organizations, such as universities and teacher groups, to build their own virtual private environment for which they pay a fee to *Tapped In* operations.

Rebuilding its user base from late 2003, TI2, as the new version of *Tapped In* is called, now has more than 17,000 participating teachers. This service, with worldwide reach and typical low-cost web efficiencies, has become an important and innovative framework for not only helping teachers, but also expands the notion of what a meeting place or classroom can be.

Teachscape—An SRI-assisted company offering high-quality teacher development

Just as *Tapped In* is an online resource for teacher development sponsored with grant money from NSF, SRI also had a hand in a for-profit enterprise called Teachscape that has also targeted online teacher development. The motivation for its founding arose outside of SRI through the efforts of its present CEO, Mark Atkinson, a former producer of television news programs. But very early on he enlisted the expertise of SRI and, in particular the insight

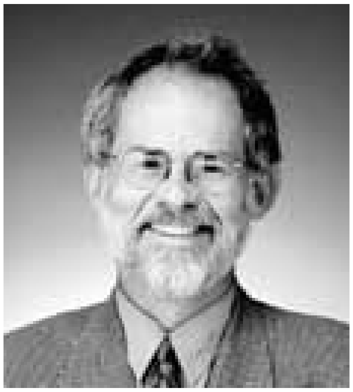

Figure 12-8. Dr. Roy Pea.

and broad educational influence of Dr. Roy Pea[7] (see Figure 12-8). As Teachscape unfolded and rooted in the technology-in-learning work SRI was doing for NSF, there came the realization that the Internet, as its communications bandwidths increased, was a perfect place to involve teachers in their quest to improve their classroom skills. Higher bandwidth is necessary because one of the important means for this development process is digital video. Video is but one component, however, of the multimedia approach of this new company.

The aim of Teachscape is to further the professional development of teachers and to do so by forming a broadly based team of educators, staff developers, multimedia producers, technologists, and researchers willing to work with educational institutions. All Teachscape resources are available in online libraries that include video-based case studies of exemplary teaching in real classrooms, teacher reflections on those videos, examples of student work in featured classrooms, and the commentary of educational specialists. Other features include study groups; facilitated discussions with experts, featured teachers, or colleagues; and self-assessment aids. Assistance is also available to help tailor the online library to the needs of a specific client.

Teachscape has an impressive list of partners. Among them are the two major teacher unions in the United States, several universities prominent in K-12 education, curriculum publishers such as McGraw-Hill, and authorities on teacher quality like the National Board for Professional Teaching Standards.

[7] His collaboration in Teachscape earned him the title of co-founder, and he currently sits on its Board. (When Atkinson brought the program to SRI it was called "Minerva.") Roy, since 2001 a professor at Stanford, is a nationally recognized leader in education research who was encouraged to come to SRI by Dr. Barbara Means in 1996 to head its Center for Technology in Learning. He would later come to head the NSF-funded Center for Innovative Learning Technologies, to be covered later.

Critical to the launching of the company, this need for better education for young Americans got the favorable attention of one of the most noted venture capital firms of Silicon Valley. Two major partners at Kleiner Perkins Caufield & Byers provided the seed money for a new charity venture fund called "**new**schools."[8] From this fund and others, like education-oriented Arcadia Partners, Teachscape received an initial $20 million, followed by several more rounds of funding. Because of its important contributions, SRI has a small equity stake in Teachscape. At present, it has clients in several states, including the support of more than 13,000 teachers in California.

Assessment and Evaluation in the Classroom

On the surface of it, determining the value of computer technology in learning seems straightforward: simply measure the differences in student performance over time in two statistically similar cohorts, one with and one without computers. Well, it is certainly not straightforward, and there are a host of reasons why the introduction of computers produced a somewhat turbulent debate about their educational efficacy. Beyond those mentioned at the beginning of this section there are:

- The wide range of teaching styles, preferences, and commitments
- The even broader range of potential computer-based applications with classroom relevance and the effort needed to use them well
- The huge spectrum of student interests and capabilities
- The controversy that early introduction of computers displaces basic skills
- The care with which experimental design and evaluation must be done to assess their value in education.

Because of this complexity, drawing conclusions about how computers can be beneficially used has taken years. Perhaps this difficulty should not be so surprising, for computers are machines built primarily to aid one's mind rather than brawn. As such, their

[8] The two partners were John Doerr and Brook Byers, who both have deep interest in seeing U.S. education practices improved and want to put some financial rigor into the for-profit and nonprofit organizations serving this field. (Venture Philanthropists: The New School Fund, *Time Magazine*, 24 July 2000)

utility may be as varied and individualistic, as rational or irrational, as the mind itself. As Barbara Means points out: if you really want to understand what is happening in educational technology, concentrate not on the technology itself as the innovation, but the *underlying learning experience*. That is what must be recognized and evaluated.[J]

Aside from the issues of cognitive and emotional complexity is the continuing evolution of computers themselves, not just what they can do but also how affordable they are. Computer-related functionality, including communications, is still evolving, and the importance of computers is unquestionably increasing. The breadth of their utility is also enough that they can be both helpful to student performance and detrimental, the latter coming from some important preoccupations outside the classroom. With the sheer breath and depth of their utility, then, defining the proper roles for computers in learning takes a lot of insightful and careful research. Through a long history of work for NSF and foundations with educational interests and a broad involvement with other educational researchers around the country, SRI has developed an excellent reputation in the field of evaluating technology in learning. We will now examine a few projects on which that reputation is built. [K]

GLOBE—The world as an environmental classroom

GLOBE, which is an acronym for Global Learning and Observations to Benefit the Environment, was created with the support of Senator Al Gore in 1992 as a way to aid the environment and at the same time help primary and secondary students learn science. It has broad and ongoing support within federal agencies such as NOAA, NASA, NSF, EPA, and the State Department. In also tries to teach children how to participate in real science projects and in that process to collaborate both within and beyond their own classrooms. Again, it is the Internet that provides this opportunity. The subject is the monitoring of our environment and the participants are K-12 students from around the world.

SRI's role in GLOBE has centered principally on its evaluation. It was again Means's influence and the efforts of Dr. William Penuel that secured this important work for SRI. It is a role SRI has maintained for the past 7 years and, through a recent extension, will continue for another 4 years. To understand what this involves, we must say a bit more about the mission of GLOBE.

As mentioned, it tries to elevate K-12 students into roles they can play in helping monitor the life-critical properties of the environment, such as our water and air. Teachers and students collect local measurements on some aspect of the environment and submit the data to scientists, who in turn mentor the teachers and students in how to think analytically and apply scientific concepts to what they are doing.[9] In a 1998 survey almost two-thirds of the teachers participating in GLOBE said their students were involved in analyzing, discussing, and interpreting such data. Some of the greatest impacts are found in the students' observational and measurement skills and their ability to work technically in small groups.[L] In their locales they can study such environmental attributes as the quality of the soil, including its conductivity and acidity; the amount of ultraviolet radiation; and the level of carbon dioxide and certain particulates in the air. These data and insights speak to their local area yet are all pooled over the planet with some collaboration being specific to other schools.

SRI has made a number of contributions to the program. It has shaped the program's recruiting strategy and refined its teacher training program. SRI evaluations recognized that GLOBE was much easier to implement in a school when multiple teachers were trained together and articulating the kind of support teachers need when building an atmosphere for student-directed inquiry. SRI has also helped increase the focus in GLOBE on that same student-directed scientific inquiry.[M] Finally, it must be said that although the online database and visualizations of GLOBE are essential in gaining a larger and more significant environmental perspective, it is the ability of the teachers to create or enable the relevant activity that is crucial to its success.

Center for Innovative Learning Technologies (CILT)

It was on a napkin at Café Barrone in Menlo Park that Drs. Roy Pea, Barbara Means, and Marcia Linn (of UC Berkeley) first outlined the concepts of what they hoped would be a new

[9] Importantly, the students follow the collection protocols set up by scientists participating in GLOBE.

NSF center in educational technology. They then recruited colleagues from Vanderbilt and the Concord Consortium to join in. Since there are not many such centers at NSF, there is an implied sense of importance to the subjects they address. The proposal to NSF was successful, and CILT was formed in the fall of 1997. It involved the four institutions and was scheduled to run for 4 years plus an incentive-based 5th year.[10] The grant was made to stimulate the development and study of important, technology-enabled solutions to critical problems in K-14 science, mathematics, engineering, and technology learning. Both the Center's leadership and its approach were to be broadly inclusive of talents and efforts around the United States. There were a number of ways in which that broad mission would be carried out:

- Concentrate on four computer-related focus areas:
  - Visualization and modeling
  - Ubiquitous computing
  - Assessments for learning
  - Community tools.
- Hold workshops within the learning technology community.
- Fund seed grants for collaboration in critical directions for the field.
- Build a network of people and resources relevant to the field.
- Fund a postdoctoral program.
- Create an industry alliance program to encourage successful products.

The project participants worked for 4 years to exploit new technologies, explore interdisciplinary insights, and critically evaluate their own collective innovations and progress. Beyond the published progress of the project, its industry-aligned collaborations brought players such as Intel, Sun Microsystems, Pasco, and Palm into the exercise. Palm also chose to participate through SRI in a separate, broadly based competition for innovative educational software for its handheld platform. Thus began a series of Palm projects at SRI to explore the classroom utility of handheld computing devices. The tasks ranged from record keeping for the teacher to real-time sensor measurements in the scientific disciplines for the students.

As of 2004, CILT sponsorship at NSF was ended. In the offing, however, is set of new NSF centers that will investigate the science of learning itself, including examining what in the brain enables learning to take place. Brain physiologists as well as cognitive scientists and educators will participate in these new centers and SRI, along with participants from the Stanford School of Medicine, will be subcontractors to one of the new NSF centers opening at the University of Washington.

Performance Assessment Links in Science—PALS

PALS is an online, digital library of standards-based science performance assessments for grades K-12. By accessing a web site, educators can find more than a hundred science performance tasks, complete with administrative procedures, student instructions, scoring methods, and response forms. There are also examples of student work and data on technical quality. These assessments have been aligned with the National Science Education Standards. The site also provides online professional development and assists in adapting the modules and their scoring to local situations. The development process for PALS is rigorous enough to satisfy state accountability requirements. Adding to all this is a secure area for educators to post directed responses and experiences. Through this confluence of assessment standards and experiences, NSF and SRI are helping advance the quality of K-12 science education.[11]

The Online Evaluation Resource Library—OERL

Earlier in this section it was asserted that a successful evaluation of computing technology in the multidimensional realm of education, requires very carefully planned experiments. Some of the evidence supporting SRI's splendid reputation in the field of education evaluation can be found in yet another web site (oerl.sri.com), devoted, in this case, to helping educators design, carry out, and report on evaluation projects. SRI operates the site on behalf of NSF with an eye toward enabling more consistent and valid results in the

[10] Stanford University became the fifth partner later when Pea joined its faculty.

[11] Dr. Edys Quellmalz is responsible for PALS.

evaluation of NSF's own projects, but its use has become truly worldwide.

OERL, led by Dr. Geneva Haertel, is a compilation of more than 70 plans and reports and more than 200 instruments that can be used directly or modified for tailored situations. Recently, a set of professional development modules on how to design surveys and evaluations has also been added to the library. Showing that the cobbler's children can have shoes, the site itself undergoes periodic evaluations by a panel of five nationally recognized evaluation experts. To perform this kind of review, data and surveys are taken on site usage. Through a 3-month period ending in March 2003, the site served more than 43,000 pages, or around 400 per day. Those requests came from more than 6,400 different IP addresses in 73 countries. The use of OERL to produce higher-quality and more defendable experiments has certainly saved effort and money, both in the United States and abroad.

A Final Observation

This section has covered a combination of (1) the development of educational software intended to support a new and valuable kind of learning or teaching experience and (2) innovative methods and measurements in the evaluation of such programs. It is the presence and excellence of both of these capabilities that have brought such success to SRI in this field. Further, SRI's objective detachment enables a broad range of partnerships with *all players* in the education technology field, be they developers, users, or agents of change such as NSF and Congress.

To end this section on the role of technology in learning and its realization at SRI, here is a quote from the abstract of a paper by some of the SRI principals in the field.[N]

> "Research indicates…that the use of technology as an effective learning tool is more likely to take place when embedded in a broader education reform movement that includes improvements in teacher training, curriculum, student assessment, and a school's capacity for change."

The natural integration of computing power into our lives is a long-term process that should be aided in no more logical place than our schools. However, that integration may be recursive in that the full integration of computing into the fabric of education may well come only with its more complete acceptance in the noneducational world. Clearly, one would hope not, because, rationally, our schools should lead the way. But the inevitable pervasiveness of this new machine and its consequences will almost certainly take us on a long and uncharted path.

Instruction Outside the Classroom—The Standards of the PGA

It was about 2 p.m. on a Friday afternoon in September of 1990 when a phone call came to Gary Bridges at SRI (see Figure 12-9). A woman with a richly southern accent related that a golf professional from Livermore, California, had told her that SRI did work in education. She was frustrated in that they had interviewed 40 other consulting firms looking for someone to do an assessment of the PGA training program and make some recommendations for change. SRI was the last firm they would call, and could she have a proposal by next Tuesday? A proposal was written that qualified SRI for further review (see box) and a site visit scheduled for that December. SRI's half-day presentation consisted of a lot of questions—so many, in fact, that the visitors, the education director of the PGA and staff, were beginning to doubt SRI's abilities. But during a working lunch, SRI's Ed Claassen summarized all the morning's discussion in seven bullets. This showed the PGA that not only did the SRI staff understand the situation better than their competitors, they were able to represent succinctly and powerfully the work to be done. Thus began a 10-year relationship between SRI and the PGA.

Figure 12-9. Gary Bridges and plaque from the PGA commending the SRI work.

SRI's work for the educational segment of the PGA opened with a needs assessment, the presentation of which played to a standing ovation and the acceptance of a multimillion-dollar proposal to address what had been discovered. The work after that has varied. The most urgent need was a training program for golf professionals, which evolved over several years. This defined the entrance schooling required of all who would become PGA members. SRI then developed the PGA certification program that evidences a golf professional's competence in a number of specialty areas, such as running a tournament, managing a profitable golf business, and teaching golf. This education and qualification program then needed to be maintained as new members joined and new needs arose.

To round out this story, it is useful to look at why being in the ranks of the PGA engenders so much pride. To become a member, you logically have to be good at golf. That means no more than 155 strokes over 36 holes. Candidates then face the SRI-designed, rigorous education and certification program involving people, business, and teaching skills that range from customer relations to merchandising, facility management, and golf-teaching methods. Candidates are tested four different times, using techniques such as performance simulations and a 100-step work experience test. Part of SRI's contribution was to transfer to the PGA the ability to maintain the program. As such, the PGA is now able to operate the entire system without further assistance. As an indication of the rigor of the program, there is a 40% attrition rate, leaving only the very best to graduate. SRI has partnered with the PGA to create an education and screening process that guarantees the professional reputation the organization has sought.

CONTRACT RESEARCH—A CASE IN SELF-DETERMINATION

There is an unappreciated aspect of an organization like SRI, whose principals on the staff have a very direct relationship with their client. How is it that such staff are motivated to go to extraordinary lengths to meet the needs of that client? Such was the case in how our work for the PGA began. A Friday afternoon call requesting a proposal by the following Tuesday was not all that unusual. What was unusual in this case was that Gary Bridges was to leave for Africa the next morning! He worked into the night, slept an hour on a cot in his office, "broke into" offices to get needed material, typed the cover letter, dropped the package into the overnight mail on the way to the airport, and called the PGA back from Africa a few days later! During that phone call, the PGA official told him SRI had qualified and to "relax; when you come home we will take the next step." Some at SRI often feel that they work more for their clients than they do for SRI. Even though not literally true, it is not a bad working hypothesis.

Endnotes

[A] HHS Fact Sheet, U.S. Department of Health and Human Services, dated February 21, 2001. That year the coverage was expanded beyond the previous 3- to 5-year-olds to include families with toddlers and even pregnant women.

[B] Nina H. Shokraii and Patrick F. Fagan, "After 33 Years and $30 Billion, Time to Find Out If Head Start Produces Results," American Heritage Foundation, July 15, 1998. Article heavily quotes the following GAO report: "Head Start: Research Provides Little Information on Impact of Current Program," GAO/HEHS-97-59, April 15, 1997.

[C] Cathy L. Watkins, "Follow Through: Why Didn't We," (California State University, Stanislaus), Effective School Practices, Vol. 15, No. 1, Winter 1995

[D] Ibid.

[E] SRI Project 7370, "Longitudinal Evaluation of the National Follow Through Program," about $900,000, June 1969 to September 1969; SRI Project 8071, "Preliminary Evaluation of Planned Variation in Head Start," $228,000, July 1969 to September 1970; and SRI Project 2980, "Follow Through Evaluation," $1.8 million, October 1973 to April 1975 to September 1970.

[F] See SRI reports Summary Report on Follow Through Testing Program, 1969–1975 by Ann R. Wright for the Office of Education, HEW, Contract OEC-0-74-0582, September 1976; and Summary of Follow Through Data by Teresa Middleton and Lawrence Durgin.

[G] Jane Stallings, "Implementation and Child Effects of Teaching Practices in Follow Through Classrooms," Monographs of the Society for Research in Child Development, Serial No. 163, Vol. 40, Nos. 7–8, December 1975.

[H] Watkins, op. cit.

[I] See http://ti2.sri.com/tappedin/. *Tapped In* is a play on the acronym TPD that stands for teacher professional development and "ti2" is short for the second version of Tapped In.

[J] Barbara Means, email of August 10, 2003.

[K] Some of the perspectives in what follows comes from a rather comprehensive look at the subject in "Changing How and What Children Learn in School with Computer-Based Technologies," found in Children and Computer Technology, 10(2), Fall/Winter 2000. This is from a topic-specific journal of the David and Lucile Packard Foundation about the future of children. The authors are Jeremy Roschelle, Roy Pea, Christopher Hoadley, Douglas Gordin, and Barbara Means, all of whom were at SRI at the time.

[L] Roschelle et al., op. cit.

[M] Dr. William Penuel, email on July 2, 2003.

[N] Roschelle et al., op. cit.